ADAPTIVE REUSE OF TRADITIONAL HOUSES OF ALMORA

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF ARCHITECTURE

By

SHAREKA IQBAL

DEPARTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)

JUNE, 2006

CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **ADAPTIVE REUSE OF TRADITIONAL HOUSES OF ALMORA** submitted in partial fulfillment of the requirements for the award of degree of **Master of Architecture** in the **Department of Architecture and Planning, Indian Institute of Technology Roorkee**, is an authentic record of my own work carried out during the period from July 2005 to June 2006 under the supervision of **Dr. Pushplata** and **Dr. P.S. Chani.**

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Shareka Iqbal.

Date 30 June 2006

Place Roorkee

(SHAREKA IQBAL)

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Pushplata 30/06/06

Dr. Pushplata
Associate Professor
Department of Architecture and Planning
Indian Institute of Technology Roorkee
Roorkee 247667 Uttaranchal India

30/06/06

Dr. P.S.Chani
Assistant Professor
Department of Architecture and Planning
Indian Institute of Technology Roorkee
Roorkee 247667 Uttaranchal India

ACKNOWLEDGEMENT

It is difficult to put into words the gratitude I feel for the help rendered by many individuals and sources for the completion of this dissertation. Therefore, I take this opportunity to acknowledge those who have given their valuable suggestions in shaping this study into a cogent form.

I would like to express my deepest gratitude to my guides, **Dr. Pushplata** and **Dr. P.S. Chani,** for their strong support kind guidance and vital suggestions through all my good and bad times. My sincere my sincere thanks also to **Prof. R. Shankar**, Head of the department, also to **Prof. S. Y. Kulkarni** and to **Prof. P.K. Patel** for all their encouragement and support during my tenure in IIT Roorkee.

I am also indebted to all the faculty of the Department of Architechture and Planning for giving me vital inputs in my specialization.

I would also like to thank my friends **Kavita Singh** and **Deepti Muley**, without whom this thesis would never have taken shape.

To my parents, family and friends for their blessings and prayers.

DATE 30 JUNE, 2006 **(SHAREKA IQBAL)**

ABSTRACT

Every citizen experiences a wonderful opportunity to appreciate the influence and significance of the structures that make up the urban landscape. The built environment, like its outstanding and unique natural surroundings, provides a vital link to its past, assists in celebrating architectural achievements, and offers a vision for the future. It is a working, functional illustration of the many chapters in the story of human settlements. Protecting this built heritage and preserving the urban story for future generations presents a real challenge, a challenge that is being enthusiastically taken up by both individuals and groups like builders, developers, architects, community groups, heritage councils, and all levels of government. Adaptive Reuse, preserving our past and building our future, conserves the built heritage by successful merging the existing heritage structures and cutting edge architectural design. The best way to preserve heritage structures is to give them a sympathetic new use. This work demonstrates how Adaptive Reuse could contribute to enhancing, preserving and sustaining the built environment.

This thesis gives a brief overview to the definition, need, criteria, benefits and negative aspects into Adaptive reuse considering its environmental, social, economic and innovative feasibility for Historic dwellings. The architects role is the main focus in any Adaptive reuse project

This thesis discusses a historic building initiated into Adaptive Reuse through an elaborate process of defining its causes of decay, and thereafter conducting the preparatory procedures of making inventories, inspections, research, analysis and recording and finally putting forth the final evaluation report. This report chanellises the cost control measures into effective degrees of interventions. Presenting these buildings to deliver the historic message is important as the concluding effort.

This thesis awakens us to both global and regional guiding instruments of contemporary Adaptive Reuse practices, the heritage conservation Charters, their assumptions, theories and practices. A cross cultural perspective assesses the various adaptations, merits and validity of the most recognized Building Conservation Charters like the Venice Charter and the Burra Charter as well as the important Urban Conservation Charters like the Washington Charter and the Australian ICOMOS Charter. Thereafter the contributions of the UNESCO World Heritage Centre in preparing the World Heritage Listing of significant historic properties, their nomination process, criteria for selection, tentative listings, and success stories are discussed.

Besides global strategies, Adaptive Reuse interventions are also being undertaken at our very national scale by the Indian National Trust for art and Cultural Heritage (INTACH), guidelined in our very Indian INTACH Charter. This chapter concludes with a discussion on the mission, services and projects rendered by INTACH in relation to Adaptive Reuse.

This chapter discusses various case studies into Adaptive Reuse both at global and local level. Herethe three main classic global examples of vernacular architecture involve the Holašovice Historical Village Reservation, Czech Republic; Old Village of Hollókö and its Surroundings, Hungary and the Historic Villages of Shirakawa-go and Gokayama, Japan. Our local example is taken from Almora, the study area itself.

This thesis discusses the various structural interventions to the various structural elements of the historic buildings at Almora, essentially beams, trusses, frames, walls and foundations. Thereafter, causes of decay in materials and the structure are analysed like, climatic, earthquake, botanical, biological, microbiological, insects and pests, besides manmade causes. Internal environment of the buildings are assessed. Thereafter building repair and special techniques are suggested. Adaptive Reuse suggestions are proposed on the type of functions to be introduced within.

Adaptive Reuse means the process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values. This concluding chapter discusses the various guidelines that should be observed following recommendations into Adaptive Reuse of dwellings

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1.1. Background

Every citizen experiences a wonderful opportunity to appreciate the influence and significance of the structures that make up the urban landscape. The built environment, like its outstanding and unique natural surroundings, provides a vital link to its past, assists in celebrating architectural achievements, and offers a vision for the future. It is a working, functional illustration of the many chapters in the story of human settlements. Protecting this built heritage and preserving the urban story for future generations presents a real challenge, a challenge that is being enthusiastically taken up by both individuals and groups like builders, developers, architects, community groups, heritage councils, and all levels of government. Adaptive Reuse, preserving our past and building our future, conserves the built heritage by successful merging the existing heritage structures and cutting edge architectural design. The best way to preserve heritage structures is to give them a sympathetic new use. This work demonstrates how Adaptive Reuse could contribute to enhancing, preserving and sustaining the built environment.

1.2. Need Of Study

Need of Adaptive Reuse in Almora arises over various factors.

Due to rapid changes and advances in socio economy, science and technology as well as travel and tourism, the traditional forms and functions cannot accommodate contemporary services and facilities, to fit in conventional practices within their historical flavour.

While some previously built structures lie discarded and neglected when their usage proved no longer viable, others were distorted with inevitable additions, alterations and substitutions using new building materials and construction techniques. These new designs fail to blend with the local context.

Again rapid expansion and extension of building industry here has compounded the environmental negligence, like drying up the natural springs (Nullas0). Moreover no building byelaws or construction guidelines exist to regulate the land use, zoning, planning and design as growth and development measures. Thus arises the need to retrofit these ancient creations with contemporary architectural elements and features to make them further user friendly and environmentally efficient, besides conserving, preserving, replenishing and reviving the essence of these indigenous designs, in the form of Adaptive Reuse.

1.3 Aims & Objectives

- To explore the possibilities of Adaptive Reuse of traditional dwellings of Almora thereby preserving, protecting and promoting the architectural integrity and civic dignity of the indigenous architecture.
- To formulate and provide Adaptive reuse measures, guidelines, methods and controls aiding both governmental or nongovernmental, individuals and groups (like owners, real estate professionals, community members, contractors, architects and town planners) to enhance and improve the historical resources and quality of life.

1.4 Scope Of Work & *Limitations*

The project is confined only to the Adaptive Reuse of selective old residential buildings in proper Almora town that have outlived their original purpose. Only owners of small properties investing in Adaptive Reuse would be involved. This does not include any monuments protected by the Archaeological Survey of India and State Department of Archaeology, like all religious properties and commemorative structures of the order of civic buildings, temples, forts, palaces and tombs owned by the Government of India, erstwhile princes and landed families.

1.5 Methodology

- **Literature Review** on
  (1) Theoretical and historical basis of Adaptive Reuse
  (2) Building byelaws and construction practices on Adaptive Reuse
  (3) Prevalent documentation and research tools and techniques for Adaptive Reuse of historic sites and architectural styles.
- **Data Collection** Access and research the governmental and nongovernmental, national and local organizations collecting, organizing, preserving and exhibiting the

written and photographic local architectural history like lists, maps, drawings, figures, graphs, tables over old buildings.

- **Field Survey** Conduct interviews and collect public opinion regarding
  (1) Identification and documentation of old dwellings
  (2) Improvement projects introduced recently or completed earlier with Maintenance, preservation and repair of artworks undertaken
  (3) Optional or mandatory review and approval procedures for proposed additions and alterations
  (4) Present and future needs, problems, issues and perspectives of the locals, keeping pace with latest trends and fashions
- **Inventory Preparation** Design a comprehensive and current database for selective samples of existing historic dwellings within Almora town, their elements and features, design and construction, forms and functions, services and facilities, as prevalent from the past.
- **Analysis** Categorise the residential buildings into full preservation type, restoration and active use type or Adaptive Reuse type, thereby designing case specific Adaptive Reuse strategies , on an "as needed" basis.
- **Recommendations** Suggest and incorporate Adaptive Reuse measures and guidelines into existing design standards and criteria adherence for each building type involving location and size, fabrication materials, colour, illumination, building message, motion.

2.1. Introduction

This chapter gives a brief overview to the definition, need, criteria, benefits and negative aspects into Adaptive reuse considering its environmental, social, economic and innovative feasibility for Historic dwellings. The architects role is the main focus in any Adaptive reuse project

2.2. Definition of Adaptive Reuse

Every town seems to have some tired, underperforming buildings as the only entity which cannot leave the old, transform or adopt the new. Adaptive Reuse converts the building to a new use, artfully retaining the character defining elements of the original. Adaptive Reuse retains the essence of the building, while allowing it to meet the challenges of a new lifetime without any condemnation or relocation. Old buildings often outlive their original purposes. Adaptive Reuse adapts these buildings for new uses while retaining their historic features. Adaptive reuse is an option to improve the quality of the available, keeping pace with the new.

An example could be a post office that still looks like a post office, but is now a school building. An old factory may become an office building. A rundown church may find new life as a restaurant. And a restaurant may become a shop. Old manufacturing buildings have been revitalized to accommodate the need for housing as also as loft apartments.

Adaptive Reuse changes a disused or ineffective building into a new one that can be used for a different purpose. Sometimes, nothing changes but the building's use. The Adaptive Reuse of a historic building has minimal impact on the heritage significance of the building and its setting. Developers gain an understanding of why the building has heritage status, then pursue sympathetic development to the building giving it a new purpose. The most successful built heritage Adaptive Reuse projects are those that best respect and retain the building's heritage significance and add a contemporary layer that provides future value. Adaptive Reuse is the only way that the building's fabric will be properly cared for, revealed or interpreted, while better using the building itself. Where a building can no longer function with its original use, a new use through adaptation is only way to preserve its heritage significance.

Policies to manage change, including adaptation, when assessing heritage development contain standard criteria ensuring that an Adaptive Reuse project has minimal impact on a building's heritage values, such as discouraging "façadism" that is, gutting the building and retaining its façade; requiring new work to be recognisable as contemporary, rather than a poor imitation of the original historic style of the building and seeking a new use for the building compatible with its original use.

Adaptive Reuse is simply a conjugation embracing all acts that prevent or slow decay and prolong the life of any natural or cultural heritage that exhibits artistic wonder and human messages. For this, minimum effective action is the best, reversible with possible future interventions. Adaptive Reuse is founded upon listing and scheduling buildings, regular inspections and documentation, establishing legislation and thereafter town planning and conservation actions. The scope of Adaptive Reuse of any historic built environment ranges from the minute consolidation of a crumbling artifact to vast town planning preservation, engulfing a range of interlocking facets and skilled activities of the town planner, landscape architect, valuation surveyor or realtor, urban designer, conservation architect, specialized engineers, quantity surveyor, building contractor, material craftsman, archaeologist, art historian and antiquary, in principal, supported by the architectural conservator, biologist, chemist, physicist, geologist and seismologist.

2.3. Values in Adaptive Reuse

Adaptive Reuse preserves and enhances the messages and context of cultural property, by assigning values to systematically prioritize proposed interventions and establish the nature and extent of individual treatment. There are three major calibrations, namely *emotional,* which includes wonder, identity, continuity, spiritual and symbolic values; *cultural* involving documentary, historic, archaeological, age, scarcity, aesthetic, symbolic, architectural, townscape, landscape, ecological and scientific; and finally *use* values as functional, economic, social and political. Partial costs allocated to separate values justify the community total. The functional utilization of a historic building in Adaptive Reuse respecting cultural values, arouses conflicting value assessments, for example between economic and cultural groups, as well as between architectural and archaeological subgroups. Therefore, wide cultural preparation, sound judgement and mature sensitivity is essential.

2.4. Ethics of Adaptive Reuse

Adaptive Reuse works rigorously observe certain standards. *Firstly,* the building condition before any intervention, including all methods and materials used during treatment is fully documented. *Secondly,* historic evidence is always justified, allowing maximum existing material to be retained. *Third,* minimal intervention is necessitated, governed by unswerving respect for all aesthetic, historical and physical integrity. This proposed intervention is technically reversible, and flexible to future interventions if required, with later access to all evidence incorporated in the object. All interventions are harmonious in colour, tone, texture, form, scale, less noticeable than the original material, yet identifiable. Some unique problems are solved from first principles by trial and error. All this is done by sufficiently trained conservators and restorers under competent advice. Thus, architectural Adaptive Reuse allows material exposure to time and weather, in an open and virtually uncontrollable environment, the external climate. The size, scale and complexity of architectural fabric and operations is huge, though functioning as a single structure, resisting dead and live loads, enabling suitable internal environment and protecting against fire hazards and vandalisms. Therefore, where a multitude of people and functions are involved, understanding the objectives, communication and supervision becomes vital for Adaptive Reuse of a building, its site, settings and physical environment.

2.5. Need for Adaptive Reuse

Sustainable development balances environmental health with economic health, using state of the art buildings, energy efficient design and materials.

The built environment provides a footnote to our histories, helping to identify our places, rather than generically "modern" or "contemporary". Historic buildings give us a glimpse of our past, lend character to our communities and serve practical purposes now.

For sustainable development, communities gain much from adaptively reusing historic buildings. Bypassing the wasteful demolition and reconstruction alone sells the environmental benefits of adaptive reuse. Environmental benefits, energy savings and the social advantage of recycling a valued heritage place, make adaptive reuse of historic buildings an essential component of sustainable development.

Criteria for Adaptive Reuseis essentially enlisted as **Architectural** function, utility, economy, environmental harmony, and aesthetics; **Societal advancement** demonstrating a commitment to social progress; **Technical advancement** demonstrating

& exploring new technologies and their architectural applications; **Preservation** demonstrating skill, sensitivity, and thoughtfulness in preservation and **Adaptive reuse** demonstrating alternative use of existing buildings regardless of their original architectural intentions.

Benefits of Adaptive Reuse are ability to revitalize, restore and preserve historic elements and features in old buildings, maintaining their significance to activate surrounding areas; relatively easy to transform old dilapidated units to luxury dwellings; Provide for visual connections of newer building to the old on either of their two sides as also to the rest of the city; additional user friendly and environmental efficiency benefits more options to choose from due to adaptive reuse.

Negative Aspects to Adaptive Reuse involve difficultly to accomplish due to an extensive review process; expensive depending on the amount of work necessary to reconstruct a particular building; historic buildings, especially if accommodating intricate art and craft, are expensive to maintain and cannot attract potential tenants, as rents are expensive with limited business support available.

2.6. Feasibility for Adaptive Reuse of Buildings

Environmental feasibility considerations involve

- One of the main environmental benefits of reusing buildings is the retention of the original building's "embodied energy" (the energy consumed by all of the processes associated with the production of a building, from the acquisition of natural resources to product delivery, including mining, manufacturing of materials and equipment, transport and administrative functions), making the project much more environmentally sustainable than entirely new construction.
- New buildings have much higher embodied energy costs than buildings that are adaptively reused. In 2001, new building accounted for about 40 per cent of annual energy and raw materials consumption, 25 per cent of wood harvest, 16 per cent of fresh water supplies, 44 per cent of landfill, 45 per cent of carbon dioxide production and up to half of the total greenhouse emissions from industrialised countries.
- The reuse of building materials usually involves a saving of approximately 95 per cent of embodied energy that would otherwise be wasted. In this context the reuse of heritage buildings makes good sense.

Social feasibility involves

- Keeping, restoring, maintaining, sympathetic recycling and adaptively reusing historic buildings ensures its heritage significance survival, rather than falling into disrepair through neglect or being rendered unrecognisable.
- Reducing the environmental, social and economic costs of continued urban development and expansion, renders the quality and design of the built environment vital to our standard of living and the impact upon natural resources.
- Our lifestyle is enhanced from the retention, protection and adaptation of certain places and areas into accessibility and useability.
- The reuse of heritage buildings in established residential areas also provides the community with new housing and commercial property opportunities.
- Location, access and public transport availability along with variety in dwelling types and sizes attracts developers and buyers to reuse projects.

Economic aspects include

- Several financial savings and returns are made from adaptive reuse of historic buildings like embodied energy savings from not demolishing a building increases with the predicted rise of energy costs in the future.
- Even more than market appeal, reused heritage buildings are popular because of their originality and historic authenticity.
- The combination of financial incentives and the commercially oriented nature of the adaptive reuse schemes outweighs any extra heritage related costs and project risks.
- These sympathetic adaptive reuse schemes create commercially viable investment assets for the owners.

Innovative returns are as follows

- The adaptation of heritage buildings presents a genuine challenge to architects and designers to find innovative solutions.
- As development pressures increase in our cities, more heritage buildings are being reused, producing some excellent examples of creative designs that retain heritage significance.

2.7. The Architect into Adaptive Reuse

The architect diagnoses all decay causes and cure. Inspections are particularly useful to archaeologists, conservators and restorers. A preliminary inspection of the total fabric decides the area and necessity of further research, type and depth of analysis, issues and manner of recording and the basis for obtaining authority and funding subsequent vital depths of investigations. After careful inspection, research, analysis and recording follows a strategic Adaptive Reuse plan of regular observation and preventive maintenance through minimum intervention. Though needing sufficient professional staff and service fees, this progressively lessens the annual expenditure of cultural property. A logical plan conceptualizes the actions of the structural, environmental and spatial systems in a historic building as one whole. The objectives, inspections, further studies and manner of presentation; difficult aesthetic and artistic questions; contradictions and interpretations; work execution and cost control, are all rationalised before undertaking any Adaptive Reuse policy and action. A firm execution policy and control finalized by a multidisciplinary, experienced expertise is delegated to one competent person saving much upon time, money, indecisiveness and damage. Good preventive forethought and management aids passive and active security and fire protection and inhibits declining standards of public behaviour, theft, vandalism and loss of life.

Basic practical experience of the architect helps execute and coordinate Adaptive Reuse teamwork as a generalist. Thorough knowledge and understanding of all architectural periods, early building technology and its ageing pathology of sinking foundations, crumbling walls and rotting timber, helps distinguish original fabric from later additions and interpret findings to preserve the artistic and historic value of an old structure. Besides, a clear comprehension of modern building practices prepares satisfactory schemes incorporating modern relevant requirements, to comply with current practice codes and building regulations. Bylaws contradicting fundamental Adaptive Reuse principles are otherwise deemed inapplicable and waived.

2.8. Architectural Conservators

An architectural conservator bears special interactive responsibilities and diverse skills to Adaptive Reuse. Trained in new technology and scientific laboratory methods for dealing with artifacts, he taps resources in sub specialities of chemistry like spectrographic analysis, carbon dating and resistivity analysis. Besides, his knowledge of archaeological techniques analyzes site evidence; computer technology retrieves recorded information while photogrammetry produces accurate dimensioned drawings.

2.9. Crafts in Role

Craft skills in Adaptive Reuse range from simply repairing and maintaining domestic properties to the highest additional skills, artistic guidance, complicated application of artificially mending and reproducing the extreme diversification of past artistry. The craftsman applies his understanding of craft history and technology, collecting reference samples of past workmanship to analyze how historic work was initiated and produced.

Good craftsmanship and the masterpiece quality come from proper training; experience upon qualitatively inspecting and studying previous repairs in many buildings over different periods; work continuity; proper pay for fair days works; public appreciation and respect for the craftsman status, such that his skills equal design and detailings suit the materials. In general, during prosperous periods when material quality is at its premium, building owners pay well for good work, though pronounced regional variations do occur within the same period. Overtime and bonusing to increase output on historic productions through undue hasty construction give bad workmanship. Also, more skilled the craftsman, less money he earns over difficult, time consuming tasks, subject to payment for quantity, not quality, for muscle and not skill. In earthquake zones this workmanship quality demarcates collapse and stability.

2.10. Summary

Our introduction to the definition, ethics, values, needs, criteria, benefits and feasibility of Adaptive Reuse, involving the various players like Architects and craftsmen, gives way to seeking the methodology employed for the same, which is discussed in the forthcoming chapter.

3.1. Introduction

This chapter discusses a historic building initiated into Adaptive Reuse through an elaborate process of defining its causes of decay, and thereafter conducting the preparatory procedures of making inventories, inspections, research, analysis and recording and finally putting forth the final evaluation report. This report chanellises the cost control measures into effective degrees of interventions. Presenting these buildings to deliver the historic message is important as the concluding effort.

3.2. Defining a Historic Building

A historic building is defined as an idealogical complexity of human messages and artistic creativity, enabling an emotional impact of symbolic continuity and cultural identity. It exhibits architectural, aesthetic, historic, documentary, archaeological, economic, social, political and spiritual values, having survived 100 hazardous years of public usefulness. The historic study of any traditional complex along with its archaeological inspection, includes the client who commissioned it; his project objectives; naming creators and actual characters involved; aesthetic principles, compositional concepts and built proportions; its structural and material condition; internal and external peculiarities; surrounding environmental context; periodic political, social and economic aspects; chronological sequence of events through its life span; construction phases over later interventions and overall success of its realization.

3.3. Causes of Decay

All the weakening, damage, deterioration, decay and ultimate loss of any traditional building, due to natural as well as manmade causes, are a uniform and universal progression over time, through which only a tiny fraction of past property, structures, objects and component materials survive as our cultural patrimony. Analyzing these depreciative causes involves the possible natural wear and tear factors and their activity rapidness, besides probable human deteriorative agents and how much to reduce their source effects.

The strength and extent of climatic, botanical, biological and entomological causes of decay, besides natural disasters like earthquake hazards, vary immensely. Also the complicated and widespread manmade causes of decay like heavy traffic and vibrations, water abstraction, atmospheric pollution need preventive maintenance strategies to inhibit loss of life and cultural property. The spatial internal environmental system of historic buildings primarily modifies the harsh enervating external local climate, favouring the inhabitants, their domestic activities, work, social, spiritual and leisure aims. Therefore, the heat and moisture equation within needs balancing, as altering one factor changes others.

Natural disasters like earthquakes, landslides, fires and lightening have spectacular, rapid, destructive effects on cultural property. Normal, milder and prolonged attrition agents fall both under the general macro climatic level, involving many factors like radiation (especially short wave), temperature, moisture in its several forms as vapour, clouds, rain, ice, snow and groundwater, wind and sunshine as well as local micro conditions such as mountains, valleys at relative altitudes, proximity to water bodies or cities. The diverse microclimates act both discretely as well as intertwined within the overall macroclimate. Adaptive Reuse seeks precise information on extreme hazards withstood by the building over a long time span.

Major manmade forces of disintegration, neglect, ignorance, vandalism, fires and arson need careful forethought and assessment, as a serious and extensive byproduct of industrialization, which otherwise enables us the economy to press claims for Adaptive Reuse.

3.4. Methodology for Adaptive Reuse

The methodology for Adaptive Reuse elaborately involves tracing up inventories of Historic buildings, making the initial inspections and reports, research, analysis and recording of detailed aspects and making the final report to draw up the cost controls for further interventions as discussed below.

3.4.1. Inventories

At national level, cultural property inventories under the government administration establish appropriate historical asset categories through elaborate graphic and descriptive recording like computers and microfilm. Thereafter, protective legislation protects these buildings from demolition, besides allocating maintenance grants and special tax relief.

3.4.2. Inspecting Historic Buildings: The Context

A comprehensive and quick initial inspection is vital. Of the two or more complex causes of decay operating simultaneously, factual obvious ones surface during first inspections against the causative hidden ones. Survey, inspection and report account for the historic property in town planning context, where planners prevent traffic vibrations diverting heavy vehicles; reduce atmospheric pollution through correct industrial and power station sitings; inhibit fire hazards by facilitating fire fighting vehicular access.

A preliminary visual inspection defines the building as a 'whole'. Existing conditions are methodically recorded to report further studies. A complete and conscientious documentation needs diligent search of records and archives. Reliance upon oral traditions is included verbatim within individual dossiers. A statistically significant number of reports, together with estimates in recognized urgency categories assess the probable cost of Adaptive Reuse policies and prioritize budgetary provisions. Accordingly, the work force is planned to allocate adequate resources. Regular inspection and revision of all assets listed in the inventories over 5 years intervals, establishes preventive maintenance plans that forestall major interventions. This reduces the Adaptive Reuse costs of the national historic stock significantly. Initial inspection equipment includes writing boards, note pads, pens or pencils, good electric torches, pen knives or awls, measuring tapes, plumb bobs, bricklayers levels, magnifying field glasses, large objective lenses, digital flash attachment cameras for quick results, screwdrivers for lifting access traps, short hooked crowbars for lifting manhole covers, hammers for testing masonry and timbers, containers for insect samples, moisture meters, pocket mirrors, pleasant refined overalls or protective clothing that slip on and off easily, gumboots or waders and cleansers for self cleaning after the unavoidably dirty survey work. For getting up close, inspecting and testing high ceilings, roof timbers, external open roofs and building gutters, two finely adjustable, portable, extending ladders are needed. A builder sends helpers at the architects service, cleaning out gutters and blocked drains with necessary tools.

All human senses understandably inspect, meaningfully research and interpret clues upon seeing water stains, insect frass, damaged paint films, wall paper and plaster; smelling damp, musty or sour odours from wet earth, thread like mycelia, moulds, dust like fungal spores and defective drains; listening to the notes of tapped or struck wood, metal or stone; touching and probing floor jumps for personal safety. Wood, a universal fire risk, ignites by electric wiring faults, hot light bulbs and lightening. Structural wood members are inspected for shakes circumferential to the original tree trunk and radial checks, twists and large knots causing weaknesses. Longitudinal timber shrinkage, being least and circumferential shrinkage being greater than radial, cause board warping, defects and indirect damage. Drawn or broken joint failure or collapse is investigated. Open grained timber end detailings that absorb moisture and also dry out more rapidly and readily are studied carefully. Rapid wet or dry sequences and daily condensation, fatigue even small wood members like window bars; abrasion, wear and tear from heavy foot traffic; wind and dust erosion and ultraviolet light disintegrate and dissolve lignin in rain water. Paint areas fail particularly near the vulnerable end grain. Clear varnishes hardly inhibit ultraviolet light, though planing hardens wood surfaces. Timbers are appropriately tested by knife, screw driver or awl prodding. Soft wood structural timber condition is tested by lifting up a splinter, which if sound is a long sliver or if deteriorated a short weak piece. Surface moulds prelude fungal attack, while fruiting fungus bodies imply dangerous fabric decay. Nail rust indicates excessive moisture; nails standing proud indicate alternate swelling and shrinking. Visual survey procedures vary subjectively, but essentially dispense the building parts methodically. A standard routine work, vertically, from top to bottom, horizontally clockwise, disentangles meanings, gaps or obscurities of the written report. A building inspection usually starts at the northwest corner, because plans conventionally have north at the top, customarily read from left to right. Otherwise, a notional north simplifies descriptions. Vertical jamb sides of all openings are accurately described as 'east' and 'west' or 'north' and 'south', wherever one stands. The multi cell building interiors are inspected room by room sequentially working clockwise and downwards from ceiling to walls, floors, doors, linings, skirtings and windows in each room.

Gravity bears the onus of making buildings stand or destroying them. Buildings are mortal, reaching a point in time when they collapse over neglect, lack of maintenance and repair. Outstanding historic buildings are physical embodiments of past cultures and supreme achievements. A historic building successfully sustains several centuries with quite serious deformations and defects. Luckily, historic buildings created long before the mathematical analysis and calculations developed by Poleni in 1742, are over designed inconsistently with tremendous strength reserves. Structural problems of historic buildings are very much intelligible without calculations. Original builders excellently correlated their hands and brains into acute observations to analyze and quantify building thrust lines, depending more upon the structural form, than the weak materials strength.

Therefore, all strains pointedly concentrate on some weak parts more stressed than others, till collapse. Building strength is studied at three levels. *Firstly,* the whole structural form; *secondly,* the structural elements, roofs, walls, foundations and the soil they rest on and *third,* the materials of component parts. Documentary sources and present structural conditions provide clues to unique problems in individual elements. Analysis starts from first principles of qualitative intuitive understanding and basic vocabulary to build, formulate and communicate insight. A qualitative structural assessment through visual inspection pilots quantitative analysis, for precise assumptions concentrating on both obvious problematic aspects as well as the real total situation. Adequately picturing the composite structural action precedes the detailed analysis of any part. Typical defects, structural forms and conditions are minutely reviewed and investigated for alarm and concern, correctly interpreting apparent distress signs to pronounce verdict as unsafe or beyond repair. Structural actions, faults and elemental failures are analyzed and recorded, while good points in the otherwise deformed structure assessed. Before any intervention, the most desirable building characteristics, past history, environmental conditions, relevant facts, objectives, needs for future Adaptive Reuse are all individually proportioned to the justifiable depth of investigation. The final choice of approach arrives after proper appraisal, consistent with the scale of operations, resources available, alternatives and future probabilities. Best future safeguard places the building under continuous care of a surveyor, assisted by a permanent small staff of skilled craftsmen to intimately know, measure and monitor the structural health and movements. Continued use over mere conservation enables the building full role play and best guarantees proper care and attention. Remedial interventions respect the character and integrity of the original structure, using different substitute materials similar to the original ones, where their physical characteristics harmonize with the original, over porosity, permeability, strength and stiffness. Ingenuous, simple and elegant solutions maximize existing material use and knit the structure together onto a further lease of life, allowing future interventions.

Any necessary structural analysis follows factual recording. An archaeologist attends and records archaeological information. A trial hole dug to initially inspect the **wall condition,** dwells much upon the foundation depth, subsoil nature and ground water level. Soil shrinkage cracks damage the structure, and adjacent trees, shrubs or wall creeping plants cause settlement by extracting water from the clay foundations less than 1 m deep in summer. In cold, soil water expands to frost heave on freezing. First inspection of historic walls needs meticulous listening to physical hammer taps, through the wall thickness; dull tap notes with no hammer rebounds indicate soft and poor masonry, bright rings and hammer rebounds mean sound masonry for some depth. Further techniques investigate the construction method and the heart condition. Moisture movement through the walls and any impervious surfaces is studied. Water injected into walls tests penetration and leakage. For an initial inspection, moisture meters indicate the amount of surface layer water but are influenced by condensation and short circuited with metal foil lining paper. Rain water penetration is carefully noted. Improperly weathered and flashed, projecting cornices and plinths in the outer wall face cause rain penetration. Moisture often penetrates window sills without damp proof courses and condensation frequently occurs around windows with lower insulating wall effect. The wall surface plane is carefully tested with a brick layers level for potentially dangerous lateral track displacement, bulges and plumbness. All cracks, both through mortar joints or right through the stone or brick masonry are recorded and studied. In time, dust settles inside dark interiors of 'old' cracks, whereas new clean faces possibly contain lose masonry fragments. Movement tendency is deduced from crack tapering and angle; signifying nothing more than thermal movement and slow structural wearing out, but very significant few indicating a likely failure. Serious crack widths are regularly recorded and reviewed annually with a Demec gauge or a micrometer reading across three pins. Light tapping with a pen knife quickly reveals other clues to the structural actions mystery, like previous crack repairs, where plaster came away from a wall. Recent repairs or improvements like foamed polystyrene to composite walls with rendering, tile or slate hanging externally and plaster lining on wooden laths internally, are noted. Cold bridges are formed by embedded metal cramps and even Portland cement grout. Photographs of structural elements are ink marked with all pertinent information and defects numbered for reference. Photographs with a scale included, made and enlarged to full size record cracks in detail. Later, suitable measured drawings mark up all the cracks, showing their length and width. A Perspex model analyses complicated structural actions, showing the main building features together with cracks recorded on both inside and outside the walls, piers or whatever. Internal cracks in red ink, external ones in black, extent of cracking pattern through the structural masonry is marked with a pencil giving the date.

Daring masonry skills designed stone, wood or masonry **staircases** in historic buildings to disperse floor loadings upon firm wall anchorage. Floors and staircases deteriorate or collapse due to fungus and insect attack in the weakened beam ends, loosened end bearings, walls moving out or loose floors strutting and wedging. Floor moved down from the skirting base boards arouses suspicion. Square section timbers in historic floors deflect much more than in modern structures, though perfectly safe. Wide, draughty square joints without tongues allow dirt accumulation. Rising moisture through capillary action is probable in brick, stone or marble tiled and plastered floor surfaces of solid ground and suspended floors in historic building. Single minded electricians and plumbers cut and damage joists at their weakest point to insert cable and pipes. Floor timbers are tested same as roof timbers. Scaffold boards spread the surveyor's weight during inspection. Floor wearing in historic buildings is specifically reported. The floor boards and traps alongside each wall are carefully lifted and inspected to view the beam. A small mirror views the side and also the underside of beams in double floor construction. Structural member dimensions, floor board thickness and joints are recorded. Open staircase soffit is easily accessible for any decay clues. Tread thickness, wedge condition and undercarriage strength of wooden stairs counts. The joints, firmness, stiffness, strength and stability of newel posts, balusters and hand rails are important.

Windows and doors are carefully inspected same time as the walls for joinery, fit exposure, draughtproofness, fire proof qualities and climatic resistance. Defective putties and paintwork are common faults. Condensation from windows also causes trouble. Insufficient opening lights at low level leaves a moist, warm air cushion in the room top. Condensation trays, draining outwards are desirable. A sagging arch or lintel indicates either structural settlement or dry rot in concealed timbers. Rot in frame bottoms and wooden sills spreads into the wall lining.

Other than structural actions, **finishing** defects like poor workmanship, shrinkage cracks, plaster detached from lath and plaster coat separation are analysed. Wooden cornice framing, scarfed joint or mitro is liable to decay. Previous decoration date acts as a baseline for defect assessment and activity rate. Retention of original existing decoration is recommended after special conservation feasibility studies. Repeated layer thickness clogs and spoils the beautiful plasterwork crispness and decorative detail. Paint types, coats and colours are archaeologically interesting. The nature, finishing and state of paintwork decay is noted. Past wrong specification, such as bitumen or plastic based paints or varnishes to refresh worn paint, pose redecoration problems. Past wrong specification, such as bitumen or plastic based paints or varnishes to refresh worn paint, pose redecoration problems. Careful scraping reveals the paint layers and suggests the restoration colour scheme. Old, brittle joinery gloss paint chips easily if knocked. The inspection report recommends whether the existing paintwork is burnt and scraped down to prepare the bare wood for complete repainting. Only traditional, easily renewable paints are recommended.

Wooden **fittings** and fixtures are carefully examined and scheduled. Unfavourable internal environment in fittings, veneer shrinkages and blistering in low relative humidity, paint swellings and haze when high, cause fungal attacks. Insect attack evidences consume time.

The inspection reports **roof** structure, load collection and transmission down to walls. Wind bracing prevents rafters from all tilting and pushing a gable wall outwards in one direction. The principle defects in the original roof timbers like faulty conversion, sap wood decay, large dead knots, shrinkage, longitudinal fissures and radial cracks, only visible at the ends weaken, wane and partially fail the member. All roof structures, interiors, member joints and ends are carefully tapped, drilled and prodded with a pen knife blade or hammer end; inspected and assessed for decay conditions and the turnings enveloped, labeled and kept for future examination. Overall condition, covering adequacy, material, slipping broken tiles or slates, previous repairs, deflecting planes, surfaces, hips and ridges of roof slope are examined. The strength and the frequency of bracket fixing are noted. Abutment and chimney flashings are inspected carefully for cracks. Any deposits, design or maintenance inadequacy within eaves and gutters are checked from ladders. All gutter slopes and their performance are checked using a brick layers level. Size and slope of eaves, overhangs and gutters and their clearance from walls influence faulty or inadequate shedding of rain water. Parapet and valley gutters between roofs, are particularly vulnerable to snow.

Fume condensation, combustion salts and tars at **chimney** tops, particularly from the slow defective gas appliances and stoves causes mortar decomposition, flue fire damage, vertical cracks and internal parging collapse. Mortar decomposition and crystallized sulphate expansion in the joints of cold, wet side lean chimneys. Rust expansion of embedded iron cramps lifts whole chimney stacks. Rusted or slacked iron tiles tying back old stacks to the ridge, are rendered useless. The joint lap, cover and details between roofing materials, resisting climatic exposure and capillary attraction or penetration through porous materials are carefully examined. Clogged wall tiles and cavity constructions cause condensation spots. Rain penetration rots abutment roof timbers, rarely properly flashed and damp proofed in historic buildings. Besides gutters, chimney stacks are the most vulnerable points for rain water penetration in most buildings. Rain penetrating down old flues, shows at the bends in dark deliquescent salt stains.

Mechanical and electrical services are carefully inspected at two levels, *first,* refraining a fabric hazard to the historic buildings and *secondly,* for functioning adequacy. With a useful 15 to 25 years life, if obsolescent during inspection; they only have value over industrial archaeology and technological history. Heating boilers are weakened by corrosion and generally live for 20 years. Water tubes in high performance oil fuel boilers are renewed even after 5 years. A galvanized steel storage tank with rust spots and blisters inside, needs renewal. The sizing, condition and performance of the pipes, plumbing, hot water and heating systems in use is checked by a technical specialist. The pipe work age and type, its historic order being lead, wood, iron, galvanized mild steel tube, copper, stainless steel and polythene is assessed. Corrosion and repairs indicate poor condition. Isolating valves completely empty the system for repair. Water is turned off and the system drained down before a historic building is left unoccupied. Different types of insufficient supports, faulty taps, valves, connections, pipe work leaks and corrosion, particularly of toilet bowls, are all noted. Insufficient supports or a faulty ball valve cause water hammer. Defective washers in dripping taps are hazardous in frosty weather. Precautions and protection from frost and condensation dripping from cold water pipes and storage tanks is checked. Sufficiently deep main water supply avoids frost, road salting and traffic. Water supply hardness causes furring of heating and hot water pipes and two further special dangers, dezincification, where zinc leaches out of brass fittings, and impingement attack, where copper pipes fail if the bends are too sharp or water velocities too great. Tapping pipe work gives some 'hit and miss' information, indicating furring possibility by a dull note. These installations are best renewed in their entirety for adaptation, with salvaged material. Electrical installation material rapidly decays, brittles and goes obsolete. Historically, a new system follows the old. Good condition wiring insulation is pliable, even in bad condition giving satisfactory resistance test. The architect, wherever possible, checks the outer wiring condition. The size and position of electrical intake, distribution boards, circuit arrangement and wiring system is given with insulation polarity, earthing resistance and continuity readings. Proper wire fixing and junction box usage assesses workmanship standards. Plaster embedded conduit always needs drops. Rusty conduits and pulled joints break earth continuity. Pendant cables, socket outlets and lights are checked for polarity, decay and short circuit. A major fire cause, poor electrical installations are reported as potential hazards by specialists in historic buildings.

Most historic buildings have no horizontal damp proof courses or under floor membranes against **moisture**. The initial inspection notes the height, variability and the summer and winter evaporation level of rising moisture due to capillary action. Any evidence establishing the water table level and salt existence in soil is recorded. Rising moisture amount is crudely assessed placing a sizable glass sheet over a solid floor for a day. Any precautions lacking in rising moisture is noted. Previous repairs and inserting various patent moisture extractors indicate rising moisture problems. Good ventilation of wooden sub floors avoids dead moisture laden air pockets. Ideally, under floor ventilation is minimum 3.5 m centres and close to the room corners.

Ideally the self evident **rain water disposal** system defects, overflowing gutters, blocked down pipes are inspected in heavy rain. Otherwise wall staining and rust marks and internal moist patches point defects. The rain water down pipes fixing and clearance is checked. Often close to the wall, they cannot be painted. They are fixed with spacers for easy painting. Rain water drains are inspected together with the drainage system. Generally the rain water is taken about 3 to 4 m (10 to 13 ft) from the foundations. Broken rain water drains threaten foundations, causing moisture penetration in basements and crypts. Driving rain penetrates doors and windows and rots sills and frame bases, especially if painting is neglected.

Almost all old **drainage** systems are defective and damaged by water tests as applied to new work. It is a matter of judgement whether the faults affect the structural health of the historic building. Tapping sound waves down a pipeline, using a garden fork listening device, finds a lost drain. Electromagnetic detectors trace drainage runs and other buried services. For example, broken drains leach out soil and permit moisture penetration from under the foundations and basement walls. Broken drains are vulnerable at entry points to a building, where settlement occurs, and under a lightly constructed drive over which heavy loads pass. Visual inspection shows the general drain condition as clean, allowing bucketful water to run freely from manhole to manhole. Delay or only percolation indicates fault. Cracked and rusty manhole condition and cover fit with and without lifting lugs is checked. They are bedded in grease and made air tight. A smoke test detects breakages or defects by the greater smoke volume percolating through the soil and smoke emissions at joints, between drains, shafts and toilet bowls. A smoke machine pumps smoke into the system after stopping all unsealed outlets. The pneumatic test, using the same machine with a pressure gauge, moves a plug down the drain detecting the greatest air leakage and breakage rate. Septic tank condition, top and bottom drain ventilation and sewerage disposal is noted. An old drainage system working without offence, is left alone, otherwise upsetting the bacteriological system for effluent disposal.

The first encounter of the architect with a historic building is making thorough and accurate inspections, eventualising future action. The **initial report** records and evaluates the significance and condition of the historic building to strategise the preventive maintenance plan. All Adaptive Reuse methodology thrives on periodically inspecting and reporting all items of cultural property, factually recording visible defects, diagnosing causes of decay and proposing an effective, minimal interventional cure. Previously available inspections and reports give invaluable factual evidence to each individual building and assess the rate of change in decision making. This meticulous examination identifies the message and values in the cultural property as a whole, defines the extent and nature of the historic building and includes its relationship to its setting with a seeing and understanding eye. The well written and well presented report is read by laymen, in short, informative, precise and clear sentences, avoiding technical words and jargon, but, if necessary, explained in a glossary. Legislation, listing and scheduling cultural property frames and structures Adaptive Reuse work.

A full report is worked up in stages with the *first* initial report visually inspecting, listing, describing and studying the building and all defects. *Second*, a maintenance plan describes approximate itemized estimates of immediate, urgent, necessary repairs and other desirable works. *Third* stage, photographic records support historical research and analysis. *Fourthly*, the initial building state, soil mechanics, humidity studies and suspect parts are recorded and opened up. *Fifth*, Structural analysis is further studied. The *sixth* ultimate stage involves final estimates, proposals, specifications and full submission report for governmental grant covering all the above factors and modifications.

The conservation architect makes his initial inspection and receives all evidence with his five senses and an open mind. Preconceptions dangerously blind vital evidence. The initial inspection necessitates studies in proportion to the significance of the problem. By detailed inspection a trained architect detects significantly evident syndrome before most measuring systems. He works in four dimensions, length, breadth, height and time, the site history, previous and present buildings reacting to decay forces. The initial inspection report is used for many purposes like a maintenance plan, developing an essential preliminary theme for further study, historical research, structural analysis, soil mechanics, moisture investigations, opening up suspect parts and identifying all decay causes. The initial report factually records the historic building condition. Explicit preliminary opinions, later variable, are distinguished from facts while reporting. Initial reports sketch the complicated building outline, floor plans and roof plan. Full reports consolidate all the building information collected, identify the decay causes and propose cures. A full report always includes measured site plans, boundaries, rainwater and soil drainage disposal, and mechanical and electrical devices. The accompanying format, specifications and cost estimates seeking any governmental grants include allowances for recording and finally reporting the Adaptive Reuse work.

Further defects materialize quickly. Climate, incidence, types and location of all plant growth, moulds, rot, insect attacks and old or new flight holes are carefully noted. Inspection date is carefully stated while recording visible defects. Survey limitations are mentioned, like inaccessible roof spaces, wood ground floor, floorboards, linoleum or other impervious material coverings and furniture preventing full inspection. No guarantee is stated to prepare repair estimates unless a specialist opens up and examines the floor. Opinions are framed that between localities, the climates and microclimates of buildings differ and affect performance materially, while exposure increases chemical actions and fungal attack.

Reports are short, concise and specific working documents. An introductory summary states the report objective. Direct insitu reports are brief and accurate extended notes. Acute observation notes the defect complications and suggests checking further points instantly by a more detailed investigation. Insertions are easily backtracked and incorporated in the correct place in a written draft document. Clarifying that the initial report is not a specification, the following paragraph is inserted in any report, "this document is a report, not a specification. It lists defects found but does not give detailed instructions for remedying them. Builders should not be expected to quote for or carry out the specialized work required without further guidance; they should be provided with a proper specification, or if the work is very minor, should be asked to submit their detailed proposals for the architect to check. Even small errors in workmanship or materials can be functionally or aesthetically disastrous." Small works devoid of professional supervision are indicated in the survey report summary, and if the builder is available are accomplished with the insitu architect. A flexible report form relates well to the building and its purposes. A standardized pro forma or schedule is devised for much repetitive detail in a building, but complicated proformas often are an end in themselves, meaningful only to the person who devises them, stultifying to those who fill them in and later a curse to those who try decoding them. Specific words are used to describe each individual building. Final reports include considerations and alternative courses of action before recommendations. Upright A4 (normal photocopy size) paper, with drawings folded in, are easily filed and retrieved as standard practice.

Besides preparing a maintenance plan, the initial report reveals serious defects for further studies and detailing. The initial report lists all visible defects, cracks, poor masonry, rising damp and defective roofs specifying further consideration, discussion and investigation by requested authority. Clear action recommendation follows an initial investigation. The architect is realistic with appropriate maintenance standards, recommending within the client financial capability, except for structural danger, where public safety is the first consideration. The authorized architect ideally gives a builder on the spot instructions for immediate attention to certain items upto specified value, saving considerable time and preventing further damage without conflicting with accountable administrative ideas, as the architect is a trusted professional man. Recommendations scaled to the contextual situation are prioritised as:

1) *Immediate work* done straight away, dealing with fabric or its users safety.
2) *Urgent work* preventing active deterioration, insect or fungus attack or rain water penetration.
3) *Necessary work* category contextually appropriating building standards, its present or proposed use over clients resources and including preventive maintenance items subdivided into good housekeeping, rolling programme and major works.
4) *Desirable work* recommending enhanced building use or appearance for reevaluation or Adaptive Reuse.
5) *Items under observation* as active movements, roofs or installations near the end of their life, needing renewal within 10 or 15 years.

Considerable skill and knowledge balances the various factors that categorise an item. The major consideration evaluates the damage occurring without repair. Roof covering renewal is one of the commonest work items. Grouping suggested works into logical building sequences, organised by trades, gives contractors worthwhile task at economical prices.

To recapitulate, a realistic initial report clearly demonstrates to the client (owner or trustees), the building condition, sequential undertakings launching the building into appropriate use and an approximate estimate to the proposed work cost. Labour and material are separately estimated and updated against inflation, reworking each unit cost at current rates. Possible high and low cost ranges worked to so many unknown hazards provide valuable information. Professional fees and expenses and any taxes (such as VAT) are also included in estimates. Archaeological investigations, art historical studies, research and photography are all estimated separately.

3.4.3. Research, Analysis & Recording

Precise complete documentation as analytical and critical reports, photographic and drawing illustrations is essential before, during and after any intervention in all works of Adaptive Reuse. Every stage of cleaning, consolidation, reassembly and integration of all materials and techniques used, all technical and formal features identified through the intervention is recorded and reported in public archives to broaden general knowledge. Quick preliminary reports followed by lengthy annual scholarly series of updates over these interventions aid in adequate budgetary provisions, popular public support and refute unjustified criticism. Documentation budgets are treated separate from Adaptive Reuse estimates.

The initial report suggests deeper investigation. The ground history, building phases, sequential construction periods, site conditions, external environmental changes, building technology, all relevant historic and archival evidence are unraveled, analysed, researched and recorded through complicated, timely decision and necessary action. Ancient illuminated manuscripts, old drawings, photographs, models, plans, sketches, general views and bas reliefs including the historic building as background, give much information, both specific and general about the building establishment, accounts, modifications, enlargements or demolition. Administrative documents, orders, contracts, sales, receipts, wills, donations, deeds, grants, censuses, street or trade directories, old newspapers and journals, both popular and technical, are extremely informative on recent construction. Enlisted records offices, archives and museums are resourceful. Sequential building operations relate historic site development directly to engineering problems in fabric reconstitution. Analytical studies and geometric diagrams ascertain all building features, including those unexecuted and unfinished, modules or proportional systems and design techniques.

Building methods, materials, general style, artistic composition, proportions and aesthetic principles approximately date buildings. Stone masons and carpenters stamp marks on tiles and bricks show the building progress. Tooling and cutting techniques roughly date masonry. Occasionally documentation is concealed within walls or foundations. Other information from the building includes initials, monograms, signatures, epitaphs, marked dates (particularly in foundation stones), coats of arms, escutcheons, emblems, mural decorations, casual graffiti and signatures.

Drawing combinations, both freehand and mechanical, and photographs picture the building clearly and exactly. Small sketch drawings convey ornamental details, shapes, colours, general appearance, perspective, surroundings, landscape beauty and attention to a special point. Photographs show shape and outline irregularities and damaged parts more clearly. Photographs also raise funds and publicise cultural property preservation. Annotated, detailed photographs record defects and cracks exactly and specifically, including a scale or common coin within for further instructions. Special films for survey record elevational photographs employ special techniques and lighting, define linear edges and avoid halation. A 2 or 3 m (6 or 10 ft) scale is inserted in the photographic plane. Negatives from a camera planted truly normal to the subject and dead vertical with two full sized scale inserted, photographically record flat subjects enlarged to a known scale for drawings. Such photographs produce every stone or brick in the correct position. Special films transferred into dyeline negatives reproduce cheap photographs.

Accurate building drawings, identify features, diagnose structural defects, propose alterations, price works and easily interpret the final recommendation report for strategic planning purposes. Accurate, measured, idealized drawings showing typical details, deformations and irregularities over a historic building survey are complicated, expensive and time consuming, involving a specialist firm. Accurate plans, sections and elevations enhance the fundamental three dimensional architectural thinking skills while 'seeing through walls' on any Adaptive Reuse repair work. Historic analysis merges easily with well coordinated mechanical services to design feasible alterations. Even a humble vernacular cottage is fully measured and recorded before alteration. Such plans are routinely sent to a central agency for availability to building historians. The historic building, its type, composition, position and its parts are drawn to convenient scales, with conventional signs, as 1:500 for site plans; 1:100 and 1:50 for general plans, isometric drawings and isometric projections; and 1:10 and 1:5 for details. Conventionally, one plan is drawn at each 1 m (3.3 ft) horizontal section above floor level, appropriately varied over the historic building configuration with a clear, dotted elevation line. A broken line marks any parts excluded in the horizontal section while a dash and two dots shows higher features. All facades in orthogonal projections, relate to the plan from an infinite point. Angular faces drawn in true elevation help accurate measurements. Sections through the more significant building parts reveal the concealed architectural features and construction. All plans trace the predetermined vertical planes of ideal sections. Surveyors accurately check all significant bearing wall curves, thicknesses, structural and decorative details (drawn large scale or even full size). Various floor heights give detailed graphic analysis to a building's particular volumetric characteristics or special architectural features. Key or location plans showing surroundings, explanatory diagrams or isometric projection drawings supplement the survey. Field measurements always need supporting documents. Diagonals, offsets, triangulations, both vertical and horizontal with a theodolite enhance survey accuracy.

Although simple in principle, the complicated photogrammetry practice also accurately measures and records the building exterior. Pairs or series of stereoscopic or air photographs delineate the subjective plan, section or elevation on a plotting machine to compute its volume. Photogrammetric technique depends on the desired accuracy, lesser the accuracy, simpler the equipment and quicker the results. Photogrammetry excels in plotting rounded and irregular objects impossible to access and measure; recording, storing and retrieving all the relevant visual information and specific measurements for later reference. An earlier destroyed historic building is reconstructed from photogram storages. Photogrammetric documentation also helps damaged buildings and special interiors. Considering the necessary precision instruments, costs and skilled operators, photogrammetry is most economical in continuous, effective group utilization. Successful, architectural photogrammetric measurements and drawings need correct interpretations. Photogrammetry accurately connects the key point coordinates by drawing and filling in details with rectified photographs. Photogrammetry fascinatingly reveals architectural and sculptural corrections for acute vision angles and differentiates well between a roof drawn on elevation and the roof on real ground.

Photogrammetry offers the following advantages:

1) Speedy photographic recording (no building scaffolding needed).
2) Precise and uniform measurements. Gives high order accuracy.
3) Saves survey time and money survey, especially on a curved, irregular object.
4) Measures fragile, delicate objects. Xray photogrammetry measures invisible features.

5) Surveys buildings impossible or dangerous to reach.

6) Reveals distortions not appreciated by the eye.

7) Pertinent data storage allows later restitution, without plotting photographs immediately.

8) Intermittent photographs (even years apart) demonstrate or check the object deterioration rate.

Surveys and photographs give a two dimensional picture; models and casts obtain a three dimensional representation. While reading drawings, particularly elevations needs much experience, laymen easily decipher the apparent three dimensional aspects in models. Wood, wood derivatives, metal, plaster, cardboard or transparent or nontransparent plastic models illustrate the volumetric and spatial arrangement of urban units, historic building groups, or a general site topography. Skillfully illuminated model photographs visualize missing parts and past constructions with amazingly vivid liveliness. Special models calculate and test the existing or projected structural resistance. Historic centre models in 1:500 scale provide invaluably assist town planning problems and their implications, assessing proposed Adaptive Reuse restorations or alterations. The 'modelscope', a tube instrument with a bottom viewing lens and top eyepiece, shows and photographs models inside. Perpex models show three dimensional relationships between structural cracks, their causes and their effects. Different colours indicate all internal and external cracks viewed simultaneously.

Casts provides exact reproductions with fluids (plaster wax or plaster and synthetic rubber compound) poured, solidified and removed from the original matrix. This method necessitates numerous carefully made matrices for complicated sculpture pieces. Coating the matrix surface with various substances harms the colour, polish or surface itself. This surface is protected by a thin aluminium foil sheet or similar material cover, avoiding folds before casting. The foil is easily removed afterwards. Dampened papier mache adhesively dries into good surface imprints. In some cases, black wax (heel ball) or common powdered graphite or dye in cotton bag rubbed over thin paper layering on the surface area gives convenient recording. For small engraved epigraph surface areas a soft pencil is gently rubbed over a paper sheet. Rubbings indispensably collate all broken memorial slabs or sculpture pieces.

A preliminary descriptive examination report on the whole building initiates further specific structural and analytical studies. The preliminary report ensures, conceives and signifies all information for further studies essential for briefing specialists, especially engineers. Suspected active vertical and horizontal movements and deformations in cracks are measured and recorded with theodolite and plumb bobs, over at least a year of seasonal thermal expansion. Accurate humidity, dampness, vibrations, atmospheric pollution, static and dynamic recording and analysis of historic buildings need waiting and watching. An initial inspection launches scaffold erection, photographic recording and exposing suspect areas for detailed inspection. Light scaffolding enables cleaning, dusting, washing, closely studying the building fabric, collecting material samples for laboratory analysis and also for palaeographic, dendrological and carbon 14 study and identification of wood, metal and stone.

The two operations (analysis and recording) go hand in hand. Structural analysis involves all methods to process available data, produce strength assessment, stability and deformations, past, present or future. Structural analysis completely describes the structure as it stands, warts and all. Three dimensional structural description performs structural analysis to various refinement degrees. Structural records describe building anatomy in three dimensional space and the fourth of time, including the existing state. The most complete record, the building itself, is too big and complicated to be grasped as an entity. An ancient building in good repair and sound over visual inspection, resorts only to structural analysis effectuating a proposed environment change by major construction or demolition works in the vicinity. For an ancient building in a poor preservation state, structural analysis assesses

1) present structural safety;
2) effects of observed defects;
3) possible cause of observed defects;
4) Remedial work necessary, if any.

Cracks ascertaining structural gaps, are masked by past repairs done, such that a superficial 5 mm crack signifies a 25 mm structural gap concealed by repointing and/or stone replacement.

Measuring deformations between the original construction date and now, has fairly low precision degree over inevitable original construction inaccuracies. Fairly crude measurement methods, ordinary leveling instruments suffice; but the best possible telescope assists reading in poor light. Leveling hard to get at places, needs light and compact instruments. Any one building section built entirely in one period is finished within $\pm$10 to 15 mm on horizontal features such as string courses, but anything built before or after has intervening differential settlement. Simple plumb lines or theodolite plumbing fixed to small heights, require a calm day externally. For multiple storeys, where a floor has different vintage from that below, fairly accurate pier shape (±25 mm) correlations ascertain possible eccentricities. A complete symptomatic pattern of drawings and models initiates a safe diagnosis. All significant defects are superimposed over sections and elevations of small enough scale for the whole building on one sheet. Geographically presenting cracks and deformations is straightforward and comprehensible. Relative elevation levels are a line diagram with exaggerated vertical scale. Out of plumbness arrows indicate the direction with the magnitude figures superimposed at the arrow level, and a particular line deformation is plotted to exaggerated horizontal scale away from the main elevation.

Ageing cracks are approximately accessible; the very old accumulate dust and dirt; only the relatively old contain varying dust degrees in the crack length and the newer have cleaner interiors and sharper edges. Most building cracks or points move with seasonal fabric expansion and contraction, in a sizeable 'envelope of movement' determined by continuous study. Initial frequent measurements at monthly intervals establish the envelope, then taken once or twice annually at the same time. If no envelope, the crack is moving actively. Significant crack movement exceeds the established envelope. Carefully examining and documenting initial settlement cracks that remain but cease to move, all previous plaster repairs, datable fixtures and other incidental features in sequential building construction provide clues whether cracks existed before fixing. Crack movements are roughly and readily studied by fixing plaster dabs or glass telltales with epoxy resin to the basic masonry. Glass telltales only 1 to 2 mm thick, with notched ends ensure good mechanical resin bond, gripping the masonry. Glass telltales react slowly to movements, showing outward movement and crack openings. Pipeclay telltales to knife edge precast concrete blocks are difficult to obtain and fix. A telltale breaking is obviously exaggerated and significant to the layman, neglecting a portent 0.01 mm movement in the building syndrome. A broken glass telltale lacks information, failing recommendation for proper long term crack movement. An elegant, accurate and economical dial micrometer, the Demec strain gauge measures the distance between stainless steel measuring points fixed very easily to the wall masonry with epoxy resin. The firm, inconspicuous dots composed triangularly, give planar measurements in two dimensions and, are cleaned if decorated over. Only one man uses the sensitive gauge in any measuring scheme, eliminating the personal factor. An Invar bar checks, averages and corrects measurements for temperature.

Micrometers in between substantial wall plugs protected against damage and corrosion, measure outward movement in the third dimension. Another complicated plug invented by J. Crockett measures three dimensionally with one micrometer. D

A geodetic survey using a theodolite from a fixed base, traditional plumb bobs and damping or optical plummets involves classic surveyor skills with very high accuracy level. Geodometers and tellurometers are sophisticated equipments needing accurate datum points. Establishing a simple, deep, permanent and immovable datum near the building needs pile driving or a nonrusting metal rod set inside a protective tube filled with durable oil, sealed and capped with stainless steel. Relative partial component movements cause cracking and deformations as against absolute movements.

The geodetic survey defines its objectives, records assumptions for posterity and enables continuity with suitable, regularly interspaced reviews. Measurements assess the building structure, its health, comparing actual past movements with projected future forecasts to avoid unnecessary repair work. The forecasts specify a ± 1 mm accuracy degree from the geodetic survey. Reviewing a fully recorded, measured and structurally evaluated building reduces the future examination programme to quinquennially checking most significant points, with complete complementary visual inspection.

Evaluating further cracks and changes refers to the initial measurements.

Certain preliminary investigations initiate a costly specialist report by soil mechanics engineers. A hole is dug and probed diagonally down to the foundation depth for water intervention without pumping. Light equipment like hand augers probe to 10 m ground depth for extracting samples, making penetration tests and indicating the bearing capacity and thickness of respective soil layers. Engineers are briefed on the problems concerned prior to a full scale informative soil mechanics survey. Expensive surveys involve heavy boring equipment and complicated laboratory tests. An archaeological excavation best explores the site.

3.4.4. Making the Final Report

The initial report absorbs all historical and environmental information, implements measurements, recordings and studies and recommends further inspection routine, initiating a full report that cover all decay factors and modifications. The final report, best written insitu, sequentially visualize all work in operational form, dealing with the repairs, consolidation and restoration of distinct elements externally, and room by room internally, prepares the work specifications and drawings enabling accurate costs. Decorations, plumbing and electrical work are separate elements in trade specifications. Thereafter the report and scheme for the historic building works is submitted for approval and grants allocation. Professional fee estimates figure recording costs, final report, plans and photographs describing the initial condition, all work executed, hidden features, various operations, trade name material compositions, sophisticated chemical treatment formulae used and their results for posterity. Ideally, product samples are archived. One report copy is submitted to the commissioning authority, two other copies deposited in the building library or archives and in a national or local records office respectively for future reference.

3.4.5. Cost Control of Adaptive Reuse Projects

Efficient cost control systems further scarce Adaptive Reuse resources flexibly meeting the demands of each individual historic building as the real client or patient. Inefficient systems increase costs over 300%. Adaptive Reuse Inappropriate initial inspection of the whole building setting, renders wrong diagnosis, expensive mistakes, restrictive practice codes, clumsy administrative and contractual procedures, low flexibility, lacking specific responsibility and poor supervision and bureaucratic delays. Defective contractual procedures, wrong technology, faulty cleaning techniques, using cement mortars, toxic dieldrin and dioxin chemical hazards and lacking bureaucratic responsibility evaporates Adaptive Reuse initiatives within a short time.

After the initial inspection, the professional adviser informs the preliminary Adaptive Reuse estimates to funding authorities in two inseparable figures, *firstly,* the realistic work costs, and *second,* the worst possible work costs. Inflation, a politico economic problem, introduces the time element impeding stagewise estimation. Estimates at current prices with six months inflation, need indexing cost systems for labour, materials, plant and overheads. Any item fluctuation is then easily revised. The unit rate method for defined work quantities, nonexistent for many work items fails over Adaptive Reuse projects.

Operational specifications assist pricing, giving the general work order on a room by room basis for each internal or external feature, described under five detailed operation headings, removals, repairs, alterations, services and decoration or finishing. Labour and material list is extracted by trades. Heating, ventilating, hot and cold water systems, electric installations and plant designed and renewed as a whole are cost specified separately by specialists, on a room by room basis attendance.

In Adaptive Reuse contracts, building contractors add a high elementary price risk unresolved by the funding body till substantial work. Full studies of all alternative Adaptive Reuse methods made after initially inspecting, opening up and exploring hidden building parts reduce risk. Scarce materials, skills, bricks or tiles shortages and lack of good hydraulic limes are typical problems assuming professional time and money. If not solved in advance, smoothly running a complicated building contract gets jeopardized and even greater costs incurred.

The works programme and scale rightly balances team size and skills for each Adaptive Reuse operation of archaeological projects, art history investigations and art work conservation. Fewer highly skilled men working rather longer than too many has best flexibility. Special portable scaffolding is entirely supplied, controlled, moved and adjusted over a long time by the contractor, entirely responsible for all safety precautions. A skilled contractor correctly hiring and diversely using an expensive construction plant, saves considerable costs. Numerous unforeseen hazards need flexible Adaptive Reuse programming and works. The principle is continuous work for the right sized team. Stopping and starting work escalates real costs leaving the expensive plant idle. Programming building work is a specialist skill, all operations following the classic time/cost curve, slow to start, rapid and productive in the middle and slow to finish. In Adaptive Reuse work, even more time is allowed for finishing for artists and craftsmen doing good quality work. Important completion dates with a good contingency factor enhance work. A sophisticated computer program with hourly labour, materials, plant and overheads costs accurately estimates the anticipated operation cost in printouts at regular intervals, for major operations. Otherwise, simple cost against time graphs are the most valuable and deception proof techniques.

Control systems are now examined. All government documentation at a national level, regularly inspects all its classified historic buildings at least five yearly for formally estimating their requirement headings, immediate and urgent repairs and minor works, necessary works (major works or rolling programme) and desirable works (need in 10 to15 years) noting itemwise observations. Frequent professional supervision and informal visits supplement such regular formal inspections and reports. After 10 to 15 years of strategic preventive maintenance, the real cost of Adaptive Reuse of historic buildings drops. Professional staff improves expertise as time moves on. Delegating appropriate responsibility for authorizing immediate and urgent repairs to qualified professionals, saves time, administrative costs and prevents further damage.

'Necessary' and 'desirable' schemes are stagewise handled differently and brought forward from preparation, estimating to approval. Once approved, sufficiently budgeting contingency funds must complete the programmed schemes. However well planned the Adaptive Reuse, occasional unforeseeable surprises like, an unexpectedly severe winter or earthquake accelerate building decay.

The funding body compares the total Adaptive Reuse project cost with building anew on a unit cost per square metre. If costing two thirds or less, then Adaptive Reuse saves building costs. If more, the cost of new roads and services infrastructure, demolition and delay are debated economically, culturally, socially and politically for finally assessing scheme benefits. Also, before the competent authority approves a conservation project, the work is evaluated if it has minimum necessity; is reversible (allowing future interventions); adheres to the Venice Charter (or the national equivalent) and the ethics outlined. The competent authority confirms specific objectives and presentation policy of the particular Adaptive Reuse scheme with the responsible professional, who supervises and coordinates the project execution within the budget. Thereafter, the building becomes his client. These provisions are necessary to ensure: (a) rapid and correct decision-making, which saves money, and (b) coherent artistic treatment, or avoidance of confusion, which also saves money. The expert in charge can always ask for advice, but his alone must be the responsibility for saving cultural property. He will lead a multidisciplinary team and ensure good communication by regular on-site meetings. He will confirm his instructions clearly in writing. He should report the budgetary situation once quarterly. In his control of his overall budget he should break this down into target costs for recognizable items of work, and so prevent one item from 'robbing' another.

There are many hazards in a contract for conservation work. One of the techniques should be to reduce the unknown dimension by preliminary opening up and detailed exploration. All archaeological work should be done in advance of a building contract, if this is possible. Flexibility is therefore necessary in arranging suitable forms of contract. If it is a simple item of fairly common work, not requiring skills that are difficult to obtain, an adjustable 'lump sum' contract with 10% included for contingencies is reasonable. If a large amount of carpentry repair is involved, provisional figures for labour and material can be priced competitively within such a 'lump sum'. 'Design and build' types of contract are totally inappropriate for historic buildings, for with these the architectural conservator abdicates his responsibilities and, in effect, hands them over to a contractor not trained in building conservation. 'Design and build' proposals may lead to the cheapest solution, so are liked by administrators, but cost is not the only factor to consider in a contract for conservation work. On anything complicated, it has been found that payment for the actual labour, materials and plant used is the best basis, provided one selects an efficient contractor, whose administration is sound and whose standards of work are known to be good. Such a firm can save 15% or 20% of the costs of conservation work by good organization, so it is not worth quarrelling about 5% in his 'on costs'. The system recommended is that competing contractors of equal quality should give target figures for the cost of the work, based on their assessment of labour, materials and plant, and then should add a percentage for their managerial services. This percentage is the competitive element. There are some subtle and some too-subtle variations of this type of contract. All contracts depend on good and efficient co-operation, but if the builder is treated and trusted as a professional, he will also make his contribution to reducing the cost of conservation.

3.4.6. Degrees of Intervention

The minimum degree of intervention necessary, various scales, levels of intensity and techniques used, are all a function of the prevalent climatic and physical conditions; causes of deterioration like atmospheric pollution, traffic vibrations, earthquake and flood hazard assessments; the principles and rules of Adaptive Reuse and the final aim and anticipated future environment of the cultural property. All interventions are autonomous as well as entwined into a whole, occurring simultaneously or sequentially in various parts as seven ascending degrees namely, prevention of deterioration, preservation of existing state, consolidation of the fabric, restoration, rehabilitation, reproduction and reconstruction, with some progressive loss of value always.

In **Prevention of Deterioration or Indirect Conservation,** all cultural property is protected by controlling the environment through regular inspections, cleaning schedules, repairs, good overall housekeeping, sound maintenance procedures and proper management. Measures include impeding neglect, agents of deterioration, damage and decay, fire, arson, theft and vandalism; controlling internal humidity, temperature and light, ground subsidence and water abstraction; and reducing atmospheric pollution and traffic vibrations.

Maintenance is the process by which a building is kept viable for the benefit of its users. With historic buildings, properly executed maintenance is in the public interest. The desirable standard of maintenance depends upon the intensity of the climatic and other causes of decay, as well as upon the needs of the users. Maintenance of historic buildings must have the support of owners and occupants. This is the simplest way of ensuring its conservation, as under constant supervision defects are more likely to be remedied as quickly as they occur. One of the basic propositions of this book is that a policy of preventive maintenance and preservation work is less expensive in every way than hopeful neglect followed by extreme measures. Human nature being what it is, the latter procedure, although so wasteful, is all too common. It must be remembered that the more sophisticated the building's design, the more essential it is to organize maintenance and the more difficult it is to carry out alterations without the danger of collapse. A weakness of the architect's professional practice is that he has little experience of the after-care of the very building he conceives. This can be made good by follow-up inspections about seven years after the building has been completed; but unless he has a lawsuit for negligence, usually the pressures of everyday affairs do not allow him to visit and inspect his own creation. Because of this, there is little feedback to designers who, in their ignorance, often repeat the same mistakes. We can learn so much from mistakes if they are analysed and understood. The pity is that they tend to get covered up, for obvious reasons. Historic buildings are a laboratory experience. They can teach architects how buildings are used and abused, how they react to their environment and where design might have been improved, for time is the shrewdest of fault-finders. This digression is meant to emphasize the importance of learning the lessons implicit in the after-care or maintenance of buildings and its importance to designers, especially those who think themselves original and *avant-garde,* but do not understand the wisdom of the ancients.

Maintenance and preservation work is very skilled and needs responsible and competent craftsmen (who should be rated as technicians). These valuable men are dying off and those that remain are discouraged by the 'stop-go' policy from which the building industry has suffered. Steady, planned, preventive maintenance would keep these specialists continuously employed. Stop-go in the flow of work has seriously embarrassed small firms specializing in high-class work on historic buildings and has contributed greatly to their overheads. This unnecessary increase makes building owners apprehensive about the cost of repairing an historic building. A possible answer to this problem would appear to be in the establishment of building-craft trusts by local authorities on a regional basis; the craftsmen employed by these trusts would treat the materials of historic buildings with a full understanding of the conservation problems involved and of the historic technology of each particular craft. Of course, many interests would oppose such a proposal, but we must put the interest of the building first. Building maintenance is a subject that tends to fall between several stools and thus to be neglected. Generally, the architect will only be concerned with major repairs and the aesthetics of preservation, whereas the maintenance staff comes into action only when something breaks down. The cleaners who look after a building and come into direct contact with every part of it do not know how to recognize symptoms of incipient problems or to whom they should report. Indeed, large intermediate areas are neglected because no one has been allocated specific responsibility for them. Most building maintenance, as practised, is concerned with tactics, with solving a particular problem, often *in vacuo,* without considering its relationship to the building as a whole. What is required is a coordinated strategy involving the owner and users of the building, the maintenance staff and the daily cleaners, all of whom can, by constant vigilance, provide an early-warning system.

If maintenance were well carried out there would be far less need for repairs or renewals. This policy can only be made to work on a basis of regular inspections. Historic buildings differ from new ones in that they are expected to last for ever—a definition of 'for ever' being 'as long as it is wanted'. An historic building is one that, for various reasons, society has decided shall be conserved for as long as possible. Electrical and mechanical services, on the other hand, generally have a safe life of about 20 years. Thus the skilful installation of up-to-date services in historic buildings deserves careful study, as a usable structure may be said to be only as up-to-date as its services. Ancient monuments such as ruined castles and abbeys do not have such problems. A second difference is that the whole building can be considered as an 'environmental spatial system'. We have the advantage that the internal environment can be measured, so any changes can be carefully considered. Nevertheless, improvements which alter the environmental balance may in themselves induce new causes of decay; for instance, traditional building construction 'breathes', i.e. allows the easy passage of moisture vapour, and this should not be prevented by the use of new and impervious materials such as Portland cement. At the same time, old buildings are much more vulnerable to damage from penetrating rain and rising damp and must be protected. The introduction of any vapour checks must thus be considered very carefully in the full context of the building's environmental system. Continuous heating also alters the environmental balance substantially and should be introduced only gradually. Thirdly, old and decrepit buildings need constant supervision and maintenance, applying the principle that 'a stitch in time saves nine', i.e. *preventive maintenance* should be part of the planned strategic programme. Preventive maintenance includes such acts as reducing traffic vibration and air pollution through the application of town planning controls. As it protects the historic building without any intervention, it is the highest form of conservation activity.

The problems of organizing maintenance depends upon an intimate knowledge of the building, its contents and its functions. For a ruin, the tasks are to protect it against frost damage by weathering and re-pointing, to remove plants and control algae and moss, to present it meaningfully to visitors, and to prevent vandalism by providing uniformed supervision. For a house, the task is to keep it wind and watertight, heated and repainted every five years. The owner must see to the repair of defects, and cleaning out of gutters and air vents twice a year, and keep a constant check on electrical defects such as overheated socket outlets. Although the cost of maintaining and conserving an historic building may seem a burden, it is the duty of owners and trustees to see that the building is handed on to the next generation in good condition. In fact, when compared with the replacement cost of the building, the cost of maintenance will not seem unreasonable, and of course the older an historic building is, the more valuable it becomes as an artefact whose structural and aesthetic integrity must be preserved. In fact, the cost is low when compared with the 2% of capital cost which modern construction requires.
The objective of maintenance policy is to preserve a building so as to secure its uninterrupted use at the users' desired level of activity. This level must be carefully considered, for to achieve it will necessitate a wide range of maintenance actions—from simply preventing damage by wind and weather to providing for intense use with sophisticated levels of comfort and decoration together with fire and security precautions.
The desired standard of maintenance should be agreed upon with those responsible and laid down as a policy appropriate to the building. It must also be economically viable. Regular inspection by staff at specific levels according to their competence should be laid down, culminating in a fully professional inspection at not less than five-year intervals.
Each historic building, however small, needs a local custodian who is charged to look around it inside and out, in all weathers, and to note any defects. He must inspect after any severe wind or rain and record his observations in a log book. If the custodian has the authority to instruct conservation craftsmen to carry out immediate first-aid repairs, needless delays can be eliminated and costs reduced. Problems can arise, however, because it is usually necessary nowadays for skilled guidance to be given to workmen for even very simple repairs, and as the custodian would be unlikely to be technically qualified he will often be unable to offer such guidance. The custodian is backed up by the cleaning staff, who can be essential primary trouble-spotters of the internal maintenance operation, for, as part of

their routine, they should see every single part of the building at regular intervals. Staff must be of a suitable grade for the building they care for, and they should be given simple training in reporting defects. Reliance upon cleaners for front-line intelligence is unrealistic if, as in so many buildings, the turnover of cleaners is frequent or they are simply not interested. Contract cleaning presents other problems. The potential of, and the need for, good-grade permanent cleaners for valuable buildings cannot be over-emphasized.

It is most desirable to provide adequate access to the internal structure of roofs by means of walkways, as well as good access externally over roofs and along gutters. Such provision is a good investment because it makes routine checks easy and effective. For the same reason, it is good policy to provide electric lighting within roof spaces; socket outlets for hand-lamps should be provided for viewing difficult places such as the underside of parapet gutters. It is a wise policy to maintain all concealed spaces clean and decorated and in good order, because this encourages a high standard of preventive maintenance.

The budget should be divided into two parts: running costs and maintenance costs. Running costs include day-to-day expenses of providing light, heat and water, cleaning the building, security and fire measures, etc., and providing staff for performing these activities. Maintenance costs, on the other hand, include payment for items needed to prevent avoidable damage to, or decay of, buildings and their plant. Doors, windows and gutters and roofs are primarily vulnerable. Also included as maintenance is the cost of replacing any of these items.

These maintenance techniques are based upon the preparation of a maintenance manual which is a sophisticated document giving assessments of work frequencies and calculation of work time units and measurement of areas. Ten different frequencies that are specified are given below:

'A' policing as required: Policing is a high-frequency task which is performed during and immediately after the use of the building by large numbers of people, removing conspicuous soil and trash so that it will not have a chance to become permanently embedded in the finish surfaces. The amount of policing will depend upon weather conditions and the building use. Each historic property will have different priorities and different problems.

'B' routine housekeeping and maintenance: This is a dry type maintenance, covering all reachable surfaces so that accumulations do not become permanently embedded due to their oily content. The frequency could be daily, twice a week, or weekly. It may vary for

different locations in the building and with the season because of peak visitor periods, or it may vary because of seasonal weather conditions or seasonal air quality.

'C' periodic maintenance: This may be a dry, damp or in some instances a wet treatment which cleanses surfaces, removing those accumulations not generally removed by the more frequent methods. If wet, it removes portions of the finish itself which have become chemically changed due to exposure, thereby renewing to a certain extent the surface. The frequency ranges from weekly to monthly.

'D' periodic maintenance: The frequency is monthly, bimonthly or quarterly.

'E' periodic maintenance: The frequency is quarterly or semi-annually.

'F' periodic maintenance: The frequency is semiannual or annual, perhaps by a contractor.

'G' periodic maintenance: The frequency is annual or biennial, perhaps by a contractor.

'H' maintenance: The treatment is prescribed by a conservator. It may be both routine and periodic at a frequency which would best protect the item. The conservator should suggest means of protection as well as treatment.

'I' maintenance: The treatment should be done by a conservator or an outside specialist.

'J' maintenance: Irregular frequency; use past experience as a guide; consider outside contractors.

A good deal of expertise and time is needed to prepare such a maintenance manual, but it is undoubtedly well worth while, as scientific preventive maintenance can save large sums of money and reduce the need for costly major works.

Having established the importance of maintenance in the care of historic buildings, the methods by which this can be implemented need consideration. This is one of the most sophisticated and economical systems in the world, because it involves the users and voluntary cleaners in the overall maintenance strategy as well as professional advisers. The extension of the system to include all important historic buildings is to be recommended. Maintenance costs should be divided into the following separate categories, which should be recorded in a log book:

(1) Small items (basically good housekeeping).

(2) Repairs to services: (a) heating, (b) electrical, (c) plumbing.

(3) The rolling programme of long term preventive maintenance carried out year by year and using scaffolding economically.

(4) Major items when in need of renewal, such as (a) roofs, (b) walls, (c) windows, doors and floor coverings, (d) services.

(5) Emergencies. A reserve of about 10% should be allowed for contingencies.

Each of these categories should be budgeted separately. If reductions have to be made, they should be spread equally unless special reasons exist. Just as a doctor keeps a case history for each of his patients, so the log book should be kept by a responsible person. A routine for the maintenance of an historic building should be laid down, and a year-by-year log book should be instituted with records of costs allocated to headings as given above. Such a procedure will enable rational policies to be established and should ensure a constant feed of data from those with firsthand information. The records should pinpoint weaknesses in design and construction and indicate 'cost-in-use', thus providing the organization (and its architects) with valuable feedback information. The study of records can lead to an assessment of the frequencies of servicing and repair in the past, and with a detailed survey of the fabric it is possible then to produce a detailed programme as the basis of future preventive work. This may have to be an elaborate document, and the clerical administration and documentation will be considerable. The analysis of cost of repairs may indicate which items are deteriorating rapidly. The whole maintenance operation is thus based on survey assessment of frequencies of work loads and on responsible feedback by the staff. Systematic maintenance also facilitates the initiation and programming of major items of repair, reconstruction and restoration, because there is a feed forward of items which may need attention. This is called the rolling programme and will necessitate the erection of scaffolding, the cost of which dominates the economics of all structural maintenance work, especially on large historic buildings. It enables a close inspection to be made by the professional advisers.

Maintenance should ideally be tackled by routines of daily, weekly, monthly, quarterly, semi-annual, annual and quinquennial inspections, followed by reports. Checklists have been prepared as an indication of what might have to be done for a cathedral. Other types of buildings might be simpler but, needless to say, each historic building is a special case and needs its own schedules based upon a knowledge of the individual building with its content and of its specific environmental and structural problems. In working out a maintenance strategy, it is desirable to have categories of repair work as defined for the log books, so that the performance of buildings of similar types can be compared on a statistical basis. Such a study might throw up significant facts; for example, the cost of atmospheric pollution or damage from sonic bangs.

In **Daily Routine** first ask cleaners to report any defects they note, i.e. broken windows or ironmongery, leaks in roof, falling pieces of masonry, telltale wood dust from beetle infestation, lime dust from spalling plaster. Check fire-detection systems to make sure they are functioning properly. A good sense of smell is essential: someone on the staff should make a fire check throughout the building in the morning and evening after work. False alarms are all too frequent in fire-detection and security installations, and it is counter-productive if 'wolf is cried too often. Do a security check. Windows and doors should be checked for security each evening; in a building used by large numbers of people during the day, one invariably finds doors and windows left open at night, with good intent, but with a real risk to security. Keys borrowed by contractors and workmen must be returned each day. Security installations should be inspected to see that they have not been tampered with. Change defective light bulbs and fuses and attend to minor faults in the electrical system. Switch off the electricity supply at night (the caretaker or night watchman should have a special circuit for his needs). Report dripping taps (they may cause icing up or an outbreak of dry rot and waste a lot of valuable water).

In **Weekly Routine** change or clean air filters of the heating or air conditioning plant or organ with humidifier. Check all thermographs, humidigraphs and other recording instruments, and change charts and study same and report. Correct faults in these instruments' calibration. Check accuracy of all clocks, including electric and winding mechanisms. Check all automatic fire-alarm and security devices in addition to the daily check of control systems.

For **Monthly Routine** have rainwater disposal outlets, gulleys, etc., cleaned out. Lubricate and adjust all mechanical drives and bearings, e.g. pulley belts, flexible drives. Check all log books.

For **Quarterly Routine,** inspect roofs (outside and inside), gutters, rainwater disposal outlets, gulleys. Check glazing. Clean windows and painted surrounds. Check doors for closing and locking and all means of escape. Service sound-reinforcement systems, tape machines and turntables, replacing worn drive belts, idlers, etc. Clean light fittings. Check ropes and weights.

At **Semi Annual Routine** sound fire alarms and give staff fire-fighting practice exercises. Clean out all gutters, downpipes and rainwater drains in autumn to remove fallen leaves and in spring to remove winter debris, and leave everything clear to cope with the heavy storms of summer. Grass growing out of gutters is a sign of neglect—if not negligence.

At **Annual Routine** rod through all rainwater and soil drainage systems. Overhaul all electric plant. Change fuses, bulbs and tubes, especially where these are not easily accessible. Check problems of fire-fighting access. Test all fire extinguishers and refill if necessary. Decorate and clean sections of the interior of the building. Touch up poor spots on external decoration in autumn. Test lightning conductors and earth resistance if in an area prone to lightning.

For **Quinquennial Routine** the architect or surveyor must make full reports every five years, especially noting structural defects that should be kept under observation. He should revise and update the long-term maintenance plan after each such inspection, and he should draw attention to any problems that should be kept under observation and studied for the next report. He should divide the proposed work into categories: Immediate, Urgent, Necessary and Desirable. Typical quinquennial housekeeping items would be to clean out all voids and spaces and report any decay found; change tap washers, as a matter of preventive maintenance. Specialists clean out sanitaryware to avoid infections. Check lightning conductors (note that on some buildings with valuable contents annual inspections are desirable).

Inspect and test electric insulation and installation. Check on mechanical wear, wear of electrical contacts, corrosion and any signs of abnormal deterioration. Inspect and test the heating installations. Redecorate externally to a good specification.

For large buildings or series of buildings this quinquennial inspection becomes the basis of a 30-year rolling programme for preventive maintenance of the structure of the fabric. Building maintenance has unfortunately not been given the status it deserves. It has not been considered at a strategic level but only on *an ad hoc* basis. Skilful management of building maintenance while respecting the principles of conservation is a high-level occupation which deserves respect. Few know the names of the clerks of works and craftsmen who maintain our great monuments, although their job is to interpret great works of art in the face of difficult environmental conditions. As in conservation of all cultural property, the key operation is the expert's inspection. The hierarchy of skill and organization for efficient and effective maintenance should be examined. Handymen who can carry out two or three trades competently are invaluable for the maintenance of the numerous buildings that make up an historic district or centre whose values are visual townscape. It is inefficient to wait for one trade to follow another in this work, so multi-trade teams of three of four handymen should work together. They should understand that it is most important for them to use the correct materials and follow traditional workmanship. They should work under instructions of a builder specializing in this field. For important historic buildings, where high-class work has to be maintained and repaired, conservation craftsmen specializing in repair and reproduction work will be required. They must know the history of their craft, understand its technology and the principles of conservation given. They should work under the supervision of a clerk of works and guidance of an historical architect and should be prepared to advise upon specialist problems. The productivity of the conservator will be less than that of a conservation craftsman, but he will have greater skills in diagnosis of faults and the application of scientific methods to conservation of historic buildings. He will be asked to advise on maintenance, repair and consolidation of works of art such as sculpture and metalwork, stained glass or wall paintings. To increase productivity, he should work with three or four craftsmen. Part of the skill needed in work organization is to get the right balance of skills for the particular problem. Clerks of works who look after historic buildings should have the skills of a conservator.

Preservation deals directly with the cultural property, retaining its existing state through repairs to prevent further decay, and stop damage and destruction by water, chemical agents, pests and microorganisms.

In **Consolidation or Direct Conservation,** in any historic property, when the reduced strength of structural elements fails future hazards, the existing material is consolidated to respect the structural system and preserve the integral form. Physically adding, applying or injecting adhesive and supportive into the actual fabric ensures continued durability and structural integrity. Each historic evidence of the whole spatial environmental system is retained while new satisfactory techniques are introduced; a suitable environment for art objects is provided or adjustments are made in favour of a new use. Besides traditional skills and materials, reversible modern techniques and methods, proven experience and appropriate technology applicable to the scale and climatic environment are sensible. Short lived materials like reeds, mud, rammed earth, unbaked bricks and wood are very well used to repair and restore worn and decayed parts. This retention of the design and original materials also buys time with temporary measures until better techniques evolve.

Restoration revives the original concept or legibility of the object, as well as periodic contributions of later additions, testifying historical or archaeological evidence. At first the historic property is cleaned, after which the original design, material, details and features, archaeological evidence and authentic documents are reintegrated. Missing or decayed decorative elements or parts are replaced to harmonize with the whole and distinguishable from the original only upon close inspection from the original. Under exceptional circumstances, the superimposed periodic work or part of little interest is removed to reveal underlying state or material of greater historical or archaeological value.

Analytical and practical inspections and repairs to chimneys, roofs, rain water disposal systems, floors, joinery, ironmongery, plasterwork, painting and correction of dampness or humidity and excess moisture need special repair and reconstruction techniques like scaffolding, shoring, jacking, drilling, grouting, cleaning and stone consolidation, besides managing labour, ordering material and using theodolite. Most old structures and traditional materials, except wood, are weak on tension, so applying prestressing induces a new lease of life.

In **Rehabilitation of Historic Buildings** the cultural property is pushed into regular use, a practice called 'mise en valeur' in French, or modernization with or without adaptive alteration. Best is original use of the fabric with fewest changes. Thus, Adaptive Reuse makes historic and aesthetic values economical and contemporary.

We mainly consider the vast number of buildings that are 100 years old or more and which make up the bulk of our urban environment. Historic buildings differ from most other cultural property in that they generally have to be used and also withstand dead and live loadings and resist all the causes of decay. Often it is necessary to find an appropriate use in order to prevent a building's decay or destruction, this being one of the hardest problems to solve in the practice of architectural conservation. The practice of adapting buildings for new uses is as old as time. As has been shown historically, rehabilitation was a natural process in the fabric of a living town or in the life of a well-built construction. Nowadays, due to the rapidly changing patterns of life and scale of activities, a more conscious approach must be adopted, especially if all the values in historic buildings and towns are to be recognized, preserved and used. Rehabilitation has social, cultural and economic advantages. Social, in that people and towns keep their identity; cultural, in that artistic, architectural, archaeological and documentary values can be preserved both for their intrinsic value and their contribution to the identity of the town; economic, in that (a) existing capital is used, (b) energy is saved, (c) demolition costs are avoided, and (d) the existing infrastructure of roads and services is utilized. In addition, rehabilitation causes far less human upheaval, political friction and physical delay, so it is not surprising that when the total budget is considered, rehabilitation in most cases saves money.

To start a rehabilitation scheme, a multi-disciplinary team is necessary. The team meet regularly to discuss their work and to establish priorities (which had to respect all the values in the historic town centre). The study of the values in the buildings and spaces that make up an historic district is based on several different surveys, which analyse the historic development, growth, functions, services and amenities of an area and the condition of each building under consideration. In one word the 'typology' of the action area or of an individual building is studied. Inspections and surveys of each building involve the making of measured drawings, preferably to 1/50 scale and a detailed schedule of all defects that can be noted. This study is crucial and the work necessary to each building can then be assessed under the main headings, immediate, urgent, necessary and desirable, and costed to see that the proposals can be justified. In the survey of the building any shortfall in potential users' requirements should be noted, but in considering the neighbourhood as a whole it may be found that these requirements are met in another way. The rehabilitation team will recommend the most suitable use for each building after making their studies. Ideally the new use should involve the minimum change, as this will preserve the values in the building and tend to reduce costs, so the closer the new use is to the original the better, generally.

When they understand the benefits of rehabilitation, town planners, building economists and architects can co-operate to re-use our existing stock of buildings either by reviving their original use or finding some suitable use in the context of the needs of the community. Historic buildings with a wide range of differently sized rooms have survived successfully because of their adaptability to many different types of use. It may be found that building regulations for a proposed new use require floors to be strengthened and calculations may show that foundations become overloaded and that costly strengthening becomes necessary. If this is the case, one should first reconsider the use and see if a more suitable alternative is possible. It is only by considering all the relevant factors that the multidisciplinary team will find the 'least bad' solution. Often the superficial appearance of buildings leads people to pessimistic opinions, because they only judge by appearances and cannot imagine the results of a rehabilitation scheme. The cost of rehabilitation is something that seems to frighten people before a proper examination is made (and this is not helped by the addition of VAT). It is true that lack of traditional skills and bad site management by builders without the flexible organization that is necessary can inflate the cost. The real cost depends on the structural condition of the building, the proposed use, the skill of the architects in devising plans and the most suitable contract procedures, and the skill and organization of the builders. The ownership pattern will affect the possibilities and also the design solutions available. Protracted procedures should be avoided, as these can lead to planning blight and financial hardship, coupled with political discontent. Two half-schemes are better than one long delayed whole. Another danger in delay is in lack of maintenance of the properties, and a lesson that can be passed on is that someone should be made responsible for the care of vacant properties and see that roofs are repaired after gales and that gutters are not allowed to get blocked or, in case of frost, that the water system is drained. No historic building should be pulled down until every effort has been made to find a beneficial use by rehabilitation. As cities are living things, the occasional need for renewal is accepted, but this is work for architects with special sensitivity and ability to analyse the problem and design in the idiom of today, yet respecting the identity and character of the historic town. To sum up, to approach this complicated problem the typology of an historic zone or building must be studied fully before any proposals are formed, the principle of minimum intervention must be applied and authorities must have a presumption in favour of conservation—then our cities will keep their identity, character and atmosphere and the communities will benefit culturally and economically.

To avoid unnecessary and damaging alterations, the new use should be as close to the original as possible. The history and archaeology of the building must be carefully studied, so that the architect is aware of the sequence in which the fabric was put together. Art historians and archaeologists should study the fabric with the architect and advise him on what material is of special value. The architect must work with history—not against it. Rehabilitation is generally considered a sound economic proposition if the cost of such work does not exceed two-thirds of the cost of building anew the same area. This figure includes an allowance for a less efficient (but often much more interesting) use of floor space in the historic building. To meet this requirement the building should at least have sound walls and floors. The roof may be defective and need re-covering, rainwater disposal may need redesign and renewal, windows and doors may be faulty and decoration in need of total redoing. It is also to be assumed that all services are defective and obsolete, for it is generally the case that they will need total renewal. It needs understanding of the building as a 'spatial environmental system' and great skill to modernize the mechanical and electrical services of an historic building. Of course, the use of the existing urban infrastructure and avoiding costs of demolition is a bonus for rehabilitation.

New regulations are always more strict and comprehensive than the ones they replace, and this progress represents a danger to historic buildings, as often officials responsible for their application do not consider the fundamental purposes of such regulations, but seek to apply them mechanically in a detailed way, so as to avoid the necessity of making a possibly troublesome decision. It is often difficult to comply with the details of building regulations, which fall into three groups: structural, fire and security and hygiene. The rehabilitation appraisal should consider each group separately. Structural regulations and codes have been made to help designers of new buildings, so if the building has survived 100 years satisfactorily, it can be deemed to have met the purpose of the regulations. Building regulations give the superimposed loadings that have to be carried by floors for various types of use. If there is a change of use, strengthening floors to meet increased loadings in offices often presents difficult problems and if storage of paper or books, as in a library, is proposed the greatly increased loads present serious problems first in the floor structure, then possibly in the walls and foundations, in which case the proposal may not be practical for economic reasons. Fortunately, walls and foundations of historic buildings generally have a considerable reserve of load-carrying capacity. In an earthquake zone, an historic building may need strengthening, which can be put in hand when a suitable opportunity given by rehabilitation occurs, but it should never be condemned to destruction because of failure to comply with regulations. Fire regulations covering fire resistance and means of escape must be complied with fully, but with intelligence, for fire is a deadly serious matter. The risk can be reduced by restricting the uses to which the building is put, and to a limited extent assets such as thick walls and well-constructed doors can be traded off against nominal deficiencies. For safety, much can depend upon the installation of automatic warning devices and sprinklers, as well as the efficiency of the local fire-fighting service, including access for fire fighting, a matter to which town planners responsible for historic quarters in cities should give consideration. Often, additional doors required as smoke checks have to be inserted in such a way as not to spoil the aesthetics of the historic building. The fire resistance of doors may be improved by adding fire-resistant sheets to one side and by making rebates in the frame deeper and of hardwood. Ceilings and floors may be improved by putting fire-resistant sheets under a plaster finish or by thickening the floor covering with plywood and treating timbers with a fire retardant. Joinery and external woodwork should be painted with fire-retardant paints. In such detailed ways the fire resistance and safety of an historic building can be raised to meet modern standards. Improved hygiene is one of the basic requirements of rehabilitation, yet standards relating to space about buildings, light and air are often not possible to meet and should be waived if forced ventilation and adequate artificial light can be provided. Such standards are not absolute, and experience of historic quarters has proved that excellent living conditions can be had without them, especially if children do not have to be considered. Provision of clean water, good sewerage, gas, electricity, heating, ventilation and efficient rainwater disposal are all necessary. Access must be given for refuse collection, fire fighting and fuel deliveries. An understanding of the purpose of the building codes and regulations is necessary to deal with them in a flexible way. Limitation of the possible uses and type of tenant may help. If a building has good points in one direction, it may be possible to trade some of its assets for deficiencies in another. Surviving historic buildings have *ipso facto* 'long life', are 'flexible' and require 'low energy' input in their construction. Insulation values in roofs, wall linings and between floors are generally easy to improve during rehabilitation, so energy requirements in use can be effectively reduced, by inserting glass wool in roofs and floors and linings backed with aluminium foil to walls.

The suitability of historic buildings for a large number of possible uses, i.e. flexibility in planning, depends to a large extent on the mix of room sizes. Small rooms of 2 to 3 m^2 are suitable as lavatories, bathrooms, larders and stores; rooms of 8 to 12 m^2 as single bedrooms, kitchens, dining spaces, clerks' offices, etc. Rooms of 12 to16 m^2 can be used as living rooms, dining rooms, double bedrooms, managers' offices, workshops and garages. Above 16 m^2 there is a wide range of possible uses, including subdivision. The above figures are entirely subjective, as no proper study is known to have been done. Measured drawings and full investigation of the building are necessary before starting a rehabilitation project. Ideally, the internal environment should be measured and recorded over a year in order to provide design data. Structural analysis and studies of the moisture content of walls and relative humidity will possibly be necessary. Using drawings to 1/50 scale, in order to show all the existing detail, alternative schemes can be prepared and costed. Drawings show possibilities that could not be visualized in the first instance. Often architects, faced with the difficulties of rehabilitation, find surprising and exciting possibilities which could not be produced when designing new buildings.

Modern services present a great challenge, so will be dealt with in some detail, for often it is difficult to reconcile their technical requirements with the principles of conservation. All mechanical, electrical and also acoustical services must be considered together in the rehabilitation of an historic building. In one sense it can be said that nowadays a building is as old as its services; certainly, new life can be given to an old building by renewing the services. However, the fabric of the historic building was not designed to take modern plant, so the installation of new services raises acute technical and artistic problems and will certainly alter the balance of the spatial environmental system. In designing the services, their eventual renewal and replacement must be considered, as well as accessibility for maintenance. Ducts should always be sized generously in case larger dimensions are required at a later date.

Improved space heating is one of the most difficult aspects of rehabilitation, for the effect of this will be to lower the relative humidity and also cause condensation in unheated spaces. There is also danger in the use of old flues which are not capable of withstanding the temperatures produced by modern boilers; ceramic or insulated stainless steel flue liners are probably necessary precautions against the risk of fire. Continuous background heating at a low temperature is generally best for fuel economy and for the fabric itself. Local heating can then be used to boost the background heat when required. With buildings of large thermal mass, intermittent heating does not produce real comfort, because the walls do not have time to warm up and it has a damaging effect on the contents of the building, particularly if they are art treasures made of wood. The following checklist gives the points that must be considered relating to the user, the building and plant requirements:

User/actors

(1) (a) Background, (b) full or (c) intermittent heating.

(2) (a) Temperatures required, (b) air changes, (c) relative humidity.

(3) (a) Cost of heating plant, (b) can running costs be afforded?

(4) (a) Type of control system suitable.

Building factors

(1) Exposure, wind tightness.

(2) Heat loss—can insulation reduce this effectively?

(3) Dampness, humidity, danger to structure and contents.

(4) Thermal mass, internal volumes, window/wall ratio.

(5) Space available for plant and fittings.

Heating plant factors

(1) Cost of fuel and labour.

(2) Size of boiler and expected life of plant and distribution system.

(3) Type of fuel and economic amount to be stored.

(4) Possible methods of production, delivery, dispersal and control of heat output.

Fuel costs depend much on governmental policy and foreign affairs. The era of cheap energy is at an end and since the future is unpredictable, it is advisable to plan for alternative fuels. Electricity has always been costly and is vulnerable to power cuts. In rural areas the amount of power available is often insufficient and, being a high-grade form of energy, electricity should not be wasted on heating unless used to power a heat pump. One of the lessons of the past is that heating plant should be convertible. Labour costs are often critical in formulating a choice for the preferred fuel. Commercial efforts were made by adjusting tariffs favourable to make electric heating popular through storage heaters and underfloor heating, but the latter proved dangerous to the fabric on clay soils as it dried out the ground and caused shrinkage of the soil under shallow foundations. Solar energy is now being exploited in countries with suitable climate, but with the British climate it is unreliable for heating. In an historic building, sufficient space may not be available for the heating plant of desired capacity, so choice may be dictated by this factor. Gas and electricity, of course, pose no storage problems, but for this reason the building owner is vulnerable to breakdowns and strikes. Besides the space needed for fuel storage, space and disposal arrangements must be made for ashes and clinkers. Soot deposit is a sign of poor combustion, which should be checked by flue gas analysis. Good arrangements should be made for cleaning flues and renewing fire bricks in boilers and flues. The size and height of the flue are usually recommended by the services consultant, recognizing the fact that under-sizing will reduce the life of the boiler. The air intake for combustion must be at least three times the flue area. The flue should be properly designed to meet the requirements of the fuel and to avoid condensation at the top, which is particularly likely with gas heating. It should be remembered that flueless gas and oil heaters produce water vapour, which increases the relative humidity inside a building, together with the danger of condensation. An obtrusive new chimney may be considered objectionable. One way of lowering its height is to divide the flue into several sections, another is to fit an extractor fan. The height in relation to the rest of the building must be considered, as flue gases containing sulphur dioxide can be reduced by careful choice of fuel; some heavy oils having a very high sulphur content of up to 6%, whereas light oils have 1-154% and natural gas none. The sulphur content of coals varies considerably, but about half is retained in the ash, so the emission of sulphur dioxide is reduced. Distribution systems for heat consist of pipe runs or ducts for hot air. Hot air heating has the advantage of being capable of upgrading to include humidification and air conditioning, if there is sufficient space for the additional plant. It creates a positive air pressure which reduces the ingress of draughts and dust. However, long duct runs are awkward and expensive and difficult to install. The architect must work out all pipe runs in detail, to see that they rise in concealed places such as behind shutters and curtains and generally follow the principles of camouflage. Encasing of pipes is not always to be recommended, as their heat output is valuable and the casing may look clumsier than the pipe itself. The placement of furniture must be planned before radiator and thermostat positions can be settled, after which pipe runs can be confirmed. The cost of the builder's work in connection with heating, normally 10-15%, may rise considerably if special holes have to be drilled in order to pass pipes through thick masonry. In designing delivery and dispersal systems, the position of doors and windows, which create draughts, is an important factor. In high buildings the introduction of heating by convection will create air movement, resulting in down-draughts from high windows. The path of draughts can be traced by use of smoke. High buildings can have a steep temperature gradient, which is not conducive to fuel economy, so a dispersal system such as radiant heating by overhead panels or floor panels is more efficient. Forced warm air from local heater units can also overcome the problems of down-draught and temperature gradient, otherwise a heating coil or tube must be placed under each high window, which is unsightly. Heat is mainly dispersed in a building by radiation and convection, conduction playing only a small part in the process. Floor panels and ceiling panels are the usual method of providing radiant heat. Floor panels put the heat where it is wanted and do not induce draughts to such an extent as other methods, but are sluggish in their response to controls and suitable only for continuous heating. Edge and ground insulation is necessary. With no pipes and radiators showing, floor heating is the ideal proposition for an historic building, especially if the floor needs relaying, but it is expensive. Radiators, which are really convectors, are the common method of heat dispersal. Cast iron is much more durable than pressed steel, but valves and fittings eventually corrode. Sizing and siting of radiators requires the detailed attention of the architect, as spaces can be ruined by badly proportioned radiators and clumsy pipe runs.

An historic building generally has a primitive electric installation, which may have been altered and extended by either professionals or amateurs. Early electrical installations with wooden covers or, later, conduit with vulcanized insulating rubber cables, or lead and rubber sheathed wiring, if more than 20 years old, are likely to be defective and impossible to alter safely. Obsolete wiring, bad earthing, overloaded cables, defective insulation, contact with combustible material giving rise to serious risk of fire, are all to be expected. The first stage is a survey and test by an electrician, who should provide a wiring plan. The standard tests for insulation and earthing often give an optimistic picture, especially as they are made before any rehabilitation work, which could cause a breakdown in brittle insulation. With rehabilitation, a greater use of electricity is likely. Certain uses of electricity, such as cooking or heating, may well have to be excluded if there is inadequate power supply. The regularity of the power supply should also be ascertained and, with special uses, duplicate supplies may be essential or alternatively a standby generator provided, with automatic changeover gear. If fire fighting depends upon the electric supply, standby plant may be essential, and certainly all fire-detection plant should have a secure supply such as storage batteries with a.c./d.c. conversion charging gear. New wiring systems may be of polyvinylchloride sheathed cable, or mineral insulated copper cable covered with plastic. The former is cheap, but the latter, costing about 30% more, is much the best because of its long life and remarkable fire resistance. It is neat to use and the reduced cost of the builder's work offsets in part its greater cost. It can be run in old conduit, if this exists. All wiring should be hidden by running it in conduit or, if on the surface, camouflaged by following the mouldings and ornament in the building. The path of all wiring must be approved by the architect and, if possible, none should be allowed to run over wood or other combustible material; in certain places, holes must be drilled to avoid unsightly wiring running across mouldings. Installation of new lighting in historic buildings is one of the many areas where the architect's artistic skill must be used, for the atmosphere, messages and character of the building can be enhanced by skill or destroyed by clumsy lighting. If lighting has to be used in day time, it may be designed with an emphasis to support the sun and natural daylight. It is a taxing problem to find fittings that are suitable for historic buildings, for often far greater output is required than is usual for domestic products. The writer has found that simple and efficient fittings are to be preferred, even in cathedrals, as they do not date or look false. Fitting should always be tested *in situ.* Pseudo-historic fittings, such as chandeliers originally designed for candlesticks, are unsatisfactory if equipped with too bright electric bulbs, whose heat output may amount to several kilowatts and whose replacement can be costly and tiresome. The heat output of lights may be a fire risk if the fitment is not well ventilated, and will certainly cause dirt streaking above the fitment due to the convection currents induced. Also, the heat output of permanent light installations should be taken into account when designing the heating plant. Dimmers are a highly desirable adjunct to the lighting of the building, which should have both spot and general diffused lighting, usable in a variable way to express the atmosphere and reflect the changes in use of the building. Modern dimmers and switches can be controlled by low-powered relays, so greatly reducing the cost of long cable runs needed previously. The extreme cases of interpretation of an historic building are when floodlighting or Son et Lumiere are installed. When designing the layout of electric installations, the route of the main intake, siting of the distribution room, and of controls for various groups of electrical equipment, such as sound reinforcement and heating plant and ducting for wiring, must all be considered. If provision is to be made for broadcasting and television, it is best to treat this separately, as these may be provided by other authorities who will require their own control rooms. Provision for maintenance and testing is necessary, and bulb changing must not be made difficult or expensive by lack of thought at the design stage. Damage by maintenance men moving ladders is a common occurrence.

The problem of large ducts and remote plant rooms required for air conditioning is difficult enough in designing new buildings, but in existing historic buildings it is acute unless the ducts can be treated as sculptural forms themselves. In order to avoid the expense of long duct runs, local plant rooms can be planned and they may have an advantage. As, in museums, different groups of objects may require different relative humidities, so the architect should seek out suitable servant spaces adjoining galleries when adapting an historic building as a museum or for other public purposes. There are many ways of manipulating heating by spraying and cooling and recirculating air in what is called air conditioning. This means that air conditioning design should be flexible, but its design depends a great deal on experience and judgement and correct briefing of the specialist engineer by the architect and a client who knows what is needed. It has the advantages of good air distribution and movement and the capability of filter installations, as well as conversion to air conditioning at a future date.

Rehabilitation of historic buildings often involves acoustical problems, for example when a malting or corn exchange is turned into a concert hall. The acoustic characteristics of the building should be measured and compared with the desired requirements. Often the building is required for both music and speech, which have different requirements with regard to reverberation time. Long narrow historic buildings with linked volumes either side give discontinuities in reverberation, while cube and double-cube rooms, domes and barrel vaults have problems with regard to reflections. The materials of which most historic buildings are made have insufficient absorption in relation to their volume, making a long reverberation time unavoidable. Faults should be identified and corrected where possible by optimum disposition of the sound source and audience and the use of reflectors. The acoustic specialist should attend typical performances in order to measure the reverberation time, decay patterns, frequency responses, echoes, flutters, resonances and eigentones. By walking round he will find out many of the peculiarities of the historic building. Then he should be able to advise on correction of faults, in the first place by adding reflectors and increasing absorption wherever the design and finishes of the historic building will permit. Failing this corrective treatment, electronic reinforcement will have to be used. There is much intuitive and some unpublished information on the role of public address engineers, who tend to be linked to firms with predetermined systems which may not suit the special problems of an historic building. For good results, independent acoustic consultants with a wide knowledge of electronic equipment are indispensable, as also are staff specially trained to operate the equipment and having a knowledge of the acoustic characteristics of the building. Siting of microphones, switching arrangements, placing of speakers and location of the central controls can only be decided in consultation between architect, equipment specialist, acoustic expert and the users of the building. If the speaker is illuminated well and clearly seen, he is also more audible. Special short-wave radio circuits and earphones may be considered as an aid to the hard of hearing. Intrusive noise, both airborne and structure borne, can reduce audibility. Most historic buildings, being heavy, can resist intrusive noise, but there are weak points which may need attention. Doors may fit badly, windows perhaps have thin glass and a loose fit, ceilings may be vulnerable to aircraft noise and need extra insulation. Increasing the weight of doors, edge sealing and use of air locks will help reduce intrusive sound penetration, while for windows, double glazing, heavy glass and sealing of edges will also help. The hum from heating plant fans or even electric lights can be intrusive, but one of the major causes of intrusive noise is motor traffic which should, if possible, be diverted.

Morally and psychologically any historic building destroyed by fire is worse than a total loss, for the loss could have been prevented. It is therefore desirable first to examine the causes of fire and then the means of lessening its extent and effect. It will be found that fire and security precautions must be taken together in order to resolve certain contradictions in their requirements, so both are considered in this chapter. Private dwellings run the greatest risk of fire.

From a study of the causes of fires, it can be seen that electrical appliances and cooking are the biggest factors. In the domestic field, children playing with matches have become a much greater risk, possibly because of the introduction of inflammable plastic-based materials. Arson has increased seriously. Heating appliances have become less of a risk as regulations concerning their installation have been strengthened.

For a fire to start, it is necessary that there should be a supply of fuel, a sufficiently high local temperature and an adequate supply of oxygen. A slow rate of combustion-gives a smoky smouldering fire, while the most rapid gives an explosion. A fire has three phases—first, growth up to 500 °C, followed by development to a maximum temperature of 1200 °C, and then decay. The combustibility of a material depends upon its state of division (e.g. wood as a baulk, beam, plank, chips or sawdust) and the temperature to which it is subjected. In industry, dusts with a high surface area to weight ratio, which enables intimate mixing with air, can even form explosive concentrations. Bottled gas, inflammable liquids and vapours constitute both fire and explosion risks. The amount of heat that can be liberated in a fire is called the fire load, and is an important consideration in fire fighting. In a fire, the behaviour of a building material depends upon its thickness and the way it is used in the building. Wood in the form of boards, light joists or ply burns rather quickly, but a large timber baulk burns very slowly and has a high fire resistance in structural terms. When steel is heated to 600 °C its ultimate strength falls from 420 MN/m^2 to 125 MN/m^2, so a steel joist can therefore collapse quite early in a fire and will have a lower fire resistance than a timber beam of comparable load-bearing capacity. Stone, although incombustible, may under some circumstances not be fire resistant, for limestone is converted into quicklime by heat and spalls off, exposing a fresh surface to fire attack (later, the water used for fire fighting will slake the quicklime and thus cause further damage). The fireproofing of fabrics, wood, plastics and paints extends the time of ignition or retards the initial rate of burning. Chlorine, bromine, fluorine, phosphorus and antimony are used to form industrial fireproofing compounds, chlorine being the most important. For wood, ammonium hydroxide, ammonium phosphate, boric acid, antimony oxide and potassium pyro antimonate are used most frequently, and are usually applied by the vacuum impregnation process, but dipping or brushing may be used if the former facilities do not exist. Fireproof paints, varnishes and polishes should be able to fulfill two conditions: (1) to provide a layer of coating which is neither inflammable in itself nor likely to propagate fire, irrespective of the nature of the substrate; (2) to protect combustible base materials such as wood against the effects of fire by thermal insulation in the first stage of a fire and then by smothering flames produced by the gases. Although no surface treatment can make any substrate absolutely incombustible, it can make a useful contribution by delaying the spread of the fire, for when fire breaks out in a building the nature of the interior surfaces may determine the time available for the occupants to escape. Finishes like wax polish on floors can melt and produce running fire, which can be especially dangerous in a public building. Escape routes should have incombustible finishes. A fire-retardant surface treatment gives fire-fighting personnel more time to save cultural property. For this reason, the protection of steel in multi storey buildings is a vital precaution, generally effected by giving a minimum of 13 mm cover of concrete and up to 50 mm to give 4 hours' protection. Plaster and preformed asbestos also provide good protection.

Minimum standards of fire protection are laid down in Britain, in addition to requirements in other national building regulations and in the Factories Acts. The objects of these standards are:

(1) To provide means for the occupants to leave the building safely and quickly if a fire starts.

(2) To design the building so as to reduce, as far as is practicable and economic, the spread of fire within both the building, and through its external walls.

In those historic buildings which have numerous visitors, means of escape must be studied carefully in conjunction with the local building inspector and fire brigade. Although legal requirements only apply to certain classes and sizes of buildings, they can be useful as a guide. In all buildings, those responsible must ensure that the occupants or visitors can leave in safety if a fire breaks out. Access ladders and alternative routes of escape should all be carefully planned. They should be inspected annually. Means of escape cannot be dealt with by a series of hard-and-fast rules, but guidance can be obtained from regulations relating to the number, position and width of exits according to the number of people likely to be in the building at any one time. The construction of the walls, floors and ceilings of escape routes must be 'incombustible' to prevent the spread of smoke and fire into corridors and stairwells, and self-closing fire-stop doors must be provided. In historic buildings, fire-stopping of intercommunicating voids must be meticulous. Some types of traditional construction, such as walls lined with panelling, may have no fire-stops. Any report on the fabric should consider possible improvements such as fire-stopping at floor levels or behind wall panelling, or using a fire retarding intumescent paint.

As mentioned earlier, the problem is linked with ease of circulation and security generally; unfortunately, security considerations often run directly counter to ease of escape in historic buildings. Fire regulations are framed chiefly with the design of new buildings in mind, rather than improvement of existing buildings, and their primary concern is, quite rightly, the safeguarding of life rather than the safeguarding of the contents of the building. Historic buildings require rather wider priorities: human life is still paramount, but as the fabric is irreplaceable and the contents frequently so, great attention must be paid to safeguarding the building itself. Thus, for historic buildings, it is suggested that the second objective given above should be broken down into three parts:

(a) To prevent the outbreak of fire.

(b) To minimize the effects of a fire by preventing its spreading (passive fire protection).

(c) To enable the fire to be fought efficiently with minimum damage to its contents (active fire protection).

Passive measures of fire protection which do not rely on mechanical devices or the human factor should be given a high priority. This places an extra responsibility on the building owner and his architect, which is made all the more onerous as historic buildings were rarely designed so as to restrict the spread of fire.

In historic buildings, extra emphasis should be put upon passive means of fire protection, i.e. encasing and subdivision. Automatic devices such as sprinklers can be useful, but it is wise to remember that sprinklers may cause damage to the contents, so their use must be ruled out if the contents are historically valuable. In some cases, after a fire, it has been remarked that the fireman's hose caused more damage than the fire itself. Once a flame has started, it will spread to any nearby combustible material and so build up until it is checked in one of three ways: by being deliberately extinguished, by running out of combustible material, or by being confined within a particular compartment with flameproof boundaries. Accompanying the flames will be dense smoke and hot gases. It is equally important to prevent the spread of these as they will make fire-fighting and rescue operations much more difficult and can themselves cause severe damage to valuable contents and cause the death of occupants by asphyxiation, so that provision of smoke vents is desirable. In designing a new building to prevent the spread of flame and gas, the basic principle is to divide the volume up into sections bounded by fireproof divisions, so that the fire cannot affect more than one section, and this is the basis of passive protection. In sophisticated schemes, stairs and lobbies are pressurized to reduce smoke penetration. In practice, the boundaries between sections will not be completely fireproof for an indefinite period, but should be so for a period long enough to allow occupants to escape and firefighting to take place. The standard of fire resistance required depends on the risk, the sum of the hazards or 'fire load', the status of the building and the purpose of the boundary—whether it forms part of an escape route for instance—and other considerations such as the value of the contents must be taken into account. Fire resistance is a different attribute from combustibility. The fire resistance of structural elements whose sole function is to protect means of escape need not be based on consideration of fire load, as the protection is required only for a short period; elements having a fire resistance of half an hour or one hour will be sufficient to protect human life. On the other hand, if a staircase is to be used as access for firemen, or if in a large building it is necessary to ensure that fire cannot spread from storey to storey via the stairwell, a higher grade of resistance will be needed. *Common causes of fire and some precautions* The ordinary domestic fire or stove is a common cause of fire, with heat and flame causing the ignition of adjacent wooden members of the structure. Another common cause of fire is a very hot spark, perhaps from defective wiring or from welding operations, landing on to inflammable material. Portable electric fires (providing radiated heat) can ignite clothes, curtains or furnishings; likewise, powerful modern light fittings can have the same effect. Lighted candles, if left unattended, should be securely fixed in holders that cannot be blown over or fall. Unattended candles should always stand on a metal tray large enough to contain any candles which may fall over. No candle or naked light should be placed near combustible material. The accumulation of rubbish or loose combustible material often causes fires or hastens their spread, so tidiness is an essential part of any fire-prevention scheme. Rubbish deposited by draughts, or collected by insects and birds or by vermin to form nests, may be a fire risk, as heat can cause this to smoulder or a spark can cause flame. A responsible person should make monthly inspections with this in mind and ensure that any such hazards are removed. The neglect of this precaution can lead to irreparable damage. Used polishing rags and mops are liable to heat up and then ignite spontaneously, depending on the type of polish. They are best kept in an outhouse if required for further use. The burning of rubbish should be carefully controlled. No combustible material should be stored in the main volume of the building or areas linked thereto unless proper fire doors or shutters are fitted. Electricity is a big fire risk: faulty wiring, overloaded circuits, badly maintained or carelessly used equipment have all been known to start fires. Short-circuits in old wiring with defective insulation is a severe hazard. Nothing should be placed close to convector or tubular heaters so as to restrict air circulation around them and any non-luminous electrical heater should have a pilot indicator light by its switch. Storage heaters and the like should have fixed wire guards for safety. Because of these risks, all electricity should be switched off when not in use, particularly at night, and if there is a night watchman's room or special plant such as refrigerators which must be continuously connected to the main supply, this should have a separate circuit arranged as a safety precaution. All electrical work should be carried out by competent electricians in accordance with official standards and regulations. The whole of an electric installation should be thoroughly examined and tested every five years and no unauthorized alterations permitted. It is found that 50-cycle frequency vibrations can loosen connections. The choice of wiring system is most important. Mineral-insulated, copper-sheathed, plastic-coated wiring is undoubtedly the best. All cables should be run clear of combustible material such as wood wherever possible and should not be fixed in inaccessible voids where they cannot be inspected. Electrical plant should be connected by armoured cables and have isolating switches with indicator lights. Temporary electric lighting and equipment is always a fire risk, particularly as workmen are liable to improvise. Such installations must be to the same standard as permanent work. No loose cables should be permitted at any time. *Precautions during conservation operations* Repair, consolidation and reconstruction operations present an additional and severe set of hazards to an historic building. Workmen busy on repairs generally increase the risk of fire through carelessness or unfamiliarity with the local fire precautions. Some of the operations carried out by builders and plant engineers involve the use of blowlamps and other equipment that produce flames and heat in areas of appreciable fire risk, for instance on roofs where the heat may penetrate to concealed woodwork. This equipment should only be used if no alternative is available, and then the work should be carried out in a safe area if possible. If the work must be done *in situ,* the operator should have at hand an assistant with a portable fire extinguisher to watch sparks as and where they fall. Combustible materials should be protected by a heat shield. No operation involving the use of flame should be carried out within an hour of the end of the working day, at the close of which the work must be inspected by a responsible person so that any smouldering may be seen before the men leave. Tarpaulins used for temporary waterproofing are another fire risk, particularly if a cigarette is dropped carelessly into a fold. When not in use, tarpaulins should be folded neatly. Smoking should be permitted only in the men's mess room and site office; a workman found smoking elsewhere should be subject to immediate dismissal from the site as a term of the building contract.

The strategy for protection of an historic building and its contents depends on preventing the outbreak of fire, particularly fire caused by human carelessness. A full system of fire-warning alarms should be installed and, if necessary, special detectors can reinforce human vigilance and can be wired by direct line to the fire brigade at the cost of an annual rental. Arrangements should be made for a responsible official to be available by day and by night in case of fire; an internal telephone or radio telephone system is invaluable for this. Closed circuit television systems which can 'see' in the dark may become more common and be linked with special security systems by direct line to a police station. Locks should be standardized so that the fire brigade can open all relevant doors with one master key. At night all internal doors should be left closed but unlocked, if security permits. A small fire can reach unmanageable proportions in less than five minutes, so the fire brigade should always be called.

Evaluation of fire extinguishers The type of extinguisher must be chosen in relation to the type of fire that might occur and the area in which it might be used. Water extinguishers have severe limitations and can cause damage to the contents of an historic building and cause fires of flammable liquids or grease to spread and are dangerous to use on electrical installations. A carbon dioxide extinguisher is good for small fires, such as might occur in a wastepaper basket. For more than a small fire it has disadvantages, being toxic and having an extremely cold discharge temperature, which would cause rapid condensation and consequential damage in an historic building. Dry chemical powder extinguishers have the advantage that they can tackle all types of fires. However, they are heavy, toxic and reduce visibility during use and leave a lot of mess which may be harmful to the contents of an historic building. The only clean and effective extinguishers on all types of fire, i.e. wood paper cellulose, electrical and flammable liquids and grease, are those using inert halogen gases. They are efficient, rapid and leave no residue. The gas is non-corrosive and has a minimal cold shock. The hand-held extinguishers are much lighter than CO_2, although equally toxic. The danger of automatic piped systems lies in false alarms, as these can waste expensive gas; some fail-safe procedures are therefore necessary. Small-bore hose reels with controls situated at the nozzle, permanently connected to a 30 mm (1.2 in) or larger diameter water supply with adequate pressure, can also be very useful if there are permanent staff qualified to use them. All portable extinguishers should be periodically tested by complete discharge, at 2-5-

year intervals depending upon the type and conditions in the building; one-fifth to one-half of all extinguishers should therefore be discharged each year. As most people are surprised or even frightened by the noise and force of a hand-operated fire extinguisher, all staff should be given the opportunity to practise in a suitable place providing for a throw of about 8 to10 m. Fire hydrants should be provided both inside and outside the building, and marked in the standard way and sited in accessible positions for the fire brigade. They should all be permanently secured and if adaptors are fitted, these should be brazed to the original outlet to prevent a 'souvenir hunter' causing a major disaster by removing the adaptor. Hydrants can be served by both dry and wet rising mains. Dry rising mains should be provided for places of difficult access, e.g. roof spaces, towers, domes and spires. Where height is great it may be desirable to provide a permanent rising main, so that water can be sprayed immediately on any fire as soon as the fire brigade can connect its pumps to the dry riser. This should also have a valved hose connection, so that when the firemen have climbed to the scene of action they can use their hoses at full bore. Alternatively, duplicate booster pumps may be fitted to give immediate response to the outbreak of fire, although proper precautions must be taken against frost damage to what would then be a wet main. It may be difficult for fully-equipped firemen to climb quickly enough to certain points, and in this case a fire lift may be provided as has been done at St Paul's Cathedral in order to protect the dome.

When a fire breaks out, serious damage and even injuries to people can be prevented if sensible steps are taken quickly, as follows:

(1) Raise the alarm and call the fire brigade at the first sign of fire.

(2) Close all doors that will help to isolate the fire and reduce draught.

(3) Attack the fire. While the fire brigade is being called, every effort should be made to extinguish or check the fire with first-aid fire-fighting equipment, but only while it remains safe to do so. Anyone not fighting the fire should be evacuated.

(4) Remove valuables. Immediate action should be taken to bring records, plate or valuable furniture out of the building.

(5) Mobilize local help. In isolated country districts, where the fire brigade must inevitably take time to arrive on the scene, the help of everyone living nearby may be needed to check the fire.

Instruction of the permanent staff of a building in fire drill is essential, so they should know what to do in case they discover a fire. When the fire brigade comes out on a practice scheme, the permanent staff of the building should be involved; regular practices at, say, six-monthly intervals are desirable as it should not be forgotten that personnel change. Staff should practice the use of equipment such as hand extinguishers, hose reels, sand and asbestos blankets. The alarm systems should also be tested. It may be inexpedient to involve the public in these practices if panic of large numbers of people is a possibility; the public should be guided out of a building rather than allowed to be stampeded by a too audible alarm. The Vatican museums have prerecorded warning messages by people of various nationalities speaking their mother tongues to ensure clarity and calmness.

Security is concerned with the prevention of crime, particularly theft of valuables in the building and prevention of damage to the fabric of the building. There can be conflict between the desired requirements of 'means of escape' for the public and security precautions for valuables—one interest requiring a door to be open, the other shut and securely locked— so it is necessary to treat each case upon its merits. However, while fire prevention and 'means of escape' standards are continually being raised, security is becoming more and more difficult to maintain to the standards required by insurance companies, so these conflicts are likely to become more noticeable. In principle there are three types of lock security: (1) to prevent people entering the building; (2) to prevent the wrong people entering a room or space; (3) to protect valuables stored inside furniture. Three systems of locks are therefore required. To overcome the conflict between security and fire-fighting, one master key for all doors is ideal, but this is easier said than done. Keys issued by a supervisor must be signed for— however exalted the recipient. Every so often (say at five-year intervals) it is desirable that the locks be changed so as to eliminate the number of' illegal' keys which come into use in the course of time. The mechanism of the locks should be capable of several arrangements to enable these renewals to be done easily and at low cost.

The wide range of detection systems available for protection against theft and damage can be divided into the following three main groups, as set out in *Table 16.2:* (a) localized point detection applied to objects (i) fixed to a wall, (ii)free standing or (iii) contained in a showcase; (b) perimeter detection; (c) volumetric detection.

A mechanical alarm system consists of four elements: a detector, a control box, an alarm signaler and the wires joining them all together. The system, like a chain, is only as strong as its weakest link; therefore it must be protected against intentional neutralization by cutting of wires, against mechanical or electrical destruction, against masking or changing the alignment or position of the detector, against involuntary neutralization such as by a power failure or breakdown. Protection systems are generally designed to give daytime protection based on localized and linear systems, supported at night by volumetric detection. Window and door bars give greater security if they are wired to anti-tampering devices. More than one complementary system gives greater security against premeditated theft. Control boxes should have a reserve supply of electricity in case of a power failure. Alarms can be sirens, flashing lights, closing of doors automatically, taped announcements or direct telephone links to the police and fire station. The malfunction of sophisticated alarm systems occurs at least 10 times for one real alarm. Because of the nuisance that these false alarms make, there is a danger that indolent staff may switch them off.

The difficulties of an old night watchman dealing with intruders should not be minimized. At night, in addition to electronic alarms, the building should be patrolled by a uniformed, able-bodied person. Uniforms confer some additional authority. The multitone internal communication system ('bleep'), while not as good as two-way radio, is a help for internal security when combined with an efficient internal telephone system which may also be linked by direct line to the police station. One of the easiest ways for an intruder to gain access is via builders' ladders and scaffolding. Thus ladders should be removed and locked at night and scaffolding made unattractive by liberal use of barbed wire and sticky paint or grease on the lower parts. Permanent illumination is another aid to security. The public who visit historic buildings in ever increasing numbers produce a range of problems because of carelessness and, in particular, illicit smoking or even deliberate arson. Vandalism is common, including name cutting, removing small objects, throwing things from galleries and roof parapets and breaking windows. Rowdyism and aggressive and uncontrollable behaviour are becoming more common, particularly with gangs of youths from any distant part. There are problems with unfortunate down-and-outs, methylated spirits drinkers, and would-be or actual suicides; also, bomb scares may involve a thorough check of the public parts of the building by staff and police. Good internal security reduces these problems. The advantages of having able-bodied men in uniform to deal with these problems are consider-able. The entrance of the building should be supervised by a uniformed man at all times and two may be necessary at peak times, for by firm and polite action they can often prevent rowdyism. Thefts of valuables or souvenirs cause a great nuisance, the only antidote being constant supervision; however, pairs of experienced thieves can, by working together, put supervisors off their guard. One historic house has equipped its host guides with whistles to blow the alarm and close external exits.

In **Reproduction,** a copy of extant artifacts replaces the missing or decayed decorative parts to maintain aesthetic harmony. Valuable cultural property, if irretrievably damaged and environmentally threatened is moved to more suitable environment and a reproduction is substituted to maintain site or building unity.

Reconstruction with new materials after disasters like fire, earthquake and war, over accurate documentation and evidence lacks patina of age. When entire buildings are moved to new sites under overriding national interests, certain cultural values are lost and new environmental risks are created.

3.4.7. Presentation of Historic Buildings

Before a conservation project is started, its objectives should be defined, then the appropriate presentation policy can be proposed. The objectives may be simply to keep a building 'wind and water tight' to preserve it on the one hand, or on the other hand to present it in its full documentary and historical context to be studied for educational and artistic purposes within the context of cultural tourism. This will mean analysing the values inherent in the building. First, there are the *emotional* values—wonder, a sense of continuity and identity; then the *symbolic* and *cultural* values of art, history, aesthetics, architecture, archaeology and the site landscape and townscape; and lastly there are the *use* values—functional, social, economic and even political. In the forming of presentation policy these values must be respected, but it may be found that there are conflicts between the claims of some of them which can only be resolved by mature judgement and cultural preparation. Such decisions are too important to be made by one man alone, but once the individual guidelines of policy for presentation have been made, they should be rigorously adhered to in order to avoid aesthetic confusion. This is where the advice of art historians and archaeologists and me wide cultural preparation of the conservation architect are so important. He must see, understand and interpret. The presentation should not destroy historical or archaeological evidence. It is essential that consideration of the values in cultural property should be assessed objectively and fairly. There is always a danger that the conservation programme will only reflect the bureaucratic objectives of the government department that is responsible. Therefore, it is wise to insist that the goals and priorities of the presentation programme are established by an interdisciplinary, interdepartmental working group that includes people genuinely interested in all values in cultural property. Their task is to reconcile their purposes as well as the direction of their movement.

When the relative importance of all the values in cultural property has been established then, having examined all the practical alternatives, the 'least bad' solution can be found. If the conservation programme goes forward before all the conflicts of competing values have been thoroughly and thoughtfully resolved, there is the risk of destroying for ever the full integrity of the historic building and its site. Also, if the conservation programme goes forward prematurely, one will face the probability of time-consuming, expensive and professionally embarrassing changes having to be made later. We are indeed only trustees for historic buildings.

A piecemeal approach to presentation is disastrous. The conservation architect must guard the 'wholeness' of the historic building in his care, so that it can be presented in an intelligible way to the public. Presentation must also take into account crowd control, together with security, prevention of crime and vandalism. When proposing the presentation of an historic building or site, it is desirable to consider all the values that have been listed earlier and define the 'message' of the building under each of these headings.

There are many messages to be found in historic buildings and sites, so interpretation may run the risk of manipulation. A good guide will always tell one something worth while, but well-trained guides with the command of many languages are all too rare: generally one has to fight off importunate would-be purveyors of misinformation and mispronunciation, who are more of a liability than an asset. The cultural tourist who has come a long way to visit, see and understand, is entitled to serious consideration and should be willing to pay for interpretation of the site or building. Interpretation can take many forms— simple printed leaflets, plans, illustrated guides and histories, models showing phases of development and museums showing artefacts related to the site. Interpretation facilities, together with restaurants, hotels, car parks and lavatories, need careful consideration in relation to an historic site. The architects who design these facilities must be extremely sensitive to the *genius loci* of the monument, as well as the surrounding landscape.

3.4.8. Avoiding Planning Blight

Planning blight is an economic disease arousing conflicting interests between economics and town planning, due to indecisive and exaggerated ambitious schemes in Adaptive Reuse, which either make history or destroy it. Minimum intervention at key points is best for a completely integrated approach from town planning at 1/50,000 scale to a full size detail. An advanced, clearly defined, analyzed and evaluated objective resolves possible contradictions in the approval scheme. Continuity of policy and consistency of artistic treatment is best achieved by nominating overall architectural responsibility subject to multidisciplinary advice.

3.5. Summary

Adaptive Reuse of historic buildings is an inter professional, multidisciplinary activity effectively combining, contributing and coordinating a range of aesthetic, historic, scientific and technical methods. Centuries of philosophical, aesthetic and technical progress articulate modern principles, organizations and applications. Solutions to the local environmental problems and preventions to the decay of fine, decorative arts and architectures need to thoroughly understand the decay and deterioration mechanisms, increase the Adaptive Reuse skills, prolong the cultural property longevity and slow the decay process. A good professional will lead and educate his building team. The work may appear to be slow to start with, but once the work-force understand, they will take great pride in the honour of giving good work to historic buildings, which they know also belong to them. One of the pleasures an architect has in this work is direct contact with skilled craftsmen—together a difficult problem is faced which neither architect nor craftsman can solve independently, so the architect says: 'I do not know how to solve this problem, what are your ideas Mr Craftsman'. A proposal will be put, and discussed and modified by the concepts of conservation which the architect must apply within his vision of the building as a whole. Then, after perhaps an hour, the insoluble problem is solved to each party's satisfaction; the craftsman knows what to do—and he executes the work with real satisfaction because he has been consulted as an equal. As bad workmanship and mistakes cannot be afforded in conservation work, the supervising architect must give his time to this form of consultation, from which he will learn a lot. Adaptive Reuse of historic buildings is, as stressed earlier, multidisciplinary teamwork, in which we must respect each genuine contribution and to which we must all give of our best.

4.1. Introduction

This chapter awakens us to both global and regional guiding instruments of contemporary Adaptive Reuse practices, the heritage conservation Charters, their assumptions, theories and practices. A cross cultural perspective assesses the various adaptations, merits and validity of the most recognized Building Conservation Charters like the Venice Charter and the Burra Charter as well as the important Urban Conservation Charters like the Washington Charter and the Australian ICOMOS Charter. Thereafter the contributions of the UNESCO World Heritage Centre in preparing the World Heritage Listing of significant historic properties, their nomination process, criteria for selection, tentative listings, and success stories are discussed.

Besides global strategies, Adaptive Reuse interventions are also being undertaken at our very national scale by the Indian National Trust for art and Cultural Heritage (INTACH), guidelined in our very Indian INTACH Charter. This chapter concludes with a discussion on the mission, services and projects rendered by INTACH in relation to Adaptive Reuse.

4.2. The Charters

Throughout the thesis the general use of the term "charters" is used to denote those documents such as Charters, Recommendations, Guidelines, or Declarations, each drafted to direct consideration to some aspect of conservation. During the examination of these documents for this study, they form a three tiered system, similar to the planning system of aims/objectives/policies. The first tier is concerned with conservation philosophy and theory being the aims of conservation; the second tier centres on the objectives and principles of conservation being the methods of achieving the philosophical aims; and the third tier, the practical policies and guidelines for achieving the objectives. For example, in urban conservation this system is easily seen in the first tier, the UNESCO *Recommendation Concerning the Safeguarding and Contemporary Role of Historic Areas;* then the second tier, the ICOMOS *Charter for the Conservation of Historic Towns and Urban Areas (The Washington Charter),* and the third tier, *Guidelines for the Restoration and Renovation of the Old City of Aleppo.*

With the growth of Globalisation, and the concomitant rise of the World Heritage Organisation in recognition of the value of the collective patrimony of the world, it has been recommended that conservation principles be established on an International basis. The numerous charters produced by UNESCO and ICOMOS serve two purposes: they present a distillation of conservation philosophy, and provide directives for conservation practice. This is to ensure that the common heritage of the world is maintained on equal standards, and that major monuments and sites may fulfill standard criteria regarding their recognition when entered on the World Heritage List.

In line with this International approach, cooperation and assistance has been recommended for countries seeking aid for conservation work. Appendix I of the *Nara Document on Authenticity* suggests Approaches should also build on and facilitate international co-operation ... in order to improve global respect and understanding for the diverse expressions and values of each culture."

The most influential of conservation charters is the *Venice Charter,* and investigation into conservation projects discussed throughout this study has found it to be quoted and used virtually as the only conservation Charter. To this is added a second influential Charter, the *Burra Charter.* This was drafted specifically for Australian use, and influences Australian practitioners for conservation in overseas countries as well as in Australia. It is the Charter since its inception in 1979, has influenced conservation, a matter of importance when critically assessing sites in Syria. Its Articles are far more incisive than those of the *Venice Charter,* and hence require a more critical consideration regarding their application.

Both the *Venice Charter* and the *Burra Charter* claim to be applicable for urban conservation. The UNESCO *Recommendation Concerning the Safeguarding and Contemporary Role of Historic Areas,* drafted in 1976, gives a good background of conservation philosophy. As a tier one document, it goes far beyond the practical issues of conserving the fabric, but realises the important issues of economic feasibility, the participation and education of the inhabitants, and the importance of stewardship for the success of urban conservation projects.

But it is asserted that these factors are lost in transference to the second-tier documents. Second tier charters, particularly the Venice and Burra Charters, focus particularly on material factors. The omission of social and cultural factors continues through to the third tier documents, and runs the serious danger of being overlooked in practical application. The charters convey an expectation that the conservation of the built environment will automatically lead to the continuation of the resident society and its culture. This well meaning approach is tantamount to a condition that could be called "conservation determinism."

The complexity of urban conservation can be appreciated from the three tiered system, just by the number of charters that have been drafted for urban and area conservation. Each type of settlement has its own specific problems, and these are reflected in the different charters that have been produced. ICOMOS in collaboration with the International Union of Architects (UIA) has produced resolutions from a joint seminar on the *Integration of Modern Architecture in Old Surroundings* (1974). *The Resolutions of Bruges: Principles governing the Rehabilitation of Historic Towns,* (1975) continues that "The preservation of historic towns, their rehabilitation and adaptation to present day needs thus form an essential part of any genuine policy for the human habitat." The list continues with ICOMOS *Resolutions on the Conservation of Smaller Historic Towns* (1975). A companion document is the joint ICOMOS UNESCO *A New Life for Historic Towns* (1976). The years 1974 to 1976 are significant, crucial in Europe for the burgeoning practice in urban conservation.

All these documents are all first tier documents. The real test is how well their resolutions have been transferred to the next tier of charters. *The Washington Charter* (1987) is the direct descendant of the UNESCO *Recommendations,* but it is asserted in this thesis that it falls very short of social and cultural requirements. The ICOMOS *Charter on the Built Vernacular Heritage* (2000) is a recent charter, drafted to answer specific urban concerns. This refers briefly to cultural values and the traditional character of vernacular settlements, and as a document for urban settlements, considers it necessary to establish principles "in addition to the *Venice Charter"*. It contains seven brief guidelines for the practitioner, and as such is included in the second tier category.

It will be seen that urban charters fall very short in guiding practitioners in the field of Adaptive Reuse. Even though they have been drafted in the form of urban charters, it is to the *Venice Charter* and *Burra Charter* that practitioners turn for guidance.

Initiating Adaptive Reuse practice in Syria makes little reference to international charters. Archaeological work is required to conform to the *Regime Des Antiquites En Syrie: Decret, Loi No. 222 (1963).* Conservation work in the Old City of Damascus has its own regulations: *Method of Restoration and Reconstruction/Rebuilding of the Old City within the Walls, Parliamentary Act No. 862.*Neither Syrian document makes reference to other charters for compilation. The *Venice Charter* forms the basis of the *Guidelines for the Restoration and Renovation of the Old City of Aleppo,* as this project is a joint German/Syrian venture, with the documentation being produced through Germany. Each of these documents is included in the critical assessment of the charters.

Experiences stemming from Western nations have resulted in the production of various conservation charters, and the proliferation of technical books on conservation practice have propagated Western philosophy and methodologies. This is particularly so for urban conservation, where examples of conservation plans produced in Eastern countries show a strong affinity with

Western models. In Muslim governments that do not have the financial, technical and managerial resources, Government planning is usually based on conventional models adopted from the first world which, apart from being capital intensive, do not make use of the considerable skills, vitality, and ingenuity that poor communities possess. Another example in a well written exercise on conservation in a local context, being a guide to area conservation aimed at Bangladesh, and including a number of examples from Eastern countries as well as Britain. The whole exercise is a European structural approach, with little guidance to local cultural concerns. The *raison d'etre* for area conservation is ".. .far from being unaffordable, can actually save money by making sensible use of existing resources."

An examination of conservation charters highlights a curious irony. As the conservation movement has grown with the desire of nations to assert their individuality and cultural identity, this has happened hand-in-hand with the acceptance of international charters. These charters have been written to ensure that conservation principles should be agreed at an international level, resulting in the desire of individuality being controlled on a global basis. Since the inception of the World Heritage Convention in 1972, the focus has been that the "deterioration or disappearance of any item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the world." This, and the necessity for the assessment of places for inclusion on the World Heritage Register to be determined on universal principles, has lead to an expectation that conservation shall similarly be determined on universal principles. This in turn has led to a proliferation of charters.

The general use of the term "charters" is used to denote these documents, unless specifically referred by their correct names, such as Charters, Recommendations, Guidelines, or Declarations. When considered together, these documents can form a three tiered system, similar to the planning system of aims/objectives/policies. The first tier is concerned with the philosophy and theory equaling the aims of conservation; the second tier centres on the objectives and principles of conservation being the methods of achieving the philosophical aims; and the third tier, the practical policies and guidelines for achieving the objectives. For example, in urban conservation this system is easily seen in first, the UNESCO *Recommendation concerning the safeguarding and contemporary role of historic areas;* the second in the ICOMOS *Charter for the Conservation of Historic Towns and Urban Areas (The Washington Charter),* and the third, the various guidelines for practical application, and specifically written for particular projects, for example, the *Guidelines for the Restoration and Renovation of the old City of Aleppo.*

To this can be added the first misunderstanding of practitioners making reference to the wrong document at any part of the system, as, for example, when referring to the *Venice Charter,* a Tier two document, for guidance at the practical application stage. Although the charters do distil generally agreed principles and methods, the understanding and detailed application in practice, if not specifically codified, will illustrate the personal approach and understanding of the practitioner. The philosophies, which underlie the charters' directives, if not clarified, remain a personal understanding. If the intention of the conservation charters and guidelines is to achieve their objective, they must be clearly written and understood at all stages, and the practitioners fully aware of their message.

As early as 1931, the realisation of the unity of human values and the perception of ancient monuments throughout the world as a common heritage saw the *Athens Charter* produced as an agreed procedure of providing guidance for preservation and restoration. Architects and technicians of historic monuments drafted it at the Congress of Athens by as a measure to bring international standards to the practice of restoration. Following the destruction during the Second World War and more alarmingly, the further destruction following that war in the guise of development, restoration and urban consolidation, it was considered necessary to reconfirm that conservation commitment.

In 1964, acknowledging the contribution of the Athens Charter, the *Venice Charter* was produced to meet the increasing problems arising from a greater awareness and critical study in answer to the ever growing conservation practice. As this practice has continued to grow, more charters have been drafted to meet the concomitant necessity for control and direction. The single most impelling guiding principle behind these charters, as taken from the *Venice Charter,* has been the common responsibility and duty to hand the world's patrimony on "in the full richness of their authenticity."

While the charters were seen to be essential in Europe following the Second World War, the difficulty now lies in their universal acceptance. In spite of the exhortation of the drafting committee for the *Venice Charter* that the embodied principles "should be agreed and be laid down on an international basis, with each country being responsible for applying the plan within the framework of its own culture and traditions," there are many examples of countries using the charter without qualification. The key words in the above quotation are *"applying* the plan," for there is no statement that each country should produce its own charter. For example, the *Objectives, Principles and Standards for Preservation and Conservation,* (a third tier document) produced for Singapore refers to the *Venice Charter,* and reproduces it in full in its Appendix, with no qualification or explanation given regarding its adaptation to Singaporean cultural requirements. On the contrary it specifically refers to the *Venice Charter* as "the fundamental international point of reference for preservation and conservation." In addition it also acknowledges other sources from London, Washington DC, and Australia (the *Burra Charter)* but without cultural qualification.

The *Burra Charter,* another Tier two document, was the first charter produced in acknowledgement of the *Venice Charter* exhortation, but now has become equally as successful in world usage as its progenitor. In October 1978, the Committee of Australia ICOMOS produced a working paper on the *Venice Charter.* By this time there had been "numerous intentions within ICOMOS (International) to amend or revise the *Venice Charter."* The necessity for the Working Paper was stated that Australia ICOMOS is interested in interpreting the Charter and in suggesting revisions. The interest in revision is presumably for the same reasons as others have (terminology difficulties and inadequacies in regard to some kinds of work) and is especially interested in testing how well it serves Australian purposes. The Australian experience is always affected by the shortness of our "European era," the bigness of our thinly populated (and thinly built) continent, two factors which lead away from the "ancient monument" mould in which the Charter seems to have been cast.

Australia ICOMOS at Burra, South Australia, ratified, and so named, the *Burra Charter* in 1979. It remained in this form with several revisions until the adoption of a major revision on the 26th November 1999. This revised version, which continues as a tier two document, has superseded the former Charter, and is, for clarification, referred in this thesis as the *Burra Charter,* and the superseded charter is referred as the Burra Charter (1988). During its lifetime the Burra Charter (1988) has been recognised by overseas countries as a good example of the adaptation of the *Venice Charter* to suit specific cultural conditions, with the new charter destined to continue that recognition. For example, in addition to the Singapore *Objectives,* the *Declaration of San Antonio* of the ICOMOS National Committees of the Americas also makes reference to the Burra Charter (1988) together with the *Venice Charter* for its compilation. References were also made to the Burra Charter (1988), during the Nara Conference. Particularly complimentary when referring to the numerous principles that have been produced for late twentieth century conservation, when stated "Other principles which were developed under specific conditions provide superb working tools, for example the too little known Burra Charter developed from the situation on the continent of Australia."

The practical nature of the charters indicates their use by practitioners such as architects, engineers, builders and others in the building construction field. The general focus of the charters is to ensure the conservation of the built fabric as evidence of history and cultural significance. However, although in the *Venice Charter* the direction is given that "restoration in any case must be preceded and followed by an archaeological and historical study of the monument," no direction is given regarding the various other practitioners such as historians, sociologists, geographers, and economists, which may be required to satisfactorily complement these studies. The *Burra Charter* refers to studies that should precede conservation work, "drawing on appropriate knowledge, skills and disciplines." Although the charters call for studies to be done, there are few documents produced to assist the practitioner in doing these studies. The *Burra Charter* has guidelines as part of its package for determining cultural significance, conservation policy, and technical direction for undertaking studies and reports. These publications assist Australian practitioners, but as the *Burra Charter* does not refer to them, it is unlikely that overseas practitioners are aware of or have ready access to them.

The emphasis of the charters points squarely to those employed in the practical and physical work of conservation. Notwithstanding these criticisms of the charters, they codify conservation philosophy and the application of techniques into specific statements or rules, and hence represent the most succinct distillation of conservation thinking and action.

This study begins with their Eurocentricity, a matter of some concern considering their use throughout the world. This factor played an important role in the discussions at the Nara Conference on Authenticity in 1994, with relation to the World Heritage Convention, where the differing cultural perceptions of authenticity were identified and discussed. Social, cultural and economic factors play a significant role in conservation, particularly urban conservation, and the use and understanding of the charters highlights the differences that can be confronted in the cultural context and its relation to authenticity.

4.2.1. Building Conservation Charters

The most influential document produced in conservation discipline has been the **Venice Charter**. Drafted at the Second International Congress of Architects and Technicians of Historic Monuments in Venice, May 1964, it was intended to have international application. In the preamble, it states: "It is essential that the principles guiding the preservation and restoration of ancient buildings should be agreed and be laid down on an international basis," and refers to the *Athens Charter* of 1931 as having contributed towards the development of an extensive international movement which has assumed concrete form in national documents, in the work of ICOM and UNESCO and in the establishment by the latter of the International Centre for the Study of the Preservation and the Restoration of Cultural Property.

Although there was an "increasing awareness ... on problems which continually become more complex and varied," the attitude of the Congress members remained that the new charter would be, as stated in the heading, an "International Charter for the Conservation and Restoration of Monuments and Sites."

It was the difficulty of satisfying the authenticity requirement of the World Heritage applications that brought attention to the universalisation of ICOMOS principles. The growing desire to reclarify universal principles is a fairly new one and follows a period of about fifteen years during which ICOMOS has encouraged particularization of existing universal principles, by promoting efforts to accompany the Venice Charter with thematic, national and regional adaptations. Many of these adaptations such as the Florence Charter (for Historic Gardens), the Washington Charter (for Historic Towns) and the Burra Charter (Australia) have proved very successful; recently however their proliferation has become a source of confusion for some, and the desire to extract the essential from the wealth of overlapping texts, that is, the desire to focus on the universal, has reemerged for many as a highly desirable objective. The Nara Document that codifies the findings of the Nara Conference on Authenticity reflects the efforts of its framers to give its ideas universal force and weight "to complement, in contemporary fashion, the considerations understood as universal when the Venice Charter was formulated." In the case of Syria, with the exception of the Aleppo *Guidelines,* no references are made to the *Venice Charter.*

The use of terms in the *Venice Charter* illustrates two important aspects: its emphasis on the authenticity of and respect for the original building fabric, and its reflection of Eurocentric attitudes. The concept of the building fabric representing evidence of history is clearly indicated in Article 3 that states: "The intention in conserving and restoring monuments is to safeguard them no less as works of art than as historical evidence." From this stems the notion that as evidence, the retention of the original fabric is vital so that we may fulfill "our duty to hand on in the full richness of their authenticity." Article 6 is concerned with preserving the setting of the monument, but states that new construction or modification that alters the relations of mass and colour should not be allowed. Article 12 concerns the replacement of missing parts but they should not "falsify the artistic or historic evidence." Even in Article 5, where the reference is making use of the monument for "some socially useful purpose," this desirable use is stated in physical limits: that no change should be made to the layout or decoration of the building. In Article 13, additions should not be allowed if they would "detract from the interesting parts of the building, its traditional setting, the balance of its composition and its relation with its surroundings." In addition, Article 9, stating the aim of restoration in terms of aesthetic and historic values, refers to the respect for original material and authentic documents.

Notably, and as commented on at the Nara Conference, authenticity is not defined. It can be assumed on the same argument that, as none of the terms used in the charter are defined, the understanding at the time of drafting, was that the members clearly understood the meaning of all the terms and assumed that all practitioners did likewise. This has proved to be a double stumbling block: first, that the concept of authenticity was not understood, even among the Western delegates, and secondly, the notion that the heritage significance of the monument lay in its fabric, which was a common Western understanding at that time. When referring to the notion of "monument" in the Charter, states a concern for the monumental had implicitly focused the attention of conservators on essentially static questions—on the ways in which elements of existing fabric could meaningfully express or carry valuable messages. A concern for the vernacular, or for cultural landscapes, or for the spiritual, has moved the focus toward the dynamic, away from questioning how best to maintain the integrity of fabric toward how best to maintain the integrity of the process (traditional, functional, technical, artisanal) which give form and substance to the fabric. Broadened the perception of heritage conservation to that of process, the Charter has not been amended to reflect this change.

Regarding the Charter's reflection of Eurocentric attitudes, the composition of the committee responsible for the *Venice Charter* was predominantly European. Nineteen members were from Europe, and one representative each from Mexico, Peru, and Tunisia. There was one member from Japan, as a representative of UNESCO. Britain was not specifically represented, although two of the European members were representatives of International Centres and their nationality not revealed. In recent years, there have been many criticisms of the Charter from numerous practitioners from non European countries. During the Nara Conference referred to criticism aimed at the *Venice Charter* for being too Eurocentric and not sufficiently open and applicable to cultures in other regions of the world. At the same conference, referred to ".. .the very European-oriented Venice Charter (1968 *(sic)),* already an historic document itself, appears not to be compatible with some traditions of non-European cultures especially if it is applied ascetically." Again, writing in relation to Central Asia, makes the observation "the shifting ground realities in many parts of Asia make it very impractical to follow the directives of these [the *Venice Charter}* articles."

It is notable that in 1962, the French *Malraux Act,* an Act for the "definition, protection and restoration of historic areas," was passed in Paris. The preamble to the Act refers to *Monuments Historiques et Sites.* This Act, which was "hailed by conservationists as one of the most important measures to be enacted in recent years for the conservation of historic areas," preceded the *Venice Charter.* With the *Malranx Act* as a model and at least three members from France present on the *Venice Charter* committee, and ICOMOS itself based in Paris, the French influence is not surprising. The Act has clearly influenced the terminology used in the Charter, as indeed the emphasis on the physical focus on conservation action has also influenced the approach taken in drafting the Charter. This is not surprising as France has had several pieces of legislation for the protection of historic buildings since 1852, and the approach of each was concerned with the physical aspects of conservation.

In a Working Paper on the *Venice Charter* produced in October 1978, Australia ICOMOS declared its interest in interpreting the Charter and suggesting revisions. The members of Australia ICOMOS, even though substantially from a European cultural background, had difficulties with the Venice Charter, stating: "Presumably, we have the same reasons as others have - terminology and ineptness in regard to some kinds of restoration work." For example, comments in the Working Paper were concerned with the term "Historic Monument." Article 1 of the *Venice Charter* states the concept of an historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or an historic event. This applies not only to great works of art but also to more modest works of the past which have acquired cultural significance with the passing of time.

The criticism by Australia ICOMOS aimed at "historic monument" suggested that a monumental example was implied, and that "a historic site which has no building is put out of peoples minds." Even though "more modest works" were specifically mentioned, the criticism considered this was an attempt to "modify the difficulty of the term 'historic monument', so clearly others have shared this misgiving." The use of the term "Monument," seen in its use in the *Malraux Act, Monuments Historiques et Sites,* in 1962, in turn may have influenced the very name of ICOMOS and the full title of the Venice Charter *International Charter for the Conservation and Restoration of Monuments and Sites.* But given the misgivings expressed above, this terminology is not only specific to France, but also alien to the thinking of other nations, including even those of a European background.

A writing in hindsight in 1972, ten years after the enactment of the *Malraux Act,* stated: "The way in which the Act has been implemented has, in fact, resulted in a considerable amount of adverse comment." The problems included the lack of social objectives, and "the failure to take into account social problems in the area when utilising restored buildings." Similarly, the *Venice Charter* ignores social and cultural aspects. This is probably a combined result of following the pattern set by the *Malraux Act,* and the reflection of the thinking at that time.

The preamble of the charter commences with the statement: "the historic monuments of generations of people remain to the present day as living witnesses of age old traditions. "The charter relates this to the international scene, with the preamble urging the application of the plan within the framework of each country's culture and traditions. Although this focuses the intention of the Charter on social and cultural factors, the articles relate mainly to material fabric. Article 5 refers to making use of the monument "for some socially useful purpose."

As late as 1982, we find that the advice of the *Venice Charter*—that each country be responsible for applying the principles within the framework of its own culture and traditions—had not been widely applied by other countries, but rather had been taken as an all-encompassing document. This may have arisen from the statement that the principles guiding conservation *should be agreed and be laid down on an international basis* (my emphasis). Belasis Daouletli *et al,* referring to the Medina of Tunis in *Monumentum,* wrote: The widening of the area in which the principles and methods of the Venice Charter are applied has raised the question of how far it can be considered universally valid. Is it possible to apply this 'code', which derives from European culture, to the treatment of a settlement born of a different historical and economic context?

This article points to the general acceptance of the Charter without applying it within the cultural framework, and its acceptance for application in an urban context rather than the single monument.

The participants in the ICOMOS International Symposium held in Washington DC, as late as 1987, recommended a resolution calling upon "National Committees to develop and encourage the adoption of national charters, based on international principles, that are adapted to its special needs and circumstances." This again illustrates that even after 25 years, concerns regarding "the dynamics of contemporary mobility (immigration, tourism, industrialization and development) ...cultural values of natives and newcomers," and that "international or national charters of some nations do not respond to the needs for the protection of the cultural heritage of some other nations" had not abated, but rather had escalated.

But even though the *Venice Charter* still ignores cultural difference and emphasises technical aspects that relate specifically to the building fabric, it still continues to be the standard for many countries. The decision to focus on the universal nature of the Charter was probably to simplify an already growing complex issue, and to consider new philosophical issues such as authenticity in its many and various understandings was to present an impossible task. With this ever-widening consideration of conservation practice and philosophy, the necessity for nation-specific charters is more relevant than ever before.

In the same manner as the *Venice Charter,* cultural and social problems were not considered an issue when, in 1978-9 Australia ICOMOS began to draft their version of the *Venice Charter* for Australian use. As the ratification of the charter took place in 1979, at Burra, South Australia, it took the name of *The Burra Charter.*

As an Initiative to the **Burra Charter** the growing interest in conservation during the 1970s on the government, professional and public levels, saw the formation of Australia

ICOMOS as a Member State of the International body. This focused interest on the standards applicable for conservation practice in Australia. In the summer of 1978, The Australia ICOMOS Newsletter published an article "The Venice Charter Annotated" calling for comments from all Australian members.

A brief description of the formation of the *Venice Charter* was given, and arguments for the writing of a new charter for use in Australia were made in the Article's Introduction. The main arguments were that Australia presented different cultural conditions to that of Europe requiring different approaches to the conservation of Australian heritage. This was not intended to denigrate the value of the *Venice Charter,* but the intention was clearly stated: "Presumably we have the same reasons as others have, terminology difficulties, and ineptness in regard to some kinds of restoration work.. We are especially interested in testing how well it serves Australian purposes. The Australian experience is always affected by the shortness of our 'European era', and by the bigness of our thinly populated, and thinly built, continent, two factors which lead away from the 'ancient monument' mould in which the Charter seems to have been cast.

The article reproduced the *Venice Charter* with accompanying annotations, calling for comment but not making suggestions at this stage. The actual rewording that would lead to the Burra Charter in 1979, would be the result of discussions and comments by members of Australia ICOMOS over the following months. The authors of the article were all foundation members of Australia ICOMOS: with a previous paper on Definition of Conservation Terms having been given. The opportunity to present an Australian conservation document was taken up enthusiastically by the members of Australia ICOMOS, and following several intense debates at ICOMOS conferences, the first Burra Charter was ratified on the 18 August 1979, at the conference at Burra, South Australia, thus giving it its notable name.

The revision of the Charter in 1999, resulting in the current *Burra Charter,* arose from changing attitudes in conservation theory and philosophy, both in Australia and Internationally. The purpose of this examination is to test its success in achieving the recognition of cultural factors, the lack of which was highlighted during the 20 years use of the original charter and its subsequent revisions, Burra Charter (1988). A further purpose is to indicate its Eurocentric background, and show its emphasis on technical matters, both of which being to an even greater extent than that of the *Venice Charter.* This is important, as practitioners in Australia are considerably involved with conservation projects in overseas countries, particularly in Asia and the Western Pacific, and most work is carried out under the influence of the guidelines of the Charter. Further to this examination of the *Burr a Charter* is reference to the July 1997 draft of the charter that was first produced for discussions the led to the new Charter. This draft had many good points, some of which were lost in the final revision, but are reviewed here as an indication of the changing ideals of conservation within Australia.

Although adapted from the *Venice Charter,* the Burra Charter (1988) has been accepted by overseas countries as a good example in its own right, taking its place alongside the *Venice Charter.* It may be because it had been drafted with the intention to suit a particular national context that it has been considered as having a more stringent focus and clarification of its meaning in contrast to the *Venice Charter.* Its acceptance is one illustration of the way Western thinking can influence conservation philosophy and action in non-European countries. But the lack of insistence to take into account cultural factors has resulted in the widening of Eurocentric conservation theory, putting greater emphasis on the retention of the physical fabric rather than examining the significance of ephemeral cultural factors. It is the Burra Charter (1988) that has been so influential, and the *Burra Charter,* with its greater consideration of Australian social and cultural factors, has to date had little influence. For example, the references in the Singaporean *Objectives* and *The Declaration of San Antonio,* refer to the old charter. The several references in the Nara Conference also relate to the old charter.

The *Burra Charter* is more successful than the *Venice Charter* in considering social and cultural factors. The definition of cultural significance includes, as well as material matters, "associations" and "meanings." The explanatory note to Article 1.16 states that meanings relate to symbolic qualities and memories. These associations and meanings are referred to in nine further Articles. The *Guidelines to the Burra Charter: Cultural Significance* that form part of the Charter's package are a notable step in the social/cultural direction. The *Venice Charter* has nothing like this to help the practitioner. Even so, within the *Guidelines* four sets of "values" are given: aesthetic value, historic value, scientific value, and social value. Article 2.5 defines Social Value as "the qualities for which a place has become a focus of spiritual, political, national or other cultural sentiment." However, the actual *Burra Charter* is the focus of interest to Australian practitioners and overseas practitioners, and is the part generally quoted in conservation documents. The attached Guidelines are rarely, if ever, quoted. This is probably due to the Burra Charter 1988, that did not have the Guidelines attached, being the one that has had the influence. In time this may be corrected.

This is not only important when applying the Charter's principles to overseas work, but is equally important for work within Australia when other cultural groups are involved. Aboriginal cultures are easily the first recognised cultural group, as Aboriginal sites of significance comprise a major component of Australia's National Estate. But thought must be given to the other numerous multicultural societies within Australia, and the cultural differences they may have regarding their places of significance. The problem of conflicting cultural values has been recognised in the *Burra Charter,* and although it could be argued that the various references to ephemeral cultural values could be applied to all cultural groups, much of this recognition reads specifically in relation to Aboriginal cultures.

The July 1997 draft of the Charter included a philosophical statement in which some emphasis was given to the wider understanding of culture: "Cultural heritage is expressed through history, traditions, customs, values, language, documents, objects, and through places of cultural or natural significance." It further defined cultural heritage places as "a tangible expression of Australian history and cultures." It is notable that in this definition "cultures" were given in the plural, and throughout the philosophical statement recognition was given to various aspects of culture including "continuing customs and traditions" and "traditional practices."

As to the importance of these cultural factors in the implementation of conservation, the Charter recognised that "different cultures within Australia may have specific cultural protocols dealing with the care of heritage places." One paragraph was given specifically to Aboriginal and Torres Strait Islander peoples, and stated that they have a "moral right to exercise responsibility for their significant places." No specific mention was made regarding the European and other multicultural peoples throughout Australia.

Surprisingly, this philosophical statement has been omitted in the adopted charter. There is no explanation of cultural heritage, but it has been included with cultural significance, and is referred to in the explanatory notes as being "synonymous with heritage significance." The emphasis, as in the Burra Charter (1988) is once more on the physical fabric *or place,* and its role as evidence. Under the heading *Why conserve?* Places of cultural significance are described as "historical records, that are important as tangible expressions of Australian identity and experience."

The technical emphasis of the *Burra Charter* is even stronger than that of the *Venice Charter.* This arises from the *Burra Charter's* insistence on the fabric's role as historical evidence. Although not specifically named, the Charter's emphasis on the retention of the fabric as historical evidence illustrates the importance *of authenticity* in the conservation process. Article 3.1 of the Charter states: "Conservation is based on a respect for the existing fabric, use, associations and meanings." Although this points to a wider cultural understanding than merely the fabric, the explanatory note which accompanies this Article—"the traces of additions, alterations and earlier treatments to the fabric of a place are evidence of its history and uses which may be part of its significance. Conservation action should assist and not impede their understanding"—lays emphasis on the fabric as evidence. The cautionary note in the Article, "changing as much as necessary but as little as possible," emphasises further this insistence on the original fabric, thus strengthening the focus to the retention of the fabric, but increasing the chance of the social and cultural aspects being overlooked.

4.2.2. Urban Conservation Charters

Both the *Venice* and *Burra Charters* are considered by their authors to apply equally to wider urban areas as well as single buildings. The *Venice Charter* states, "The concept of an historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization." The term "urban or rural setting" is left, perhaps deliberately, a little ambiguous, and could be taken as merely the setting for a specific monument, the small and immediate surroundings, or as an historic area in its own right. The *Burra Charter* is less ambiguous, and clearly defines *place* as "site, area, land, landscape, building or other work, group of buildings or other works."

Relating to the old mill towns of Victorian Britain one concludes that people can accept "bad" history, that it validates memory, and that there is a willingness to accept the bitter times with the good, as being part of the whole and complete story of life. So we turn to the various urban charters to examine their efficiency in handling social, cultural and economic values in urban conservation.

At the **UNESCO Recommendation** in 1976, the General Conference of UNESCO met in Nairobi, and among the resolutions of that conference was the *Recommendation concerning the safeguarding and contemporary role of historic areas.* In contrast to the focus of the *Venice Charter* on single monuments and sites, the *UNESCO Recommendation* centred on area conservation. The *Recommendation* commences by stating that historic areas are part of the daily environment of human beings everywhere, that they represent the living presence of the past which formed them, that they provide the variety in life's background needed to match the diversity of society, and that by so doing they gain in value and acquire an additional human dimension.

To this is added their historical value, as they afford "the most tangible evidence of the wealth and diversity of cultural, religious and social activities." But even here the historical concerns are focused on the social consequences, for example, "historic areas are an immovable heritage whose destruction may often lead to social disturbance, even where it does not lead to economic loss." Again, the perceived dangers of globalisation, are seen in terms of "a growing universality of building techniques and architectural forms that may create a uniform environment throughout the world." The answers are seen in recognising historic areas that make "an outstanding contribution to maintaining and developing the cultural and social values of each nation." Further to the globalisation approach, and the "dangers of stereotyping and depersonalization," historic areas are seen not only as living evidence of days gone by, but also as being "of vital importance for humanity and for nations who find in [them] both the expression of their way of life and one of the cornerstones of their identity."

The intention of the *Recommendation* is that each 'State' (the term used for each nation or country) is responsible for its own heritage. Examples of the form of measures are given, being in summary, the exchange of information, organization of seminars, the provision of fellowships and the dispatch of scientific, technical and administrative staff, action to combat pollution, the implementation of large scale projects, co-ordination where projects affect adjoining States or there is a common interest. The implication is that each State understands its own cultural mores and hence knows what is best for the conservation of its heritage. This combined emphasis on the involvement of the society and the understanding of its culture ensures that conservation projects would more likely to be an authentic presentation of that State's social and cultural values.

Understanding that the *Recommendation* was only a recommendation, it remained for committed nations to translate this document into workable charters.

The ICOMOS *Charter for the Conservation of Historic Towns and Urban Areas* was adopted in 1987 at the ICOMOS General Assembly in Washington DC, and is known as the **Washington Charter**. The Charter has been produced in two formats. The first was that published in *ICOMOS Information* No.2 - 1987, and the second being that produced on the Website. The latter version has a short explanatory statement that comes before the preamble, and does not form part of the Charter proper. It states "the terms of the charter are purposely broad; internationally, there are many methods of planning and protection for historic urban areas, many ways that urban development may impact on the patterns of post-industrial societies, and this diversity is addressed in the Charter."

However, the current Website version (April 2004) omits this opening statement. This later version also omits the preface to the original Charter (1987) by the ICOMOS President. His statement that its publication "offers a solution to a question which has concerned the founders of ICOMOS since 1964," and that it was to complement the *Venice Charter,* indicates that the *Venice Charter* was not considered at that time applicable for area conservation. He concludes that the text is "true to the goals laid out in the 1976 UNESCO Recommendation... but far from merely repeating this document, the articles of the new charter combine a philosophical approach and practical goals."

The 16-point *Charter* codifies some of the practical requirements of the *UNESCO Recommendation* to a set of broad principles for conservation. It refers to social, cultural and economic issues, but only in the most general terms in the preamble (Articles 1 - 4). It refers to embodying the values of traditional urban cultures, and "irreversible cultural, social and even economic losses."

The first article, under *Principles and Objectives,* points to social and economic concerns as being an integral part of urban and regional planning for the effective conservation of historic towns.

Although Article 2 refers to qualities to be preserved including spiritual elements, the qualities specifically listed are all of a material nature: qualities to be preserved include the historic character of the town or urban area and all those material and spiritual elements that express this character, especially:

a) urban patterns as defined by lots and streets;

b) relationships between buildings and green and open spaces;

c) the formal appearance, interior and exterior, of buildings as defined by scale, size, style, construction, materials, colour and decoration;

d) the relationship between the town or urban area and its surrounding setting, both natural and man-made; and

e) the various functions that the town or urban area has acquired over time.

First, there is mention of spiritual elements along with the material. This promises to fulfil some of the aims of the *UNESCO Recommendation.* But the qualities in a) to d) are of a material nature concerned with urban patterns, building and spatial relationships, and formal appearance. Part e) refers to functions, the most ephemeral of the list, and is the only one which comes closest to social and economic concerns. Social and cultural values are not mentioned, which leaves the impression that the "spiritual elements" underlie all of the above actions, and will, in a deterministic fashion, be automatically achieved. This assumption is of greater concern when taken with the final statement that implies that these stated qualities comprise "the authenticity of the town or urban area." This is the only mention of authenticity in the document, which indicates that, like the *Venice Charter,* authenticity is an ideal to be attained.

To the Charter's credit, Articles 3 and 15 are concerned with the participation, involvement and education of residents, and in Article 5 that the residents should support the conservation plan. The well meaning concerns of the *UNESCO Recommendation* are lost in this practical Charter. It is almost impossible to see how this Charter can claim, as stated by Parent, to be "true to the goals" of the *UNESCO Recommendation,* and exactly where they "combine a philosophical approach with practical goals." Where the *UNESCO Recommendation* took the broad global approach, and specifically referred to policies being "based on principles which are valid for the whole of each country," the Charter has considerably narrowed this approach, which continues to promulgate material attributes and, given the lack of direction in its 16 short Articles, risks the probability of specific social and cultural values being overlooked.

Australia ICOMOS Urban Conservation Charter followed the first adoption of the Australian ICOMOS Burra Charter in 1979, wherein thoughts were turned to the production of an urban charter. In March 1982, (notably five years before the adoption of the *Washington Charter),* Australia ICOMOS produced a draft *Charter for the Conservation of Urban Areas.* Largely based on the definitions and structure of the Burra Charter (as amended in 1981), the draft set out conservation directives that echoed those of the charter, but including specific definitions and articles for enhancement, infill, and redevelopment. No reference was made to the *UNESCO Recommendation* having been consulted.

Acknowledging that the *Urban Charter* was only a draft, and there was little or no discussion from conservation practitioners on its contents, it at least indicated the first thoughts of those who drafted it. Almost all of the directives centred on "Basic Character" and/or "Cultural Significance." Basic character was defined as "the distinctive combination of development pattern and people's activities in an area." Economic and social changes were both considered in terms of cultural significance, which in turn was defined as "aesthetic, historic, scientific or social value for the past, present or future generations."

The opinion was held that the articles reflected those of the *Burra Charter* and that it was unnecessary to produce a new charter, the former being sufficient for the urban context. Further to this, the fact that the draft gave little consideration to real urban matters but merely expanded on the Burra Charter (1988), points to the shallowness of the exercise. The definition of "place" in the Burra Charter (1988) was given as "site, area, building or other work, group of buildings or other works together with associated contents and surroundings." The explanatory note to the article included "structures, ruins, archaeological sites and landscapes modified by human activity." The *Illustrated Burra Charter* defined this further giving the scope of the principles and procedures as including "a whole district or a region." This understanding of the scope of the *Burra Charter* continues to this day. The definition of "place" in the current *Burra Charter* is similar to that above and the explanatory note clarifies this further by stating: "The elements described ...may include ...urban areas, towns, industrial places, archaeological sites and spiritual and religious places."

This would not be such a problem if conservation practitioners and administrators were aware of the various charters available for the various tasks. It is true that the charters are pointers for practitioners as signposts on the conservation path, and directives for more detailed guidelines.

To this can be added the proliferation of **other charters** that point to a growing awareness of the complexity of urban conservation, that each type of historic urban settlement requires its own particular directives. These show in the headings of each charter.

The Resolutions of Bruges: Principles Governing the Rehabilitation of Historic Towns (1975) is a tier 1 document that acknowledges the value of towns as mirrors of society, history, traditions and identity. The ICOMOS - UNESCO Recommendation *A New Life for Historic Towns* (1976), another tier 1 document, acknowledges historic sites as "the most authentic evolution in the history of society." The ICOMOS - UIA, following a seminar, adopted resolutions on the *Integration of Modern Architecture on Old Surroundings* on 19 October 1974, a tier one document.

As the name suggests, the ICOMOS *Charter on the Built Vernacular Heritage* (October 2000) concentrates on a specific type of built environment, in the recognition that vernacular buildings and villages require a particular form of conservation, and that the charters for larger towns and urban centres do not meet these particular requirements. Similarly the ICOMOS resolutions on the *Conservation of Smaller Historic Towns,* (May 1975), acknowledges the *Bruges Resolutions* and focuses on smaller towns that have not expanded beyond their historic core. Both of these documents are tier 1, indicating the concern of ICOMOS practitioners during the 1970s for urban conservation and the recognition of the complexities arising from the diverse conditions of each type.

Each of these charters vary in the degree to which they refer to social and cultural factors, relying mostly on the physical aspects, even to the integration of modern architecture and functions, serving both socio/economic and physical concerns. If it was hoped that these documents would lead to the next tier of succinct objectives, the drafters must now be very disappointed. The UNESCO *Recommendation concerning the safeguarding and contemporary role of historic areas* followed several of these documents. The definition says it all: "historic and architectural (including vernacular) areas" shall be taken to mean any groups of buildings, structures and open spaces including archaeological and palaeontological sites,...and... among these "areas", which are very varied in nature, it is possible to distinguish the following in particular: prehistoric sites, historic towns, old urban quarters, villages and hamlets as well as homogeneous monumental groups.

The specificity of the requirements for each type of settlement and their conservation is diluted in this otherwise excellent document, and in turn is further diluted in the *Washington Charter.* In contrast, both the *Burra Charter* and the *Venice Charter* are referred for urban conservation as well as single monument conservation. For example, as cited above, the *Objectives, Principles and Standards for Preservation and Conservation* for Singapore (1993) are based largely on the *Venice Charter,* with reference to the Burra Charter (1988). The *Objectives* concentrate almost entirely on fabric conservation; the only reference to social matters is the definition "Social Value" that reads almost word for word like the definition in the *Burra Charter Guidelines.* Reinforcing the single building approach, the U.S. Department of the Interior National Park Service *Standards for Rehabilitating Historic Buildings,* are also cited. The only reference to urban conservation is the Circular *Historic Buildings and Conservation Areas - Policy and Procedures?* But it is the *Venice Charter* that is reproduced in full at the back of the document, indicating the urban significance assigned to the *Venice Charter* in formulating the Singaporean *Objectives.*

The *Guidelines for the Restoration and Renovation of the old City of Aleppo* in its "Preface - Importance of guidelines" and with reference to the need to develop its own conservation strategy, states: "This strategy should fulfill national needs, traditions and international conservation standards such as the Venice Charter and the World Heritage Convention." The Preface continues: "In these guidelines a detailed catalogue of restoration standards, developed on the basis of the Venice Charter is formulated." Here again is a specific case of urban conservation taking its lead only from the *Venice Charter,* and having no other reference to any urban conservation charter. The reference to the *World Heritage Convention* is not explained. It is a first tier document, and is concerned primarily with the responsibility and administration of International assistance in conservation programs throughout the world. It has no guidance for social, cultural, nor indeed any practical matters relating to conservation other than International assistance for funding, technical expertise, and training. In the case of Aleppo this forms the legal justification for the German Government to assist in this Syrian project. As neither the *Venice Charter* nor the *World Heritage Convention* give directives for social, cultural or economic planning, the Aleppo *Guidelines,* although intentionally aimed at preserving the fabric of the Old City and promoting economic and social development whilst purporting to fulfill national needs and traditions, have the potential to slip into single building conservation, and falter as a comprehensive urban conservation project.

The Chairman of Australia ICOMOS referred in the Working Paper (October 1978) to numerous intentions within ICOMOS International to amend or revise the *Venice Charter,* and cited discussions in England and Moscow as examples. At the 9th General Assembly of ICOMOS held in Lausanne in 1990, Australia ICOMOS again attempted to introduce changes to the *Venice Charter*. This proposal was discussed by 150 participants, but it was agreed that the Charter had "stood the tests of time and experience," and recorded in the proceedings in terms that recalled the Charter itself, even if in a somewhat tongue-in-cheek manner, that the "Venice Charter is an historic monument that must be protected and conserved and that it needs no restoration, no renewal and no reconstruction." These were of a technical and physical nature: the problems of sites and ensembles, urban conservation, the vernacular architecture of primitive buildings, industrial archaeological sites, 20th century architecture and its building materials, works of art that decorate the interior as well as the exterior of monuments, the setting of buildings and their physical context, and the problems of monuments and ensembles that have been destroyed or seriously damaged by earthquakes and other natural disasters. ICOMOS International Committee members in particular seemed to feel that their concerns were insufficiently addressed by the Charter.

Some of these issues have already been addressed in subsequent charters for example, the ICOMOS *Charter on the Built Vernacular Heritage,* and *The Declaration of Dresden.* It is notable that the "problems of... urban conservation" was included even though UNESCO had already addressed urban conservation in 1976, followed by the ICOMOS *Washington Charter* in 1987. Even with these documents, the participants were of the opinion that the *Venice Charter* was the charter that should be used for urban conservation even though specific documents had been prepared for this purpose. In addition to these misunderstandings, social and cultural concerns were not considered, their only reference in this respect being that "among the social, economic, and political changes that have occurred since the Charter's adoption that affect its applicability today are society's increased mobility; mass tourism; and industrial development." It can be seen from this that any genuine concerns regarding cultural or other social matters have been the cause of some concern to many representatives of cultural heritage agencies throughout the world, but given the conservative nature of the ICOMOS Committees these concerns have been passed on unheeded.

Other conservation charters make reference to social and cultural factors in varying degrees. The *ICOMOS New Zealand Charter for the Conservation of Places of Cultural Heritage Value,* adopted in 1993, pays particular concern to the indigenous heritage of Maori and Moriori cultures and their relationship to "family, hapu and tribal groups and associations. It is inseparable from identity and well-being and has particular cultural meanings." Further to this specific reference to indigenous cultures, the charter refers to general social and cultural issues in the same manner as the *Burra Charter.*

Turning to Syria, the Damascus Parliamentary Act No.826 *Method of Restoration and Reconstruction/Rebuilding of the Old City within the Walls* has no social or cultural concerns, the briefest reference relating only to the amalgamation and ownership of property titles. Its enactment in 1995 was to bring some control to conservation of single buildings in the Old City, and practical conservation issues were only addressed, social concerns seeming not to be part of this consideration. Similarly, the *Regime Des Antiquites En Syrie,* although drafted with the intention to include conservation to all antique sites and present day historic urban centres, does not consider social and cultural concerns.

One notable charter is the *The Deschambault Charter* - the *Charter for the Preservation of Quebec's Heritage* adopted by the ICOMOS Canada French-Speaking Committee in April 1982. This charter belongs to the tier 1 (aims/philosophy) in the system, as the articles are general in nature, referring to desirable aims rather than specific objectives such as those of the *Burra Charter.* Socio-cultural concerns are present, with considerable emphasis given to community participation, and both collective and individual commitment arising from a common community desire to preserve the heritage of Quebec. In the definition of heritage and preservation, it notes finally "that the people in their environment, who have their own customs and traditions, whose memory is furnished with a particular folklore, and whose way of living is adapted to this specific setting, are a human and social treasure that also requires protection." Article I is headed "The Citizens of Quebec are the Foremost Protectors of the National Heritage," but little direction is given in the charter for the citizens to implement the aims. "Specialized expertise" and "interdisciplinary teams" are referred to, and "those who may become involved in actions to preserve our heritage" are required to disseminate information and documents to the public in such a way that non-specialists can understand them. This implies that specialised professionals are to be employed, but although this is not specified in this document, it indicates the necessity that should be addressed in a second tier document.

The opportunity to produce meaningful charters for area conservation has to date been bypassed. The requirements of the *Burr a Charter* and more so those of the *Venice Charter* ring hollowly when compared with the concerns expressed by the *Recommendation.* How can these two charters hope to achieve the recommendations of UNESCO when their Articles are but a shadow of the ideals and aims of the *Recommendation!*

Referring again to the "Technical, economic and social measures" of the *UNESCO Recommendation,* the requirements that, in addition to architectural surveys of the area, thorough surveys of social, economic, cultural and technical data and structures and of the wider urban or regional context are necessary.

The last sentence emphasises the importance given to these studies, and the whole Article illustrates the wide scope and complexity of urban conservation. How much more wide reaching is this vision than that reflected in the *Burra Charter's* expected coverage. Although stating that "work on a place should be preceded by studies to understand the place which should include analysis of physical, documentary, oral and other evidence, drawing on appropriate knowledge, skills and disciplines." How much less are the "opportunities to contribute to and participate in understanding the cultural significance," than those exhorted by the *Recommendation* of thorough surveys of social, economic and cultural data, demographic data, economic, social and cultural activities, ways of life, and social relationships? This is not to say that the *Recommendation* only calls for surveys and does not allow for the proper implementation without consultation. The Articles require that safeguarding activities should couple the public authorities' contribution made by the individual or collective owners and the inhabitants and users, separately or together, who should be encouraged to put forward suggestions and generally play an active part.

Administrative measures in the Burra Charter refer to the practical means of conducting professional work in order to achieve the best conservation objectives. Grouped under the heading Conservation Practice, the Articles direct that work should be preceded by studies to fully understand the place's cultural significance; the methods of presentation of the findings and recommendations for conservation action; responsibility for decisions; direction, supervision and implementation; documenting the evidence and decisions; and keeping the records for future reference. Article 26.3 requires that groups and individuals with associations with a place should be allowed to participate in the collection of information and to participate in the conservation process.

The mechanism for success is incorporated in the Charter, but again the insistence of the fabric takes precedence over the ephemeral qualities. The squatter population in Bosra could have brought a further understanding of a present-day culture in the context of the ancient Roman ruins and the continuity of successive cultures, but the opportunity has been lost over the conservation of yet another set of Roman ruins not even unusual in Syria.

4.3. Unesco World Heritage Centre

What makes the concept of World Heritage exceptional is its universal application. World Heritage sites belong to all the peoples of the world, irrespective of the territory on which they are located. The United Nations Educational, Scientific and

Cultural Organization (UNESCO) seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity. This is embodied in an international treaty called the Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by UNESCO in 1972.

UNESCO's World Heritage mission is to encourage countries to sign the World Heritage Convention and to ensure the protection of their natural and cultural heritage; encourage States Parties to the Convention to nominate sites within their national territory for inclusion on the World Heritage List; encourage States Parties to establish management plans and set up reporting systems on the state of conservation of their World Heritage sites; help States Parties safeguard World Heritage properties by providing technical assistance and professional training; provide emergency assistance for World Heritage sites in immediate danger; support States Parties' public awareness-building activities for World Heritage conservation; encourage participation of the local population in the preservation of their cultural and natural heritage; encourage international cooperation in the conservation of our world's cultural and natural heritage.

The **World Heritage List** includes 812 properties forming part of the cultural and natural heritage which the World Heritage Committee considers as having outstanding universal value. These include 628 cultural, 160 natural and 24 mixed properties in 137 States Parties. Among these 121 properties are listed as Adaptive Reuse initiatives.

4.4. Creating The World Heritage List

A number of properties were added to the List each year since the first World Heritage Committee meeting in 1978. The total number of properties on the World Heritage List is greater than the sum of the properties listed, because adjacent properties were merged in some instances.

For the **Nomination** process only countries that have signed the World Heritage Convention, pledging to protect their natural and cultural heritage, can submit nomination proposals for properties on their territory to be considered for inclusion in UNESCO's World Heritage List.

The first step a country must take is to make an 'inventory' of its important natural and cultural heritage sites located within its boundaries. This 'inventory' is known as the **Tentative List**, and provides a forecast of the properties that a State Party may decide to submit for inscription in the next five to ten years and which may be updated at any time.

It is an important step since the World Heritage Committee cannot consider a nomination for inscription on the World Heritage List unless the property has already been included on the State Party's Tentative List. A Tentative List is an inventory of those properties which each State Party intends to consider for nomination during the following years. States Parties are encouraged to submit in their Tentative Lists, properties which they consider to be cultural and/or natural heritage of outstanding universal value and therefore suitable for inscription on the World Heritage List. States Parties are encouraged to prepare their Tentative Lists with the participation of a wide variety of stakeholders, including site managers, local and regional governments, local communities, NGOs and other interested parties and partners. They should submit Tentative Lists, which should not be considered exhaustive, to the World Heritage Centre, preferably at least one year prior to the submission of any nomination. Again the Parties are encouraged to re-examine and resubmit their Tentative List at least every ten years. States Parties are requested to submit their Tentative Lists using a Tentative List Submission Format, in English or French, containing the name of the properties, their geographical location, a brief description of the properties, and justification of their outstanding universal value. Nominations to the World Heritage List will not be considered unless the nominated property has already been included on the State Party's Tentative List.

By preparing a Tentative List and selecting sites from it, a State Party can plan when to present a **Nomination File**. The World Heritage Centre offers advice and assistance to the State Party in preparing this file, which needs to be as exhaustive as possible, making sure the necessary documentation and maps are included. The nomination is submitted to the World Heritage Centre for review and to check it is complete. Once a nomination file is complete the World Heritage Centre sends it to the appropriate Advisory Bodies for evaluation.

A nominated property is independently evaluated by two **Advisory Bodies** mandated by the World Heritage Convention: the International Council on Monuments and Sites (ICOMOS) and the World Conservation Union (IUCN), which respectively provide the World Heritage Committee with evaluations of the cultural and natural sites nominated. The third Advisory Body is the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), an intergovernmental organization which provides the Committee with expert advice on conservation of cultural sites, as well as on training activities.

Once a site has been nominated and evaluated, it is up to the intergovernmental

World Heritage Committee to make the final decision on its inscription. Once a year, the Committee meets to decide which sites will be inscribed on the World Heritage List. It can also defer its decision and request further information on sites from the States Parties.

To be included on the World Heritage List, sites must be of outstanding universal value and meet at least one out of ten **selection criteria**. These criteria are explained in the *Operational Guidelines for the Implementation of the World Heritage Convention* which, besides the text of the Convention, is the main working tool on World Heritage. The criteria are regularly revised by the Committee to reflect the evolution of the World Heritage concept itself. Until the end of 2004, World Heritage sites were selected on the basis of six cultural and four natural criteria. With the adoption of the revised *Operational Guidelines*, only one set of ten criteria exists, namely,

a) to represent a masterpiece of human creative genius;
b) to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;
c) to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;
d) to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history;
e) to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;
f) to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria);
g) to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;
h) to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;
i) to be outstanding examples representing significant on-going ecological and

biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals;

j) to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation,

of which six are cultural criteria while the remaining four are natural. Since 1992 significant interactions between people and the natural environment have been recognized as cultural landscapes.

The World Heritage Convention is not only 'words on paper' but is above all a useful instrument for concrete action in preserving threatened sites and endangered species. By recognizing the outstanding universal value of a site, States Parties commit to its preservation and strive to find solutions for its protection. If a site is inscribed on the List of World Heritage in Danger, the World Heritage Committee can take immediate action to address the situation and this has led to many successful restorations. The World Heritage Convention is also a very powerful tool to rally international attention and actions, through international safeguarding campaigns. Often, the World Heritage Committee and the States Parties, with the assistance of UNESCO experts and other partners, find solutions before a given situation deteriorates to an extent that would damage the site.

4.5. INTACH

Our very own answer to the problems of Adaptive reuse lies in the Indian National Trust for Art and Cultural Heritage (INTACH) is a nationwide, nonprofit membership organization set up in 1984 to protect and conserve India's vast natural and cultural heritage.

India is a land of extraordinary heritage and while government agencies are able to protect few thousand monuments, there are literally thousands of beautiful heritage sites that remain unprotected. To address this urgent need to protect our common national heritage, INTACH was set up in 1984 and today, we are pioneers in the field of heritage conservation in India. INTACH strives to spread heritage awareness among public; Protect and conserve India's heritage; document cultural resources of India; formulate heritage policy and regulations; train and develop skills and related professions; emergency response to save heritage; form strategic partnerships and collaborations. To sensitize the public about the pluralistic cultural legacy of India means instilling a sense of social responsibility towards preserving our common heritage. To protect and conserve the natural, built, and living heritage by undertaking necessary actions and measures, documenting unprotected buildings of archaeological, architectural, historical, and aesthetic significance; and cultural resources; is the first step towards formulating conservation plans.

To develop heritage policy and regulations, and make legal interventions to protect our heritage, when necessary, involving the heritage Regulations and INTACH Charter. The first step towards protection of our heritage is the development of heritage policies, regulations and guidelines at the local, regional and state level. INTACH has already begun this process by acting as an advisory body and initiating the development of heritage policies for coastal areas, natural sites, heritage villages, hill stations and other sites of historical and cultural significance. The Punjab State Assembly has approved The Punjab Regional and Town Planning and Development (Amendment) Act, 2003, to bring in provisions that would specifically address conservation issues.

The Act, a landmark achievement was formulated by INTACH and the Government of Punjab, in consultation with the Bombay Environmental Action Group. This is the second Act to be introduced in India after the Maharashtra Regional and Town Planning (Amendment) Act 1994 and has been a breakthrough in the field of heritage conservation. Some of its major clauses are: a definition of heritage sites; for the first time in any Act, natural features of environmental significance and of scenic beauty have been specifically included in the definition of heritage sites; protection of heritage sites for areas within municipal limits and also for areas outside, that come under the purview of the Regional Plan. Concepts like the Transfer of Development Rights (TDR) have been introduced to compensate the owners of heritage buildings who are not allowed to develop their property. It is imperative that many more states emulate Punjab and Maharashtra by formulating effective heritage regulations - while restoration protects many endangered sites, legislation can protect several thousands! INTACH makes legal interventions through Public Interest Litigations when actions of the local or national administration are a threat to the heritage of the country; to provide expertise in the field of conservation, restoration and preservation of specific works of art; and to encourage capacity building by developing skills through training programmes; to undertake emergency response measures during natural or manmade disasters, and to support local administration wherever heritage is threatened.

INTACH renders services to specific aspects of cultural heritage conservation initiatives: Architectural Heritage; Natural Heritage; Material Heritage / Art Conservation; Living / Cultural Heritage; Heritage Education and Communication; Heritage Regulations; IDC - INTACH Documentation Centre and Library. INTACH plays a vital role in: Listing heritage buildings and sites; Documentation; Conservation; Protection of Heritage Conservation Zones; Revival of Traditional arts and crafts; Listing of historic properties that remain unprotected and in the need of conservation; Documentation of the comprehensive assessment of a building, site or precinct to develop a conservation strategy; Conservation of historical buildings that are neglected, endangered, and require immediate attention for saving their heritage character; Protection of Heritage Conservation Zones or areas of unique architectural, cultural and historical value including both tangible and intangible heritage; Revival of traditional arts and crafts through development of crafts centers and skill development programmes at heritage sites.

The projects are concerned with protection of historical buildings, their adaptive reuse and mobilization of resources to save tangible and intangible heritage. Completed Projects in 2004 include Restoration and Reuse of Gohar Mahal Complex, Bhopal, Madhya Pradesh; Reconstruction of Heritage Emporium Building, Srinagar, Jammu & Kashmir; Listing of Historic Properties- Haridwar district, Nanital district, Dehradun, Mussoorie, Uttaranchal; Mani Manir Conservation Project, Morvi, Gujarat ; Samaina Gate, Patiala, Punjab; Emergency Restoration of Rudrani Temple, Bhuj, Gujarat; Than Monastery, Kutch, Gujarat; of Lakhir Chand Gate, Morvi, Gujarat; Emergency Restoration of Vegetable Market, Kutch, Gujarat; Restoration of White Eagle School, Kutch, Gujarat

Ongoing Projects involve Jaisalmer Conservation Initiative; National Register Programme; Listing of Historic Properties - Almora district, Uttaranchal, Shimla, Himachal Pradesh; Restoration of Clock Tower of Ranjit Vilas Palace, Wankaner, Gujarat; AHVY Arts and Crafts Project; Integrated Development Plans for Raghrajpur, Orissa; Reis Magos Fort, Goa ; Aina Mahal, Bhuj, Gujarat ; Agra Listing, Agra, Uttar Pradesh; Cultural Resource Mapping of Tripura State, Tripura; Construction of Gateway to Kashmir at Qazigund, Jammu and Kashmir; Sringar District Listing, Jammu & Kashmir ; Listing of Dundlod Village, Dundlod, Rajashtan ; Reconservation of Durga Devi House, Pragpur, Himachal Pradesh and Patiala Darbar Hall Restoration, Punjab

Proposed Projects include Conservation Plan for Sainik School, Kapurthala, Punjab; Craft Haat of Patiala, Punjab; Chanderi Conservation Plan, Madhya Pradesh; Taj

Mahal, Bhopal, Madhya Pradesh; Urban Haat, Agartala; Dehradun Urban Haat, Dehradun, Uttaranchal ; Awadh Haat, Lucknow, Uttar Pradesh ; Heritage Village, Mana, Jageshwar, Uttaranchal

4.6. Summary

Examining the Charters in the three-tiered system reveals that important factors for Adaptive Reuse are lost in the transference, even from the first to the second tier. It should be the responsibility of the drafters of Charters that these factors are at least referred in subsequent documents. Even then it cannot be assumed that practitioners will be aware of the philosophical background to the Charters' directives, particularly in relation to social and cultural factors. The insistence by the Charters on conserving the fabric is understandable as they were prepared for the purpose of building practitioners to save the fabric. But given the Charters' emphases on this practical implementation, the intangible cultural and social factors are in danger of being overlooked. One of the consequences of this "overlooking" aspect may arise from the misunderstanding of what constitutes authenticity in relation to cultural significance.

The next chapter discusses some examples of Adaptive Reuse [projects, both global as well as national, very much in tune with their cultural context.

5.1. Introduction

This chapter discusses various case studies into Adaptive Reuse both at global and local level. Herethe three main classic global examples of vernacular architecture involve the Holašovice Historical Village Reservation, Czech Republic; Old Village of Hollókö and its Surroundings, Hungary and the Historic Villages of Shirakawa-go and Gokayama, Japan. Our local example is taken from Almora, the study area itself.

5.2. Case Study 1: Holašovice Historical Village Reservation, Czech Republic

Holašovice is an exceptionally complete and well-preserved example of a traditional central European village. It has a large number of outstanding 18th- and 19th-century vernacular buildings in a style known as 'South Bohemian folk Baroque', and preserves a ground plan dating from the Middle Ages.

Holasovice belongs to the folk architecture of southern Bohemia, more specifically to that of Hlubocká Blatská. There was a large increase in building activity in the region at the end of the 19th century. The traditional local technology reacted to the building and craft expression in the new manorial and town architecture, which was copied by the village people at a time when material conditions were improving. This was not the only formal resemblance. Village craftsmen were more often in contact with the manorial building techniques and those in the dense network of towns in both Bohemia and Austria, which have had long-lasting trade and employment contacts. The result was the gradual adoption of construction techniques and modes of expression by master bricklayers, who created the magic of the folk architecture of the region, using logic of structure and form of which they had little understanding to produce buildings for their customers in the villages.

The cultural tradition and its survival within the village area and the entire region can be documented on several levels. Detailed analysis of buildings demonstrates an inertia in the use of decorative forms and the change from older to new technologies. In so far as the volumes and details of the new buildings are concerned, there was a consistent respect for tradition.

In comparison with other villages in the region, Holasovice is a remarkable example of mature local building practice (South Bohemian "Folk Baroque") in terms of the state of conservation of individual buildings and their layouts, dating back to the 13th century.

The fish ponds of South Bohemia are good examples of man-made late medieval and Renaissance landscapes. Most of the settlements in the area were founded after a vast area of wetland had been drained. The result is a picturesque countryside of fields, meadows, and ponds around the villages. This is a highly organized cultivated landscape centred on picturesque villages and their architecture. The whole district has in recent years become a favoured tourist area.

Holasovice is situated in the heart of South Bohemia, 15km west of Ceské Budejovice and 18km north of Ceský Krumlov (inscribed on the World Heritage List in 1992). The village consists at the present time of 120 buildings arranged round an elongated village square, with a small chapel and cross on it, and some more recent buildings on the outskirts. The historical reservation that forms the subject of this nomination consists of the original village as surveyed in the Definitive Cadaster, which includes 23 farmsteads that are protected architectural monuments, along with their attached farm buildings (barns, stables etc) and gardens or tofts. The farmsteads are all built with their gable-ends facing the square. Only some typical examples will be described in this evaluation. Farmstead No 3, a three-sided group, has a classic South Bohemian double-gabled front elevation with a large entrance gate and a smaller gate in the wall. On entering the main gate the visitor finds a two-storey granary on the left, with an attic larder. Beyond the granary is a block with stables and a vaulted cellar. The farmhouse, consisting of two rooms, is to the right. The entrance hall is partitioned by a staircase which gives access to the attic space; the block contains the large main living room and a traditional "black kitchen." Both the main gables are finished with Baroque voluted curves and with stucco pilaster strips. The configuration of the main buildings has hardly changed since they were recorded in the early 19th century, although artistic changes were made on the gables, dated to 1857 and 1863 by inscriptions on the granary and farmhouse gables respectively. Farmstead No 8 is the largest in the village. The main farmhouse, to the left on entering, is a modest chamber type structure with two rooms, and this adjoins a long cow-house, divided into two vaulted rooms; this wing is dated on the facade to 1861. To the right of the entrance is a massive three-storey granary, the present form of which probably dates from the mid 19th century. The courtyard is closed at the rear by a spacious stone barn, built towards the end of the 19th century to replace an earlier timber structure. Another large farmstead, this time on the eastern side of the square, is No 15, again on three sides of a central courtyard. Seen from the square it is a classic double gabled structure with an arched entrance gate. It has undergone a number of alterations over the past two centuries, which have led to the replacement of the Baroque gables by less ornate triangular ones. Historically the most important component of the ensemble is the granary, situated to the left on entering. It preserves its original form and decoration (which was relatively simple) more faithfully than most of the other buildings in the village. In a number of cases, elements of farmsteads (granaries and barns) were converted in the years preceding and following World War II into retirement dwellings; this process involved substantial reconstruction. In addition to the farmsteads there are several farm labourers' cottages that are much smaller and simpler in design. The village smithy and the smith's house are located in the middle of the village square. A facility of this kind is known to have existed in Holasovice since the beginning of the 18th century. It was originally located on the west side of the square, but was moved to its present position in 1885 (the date "1841" on the smithy itself probably relates to that of the building that was relocated). Both buildings are single-storey structures with saddle roofs, and the smithy has a characteristic arched opening on the square (now closed, since it has been converted for residential use). The other architectural feature in the village square is the small Chapel of St John of Nepomuk. This is a slender structure with a tall bell-shaped front. The rectangular interior is vaulted, with two lunettes closing it. The chapel has a saddle roof hipped at one end and with a four pillar lantern spire containing a bell in its centre. It appears to date from the mid 18th century (Fig. 5.1and Fig. 5.2.).

The Committee inscribed this site on the World Heritage List on the basis of *criteria (ii) and (iv)*:

> *Criterion (ii):* Holašovice is of special significance in that it represents the fusion of two vernacular building traditions to create an exceptional and enduring style, known as South Bohemian Folk Baroque.
>
> *Criterion (iv)*: The exceptional completeness and excellent preservation of Holašovice and its buildings make it an outstanding example of traditional rural settlement in central Europe.

5.3. Case Study 2: Old Village of Hollókö and Its Surroundings, Hungary

Hollokö is an outstanding example of a deliberately preserved traditional settlement. This village, which developed mainly during the 17th and 18th centuries, is a living example of rural life before the agricultural revolution of the 20th century.

The Convention has specifically provided for the inscription on the World Heritage List of those sites which constitute "an outstanding example of a traditional human settlement which is representative of a culture and which has become vulnerable under the impact of irreversible change" (criterion V). Application of this criterion is problematic because of the technical and socio-economic upheavals affecting all cultural areas of the world without exception. It is, therefore, particularly urgent to conserve the memory of some of the great examples of traditional urban and rural structures which are now in danger of disappearing in the more or less distant future. With this in mind, the choice must not only be made carefully but must also be subject to careful prospection and study. Simply to include on the World Heritage List such sites as a high altitude village, a lake dwelling, an oasis or a hacienda is not enough to ensure their future: the risk of destruction, decline, insidious change or radical transformation of such sites must be carefully examined. The Hungarian nomination of the village of Holloko and its surrounding area deserves the Committee's attention both

(a) because of the intrinsic exemplary value of the site and

(b) because of the guarantees offered by the remarkable conservation policy started for the village in 1972, strengthened by further measures taken in 1977 and crowned with success during the last ten years (an extension of the conservation area was even proposed in 1981).

About 100 km north-east of Budapest, Holloko is a small rural community whose 126 houses and farm buildings, strip-field style farming, orchards, vineyards, meadows and woods cover 141 hectares. The village and the surrounding area are given the same protection as a historic monument such as the castle. Mentioned as early as 1310, this castle, whose ruins lie to the north-west of the village today, played a decisive part in the feudal wars of the Palocz and the Hussite wars. It served as protection for the village whose ruins have been found a little way from its walls. At the end of the Ottoman occupation (1683) the castle and the village were finally abandoned and the present village grew up below. It developed gradually throughout the 18th and 19th centuries. As was customary in the region, the first generation of inhabitants settled on either side of the main street. In this one-street village, subsequent generations built their houses at the back of the narrow family plots, thus progressively enlarging the built up area. The barns were built apart from the village, on the edges of the fields, according to Palocz custom. The development of the village and the soil can be traced from various documents. In 1782 it was still a typical one-street village. Later, a second street developed to the east of the main street. In 1885 plan shows the topography was already like that of the present-day plan: the amount of cultivated land had reached its maximum by the middle of the 19th century and the village could therefore grow no further. Some limited growth started again in 1960 and is now strictly controlled. The inhabitants of Holloko never heeded a 1783 decree prohibiting the use of wood for building, considered to be too inflammable. Consequently the village was periodically devastated by fire. The last of these fires dates back to 1909 but the houses were again built according to the traditional techniques of Palocz rural architecture: half-timbered houses on a stone base with rough cast white washed walls, enhanced by high wooden pillared galleries and balconies on the street side protected by overhanging porch roofs. The church with its shingled tower is simply a transposition of this domestic architectural style.

In recommending that Holloko should be included on the World Heritage List on the basis of criterion V of the "Guidelines", ICOMOS wishes to point out clearly the reasons for this decision.

1. Holloko is not a museum village devoid of any traditional activity but a living community whose conservation not only includes farming activity but also ensures its success.

2. Holloko provides a certainly exceptional and may be unique example of voluntary conservation of a traditional village with its soil. The plots that were modified by the regrouping of land were returned to their original strip shape within the framework of the 1983 "preserved natural region" project, which is so characteristic of the old system of land occupancy linked with family farming. The vineyards, orchards and vegetable gardens have been recreated; the ecological balance has been restored, even in the forestry environment, taking infinite care to respect historical authenticity.

3. Holloko not only represents the Palocz sub group within the Magyar entity, but also bears witness, for the whole of Central Europe, to the traditional forms of rural life which were generally abolished by the agricultural revolution in the 20th century.

The proposed cultural property is included on the World Heritage List on the basis of criterion (v) (Fig. 5.3. and Fig. 5.4.).

5.4. Case Study 3: Historic Villages of Shirakawa-Go and Gokayama, Japan

Located in a mountainous region that was cut off from the rest of the world for a long period of time, these villages with their Gassho style houses subsisted on the cultivation of mulberry trees and the rearing of silkworms. The large houses with their steeply pitched thatched roofs are the only examples of their kind in Japan. Despite economic upheavals, the villages of Ogimachi, Ainokura and Suganuma are outstanding examples of a traditional way of life perfectly adapted to the environment and people's social and economic circumstances.

The Committee decided to inscribe the site under criteria (iv) and (v) as the villages are outstanding examples of a traditional human settlement that is perfectly adapted to its environment. The Committee noted the successful adaptation to economic changes and that survival can only be assured through constant vigilance on both sides, the Government authorities and the inhabitants.

Japan is one of the world's most important examples of a country which has developed an architectural tradition based entirely on wood. Since ancient times, from the emperor's palace, the residences of the aristocracy, and the religious architecture of Buddhism and Shintoism to military facilities such as the castles of the warrior period, all architecture was made of wood. Within the framework of development of each architectural type, the design of form and structure, the techniques of joinery, the process of fabrication, and the techniques of colouring and painting have become highly developed and have produced a great variety of architectural styles and expressions during the long history of Japanese architecture. Not only upper class architectural types but also vernacular houses and accessory buildings for ordinary people have been made mostly of wood, with very few exceptions. Vernacular houses are classified into two basic types: the machiya or town house, and the minka, the houses found in typical farming or fishing villages. The nominated property is a set of farming villages and the groups of historic houses in those villages. In Japanese farming villages the most typical farmhouse style is a single storey rectangular plan structure with the entrance on the long side, and with exterior walls that have exposed wooden posts and clay infill, hipped gable roofs, and reed thatching. There are, however, various other farmhouse types, and this wide variety is one of the factors that Japan can point to as an example of a vernacular architectural tradition which has universal Value. The generalised model of the Japanese village house is relatively small, with a low ridge and a roof pitch Less than 45'; the overall image is of a house form that rests comfortably on the earth, suggesting not confrontation with nature but rather passive harmony with it. In sharp contrast to this image, the nominated gassho houses of the Shirakawago Gokavama area are built in a unique style not be found in any other region Of Japan. They have one of the most rational structural systems to be developed in Japan. Their special identifying features are:

1. The building Size is larger than in most other regions. They have tall, steeply pitched 60° gabled roofs, giving an overall impression of confrontation with nature.
2. In ordinate Japanese farmhouses the structural space inside the roof is seldom used, and then only for passive functions such as storage. In the gassho style houses, however, the considerable space resulting from the steep roof structure of open truss frames is typically divided into three or four levels which are actively used for functions such as raising silkworms or for the storage of mulberry leaves.
3. The structural weak points associated with the adoption of the repetitive system of truss frames which make up the gable roof structure is the lack of resistance to lateral forces perpendicular to the truss frames. This problem has been solved in the gassho structure by using diagonal bracing within the sloped plane of the roof, to make the roof itself a rigid plane with strong lateral resistance. This technical innovation is not found anywhere else in Japan.

The following points help to illustrate further the outstanding value of these gassho houses and villages, and to demonstrate why they deserve special attention for protection:

1. The Shirakawago and Gokavama areas were remote and isolated with very difficult access, surrounded by the steep mountains of the Chubu region. Until the 1950s relations between this area and the outside world were very limited.
2. Because of this isolation, the culture of the Shirakawago and Gokayama areas developed relatively independently from the surrounding region, confined to narrow valleys connected by the Sho river. The unique culture of the area was moulded on social Systems and lifestyle customs derived primarily from a single spiritual source, the Jodo Shinshu Sect of Buddhism.
3. The architectural Style of the gassho houses can be found only in these areas. When their numbers reached their peak, in the late 19th century, there were no more than 1860 of them, out of a total of 5.5 million farmhouses in Japan.

4. The number of gassho houses and villages has decreased nearly to the point of extinction, largely owing to the social changes resulting from Japan's rapid economic development after World War II.

5. The properties selected for this nomination are those where gassho houses survive in groups and the original village landscape survives intact, and also where protective measures have been taken in accordance with appropriate conservation laws and regulations.

The nominated properties meet the requirements of criteria (iv) and (v) of Article 24(a) of the Operational Guidelines for the Implementation of the World Heritage Convention (WHC/2/Revised February 1994).

The Central Part of the village is located on a terraced plateau on the east side of the Sho river. Only one household remains on the other side of the river. The layout of the village is dominated by the 6 m wide road running north-south through the centre, with a network of village roads, 2-4 m wide, spreading out from it. Whilst the route of the basic layout dates back to the EdO Period, the wide road was cut through in 1890 and is a Visual intrusion into the earlier village landscape. Most of the houses are on individual lots separated by cultivated plots of land, reflecting the traditional land-use. The lots are Small and irregular in shape. On the sloping land near the base of the mountain the houses are on terraces Supported by Stone retaining walls. Their boundaries are defined by roads, irrigation channels, or cultivated plots, not walls or hedges, and so the landscape is an open one. Most have ancillary Structures such as toilet buildings, Wooden-Walled storehouses, and grain-drying shelters, which are usually located (with the exception of the toilet buildings) well away from the dwelling houses, to minimize fire risk. The house lots are surrounded by irrigated rice fields and city-crop fields, also small and irregular in shape. In the past the latter were used for growing mulberry trees, for sericulture, but they are now given over to the production of vegetables. The rice fields are fed by means Of a network of channels. There are larger cultivated plots on the outskirts of the village, to the south and north. The designated Group of Historic Buildings is composed of 117 houses and seven other structures. Of these, sixth are in the gassho Style, most built during the 19th century (the last new gassho house was built at the beginning of the present century. They are all aligned parallel to the Sho river, giving a very harmonious and impressive landscape. The majority have three rooms tone large and two small), in addition to an earthen-floored space, but there are also some four-room houses. For the most part they are entered through doors on one of the long sides. In addition to the pure gassho houses, there is one which has been modified with the addition of a second storey. Seven houses are post-and-beam structures with rafter-framed roofs, built in the Present century and with an overall resemblance to the gassho style. The ancillary buildings have wooden walls and thatched gable roofs, resembling the gassho houses. The Village has two Buddhist temples, Myozen-ji and Honkaku-ji. The guardian deity of the village is housed in the Shinto shrine, Hachiman Jinja, situated at the base of the mountain and surrounded by a cedar grove.

This village, which was the site of the most intensive sericultural operations until 1950, is similarly located on a tested Plateau above the Sho river. Its layout is focused on the old main road, which rises gently with winding Village roads branching off from it. However, a wide road for vehicles was cut through the Centre of the village in 1958, disrupting its landscape. The houses and plots are broadly identical in form and size with those at Ogimachi. The Group of Historic Buildings includes twenty gassho style houses, most with a four room square layout. A Significant difference is the fact that the entrances are usually at one of the gabled ends, by means of a porch with lean-to roof. There are five gassho houses converted into two storey buildings in the present century and seven 20th century reproductions in post and beam form. The guardian deity of the village is housed in the Jinushi Jinja Shinto shrine, and the Buddhist Centre is the Shonen-ji temple of the Jodo Shinshu Sect.

The site of Suganuma is similar to those of Ogimachi and Ainokura, on a terrace overlooking the Sho river, but it is much smaller, with only eight households and a population of forty people. Nine gassho houses survive, the most recent built as late as 1929. They resemble those Of Ainokura rather than Ogimachi.

4 Management and Protection Legal status

Ownership of the individual buildings in the three villages is diverse, including the Government of Japan (Ministry Of Construction), the Prefectural and District Authorities, the Japan National Trust, agricultural cooperatives, religious bodies and individual owners. Each of the three Villages is a Preservation District for groups Of Historic Buildings, as defined in Article 2 of the 1950 Law for the Protection of Cultural Properties. This designation requires, inter alia, the preparation of preservation plans for protection, restrictions on activities that may alter the existing appearance of the Preservation District and authorization procedures, and the provision of subsidies for approved actions. Ogimachi has been raised to the status of Important Preservation District for Groups of Historic Buildings, and the elevation of Ainokuta and Suganuma to this status is currently under discussion. These two villages were previously designated Historic Sites Under the provisions of Article 69 of the 1950 Law, which lays certain obligations concerning maintenance upon property owners. Overall responsibility for the preservation of the three villages rests with the national Agency for Cultural Affairs in Tokyo. The associated bodies are the Council for the Protection of cultural Properties and its Committee of Experts (for matters related to the 1950 Law), the Environment Agency (for matters concerning the Natural Park Law), the Ministry of Agriculture, Forestry and Fishery/Agricultural Land Law and Law on the Establishment of Agricultural Promotion Areas), the Forestry Agency (Forestry Law), the Ministry Of Construction (River Law), Gifu Prefecture, Gifu Prefecture Board Of Education, Toyama Prefecture, Toyama Prefectural Board Of Education, Shirakawa-Mura (District), Taita-Mura, and Kamitaira-Mura.

Direct management of individual buildings is the responsibility of their owners, and all work is supervised as prescribed in the very comprehensive Preservation Plans. However, there are subsidies available from local and central government for major projects. In all three villages the main irrigation channels, trees, and associated areas of forest are listed as Environmental Features in the Preservation Plans. Here similar constraints apply as for the buildings. The Agricultural Land Law strictly controls any change of use of agricultural land. There are double buffer zones around each of the villages. At Ogimachi the area immediately surrounding the village is designated as a Historic Cultural Landscape Protection District, and this constitutes the first buffer zone; the Second is an extended area that is controlled by the same regulations, the Shirakawa-Mura Regulations related to the Control of the Natural Environment. The Gokavama Prefectural Natural Park, designated in accordance with the Toyama Prefectural Natural Parks Regulations, provides the inner buffer zone for both Ainokura and Suganuma. Outside there are further protected areas, under local regulations. The effect of all these regulations, which impose considerable constraints on any kind of activity that might be deemed harmful, is to provide very effective control over the setting and environment of all three villages.

The lifestyle of the villages in the Shirakawa-go/Gokavama area, which had hitherto developed slowly but steadily over several centuries, underwent radical changes during the period of economic change between 1950and 1975. There was considerable depopulation as inhabitants moved to the cities, and many traditional gassho houses were demolished, to make wav for modern replacements. Of the 94 villages with gassho houses recorded at the end of the 19th Century, Only 25 survive to the present day, and the total number of houses has been reduced from some 1800 to 148.

The National Commission for the Protection of Cultural Properties (now the Agency for Cultural Affairs) initiated scientific research on these houses in the 1950s, with the result that five were designated Important Cultural Properties. The concept of preserving entire villages began at Ainokura and Suganuma, both of which 45 were designated National Historic Sites in 1970. As a result any demolition, relocation, or non-historic remodeling of gaSShO houses is prohibited (restrictions accepted by all the residents). Presentation of Ogimachi village was initiated by the residents themselves. They formed the Association for the Protection of the Historic village Landscape in Shirakawa-go Ogimachi village in 1971 which, with the establishment of the Village Residents' Charter in the same year, created a movement to preserve the whole village -not Only the houses but also the fields, irrigation channels, roads, and forests. Routine repair work has always been carried out by the owners, and in some cases by collaborative efforts be groups Organized within the kumi, using traditional techniques and materials. Most of this involves replacement of thatched roofs, though in some cases deterioration has necessitated major conservation work involving total or partial dismantling, following the long-established Japanese practices and principles. In such cases the services of an experienced conservation architect are used to ensure historical authenticity. Fire is a major hazard for thatched buildings, and elaborate fire-extinguishing systems have been installed in all three villages. Fire-fighting squads have also been organized among the residents.

The level of authenticity of all three villages is high. The authenticity of place is total: the sites of the three settlements are important historical evidence in themselves. Authenticity of function is also high: the traditional farming lifestyle persists unchanged (apart from the introduction of appropriate mechanized equipment) and there is a strong sense of community. A certain element of presentation has been introduced to satisfy the increasing numbers of visitors, but the kitsch element that disfigures so many traditional settlements elsewhere in the world is absent, and is likely to remain so. The authenticity of materials and techniques is equally high, in conformity with the respect shown to historic buildings by Japanese conservators in their Work: the same standard & are applied t0 these Vernacular buildings as to the temples of Horyu-ji or Kyoto.

The three villages that make UP the nomination are very well presented and protected examples of traditional settlements of Vernacular buildings. Ogimachi is the largest of the three and in some ways the most impressive. The Village fabric of each has been disturbed to some extent by the intrusion of through roads for vehicular traffic, that at OgimaChi in 1890 and the other two in 1958; however, the network of lanes winding between house plots and small fields interlaced with the irrigation channels is largely intact and so the Overall appearance is not seriously impaired. It is of considerable significance that the social structure of these villages, of which their layouts are the material manifestation, has survived despite the drastic economic changes in Japan since 1950. As a result they preserve both the Spiritual and the material evidence of their long history.

The nomination dossier is specific on this point: this group of villages is unique in Japan, where the gassho-style house lies outside the vernacular farmhouse tradition. In view of the isolation of Japan from external influence for over the three hundred years when this specialized type of farmhouse evolved, it is justifiable to assume that these villages are unique at a regional level. IKOMOS recommend actions for future action There is a plan to construct a new four-lane national highway, the Tokai Hokuriku Jidosha-Do, over 185 km between Ovabe Gin/ and lchinomiva City. A section of this will pass 500 m west of Ogimachi. The statutory environmental impact assessment Carried Out in respect Of this project judged the most serious impact to be on the scenic landscape of the Ogimachi area. It is planned to plant trees to act as screens, and the design of bridges will be carefully controlled so as to protect the landscape. It is proposed therefore that the Japanese authorities be requested to carry out a further review of this Project, and in Particular of the mitigating action that is proposed, in the form of a detailed landscape survey, so as to ensure the minimum impact on the Ogimachi landscape, which is an integral element of the nomination.

That this property be inscribed on the World Heritage List on the basis of criteria (iv) and (v): The historic villages Of Shirakawa-go and Gokayama are outstanding examples Of traditional human Settlements that are perfectly adapted t0 their environment and their social and economic raison d'etre. They have adapted successfully to the profound economic changes in Japan in the past half-century, but their survival can only be assured by constant vigilance on the part of both government authorities and the inhabitants themselves (Fig. 5. 5.).

5.5. Case Study 4: Uttarakhand Paryavaran Shiksha Kendra, Uttaranchal

This renovation was carried out by Ar. A. K. Joshi for Uttarakhand Seva Nidhi in July 1995 at a cost of Rs. 900,000. A three storeyed house of the early 1890s, in the

Jakhan Devi locality of Almora was restored as the office of Uttarakhand Paryavaran Shiksha Kendra, for the Uttarakhand Sewa Nidhi, a public charitable trust begun in 1967, for environmental conservation and rural development.

The building remained in a state of extreme despair, closed for nearly three decades till acquired by the Uttarakhand Sewa Nidhi. There were several options from total demolition to reconstruction. Finally Ar. A. K. Joshi decided to restore the building to Adaptive Reuse through nominal structural intervention, reviving old elements and adapting to modern needs, also appropriately reflecting the basic philosophy and concern of the Uttarakhand Sewa Nidhi.

Internal spaces were functionally retained as original, housing the conference chamber, office rooms, executive chambers, seminar, classrooms, lounge. Three main modifications done were the external walls, the structural system and the roof. Local masons and carpenters, experienced with the traditional construction and structural methods were entrusted with the woodwork and masonry, using indigenous stone and wood to replace and replenish the building materials. Carved wood friezes and decorative motifs on the outside walls were repaired, and where required replicated in original form and style. Special treatment was given to the intricately carved wood framework of the Kholi, the traditional main entrance projecting approximately 60 cm from the front wall. The windows on each floor were retained in original, except where hinged leaves needed substitution by fixed single pane frames. The Chakh, the traditional rectangular landing platform immediately behind the Kholi was also retained. The original ash plastered stone wall structural system distributed the load of upper structure through the cross beams resting on them. The tradition stone flooring pattern on the ground, and the rammed mud floors on a wooden framework on the upper storey were retained. In some rooms the plaster over the walls and fireplaces was scrapped and the underlying stonework repaired and facelifted.

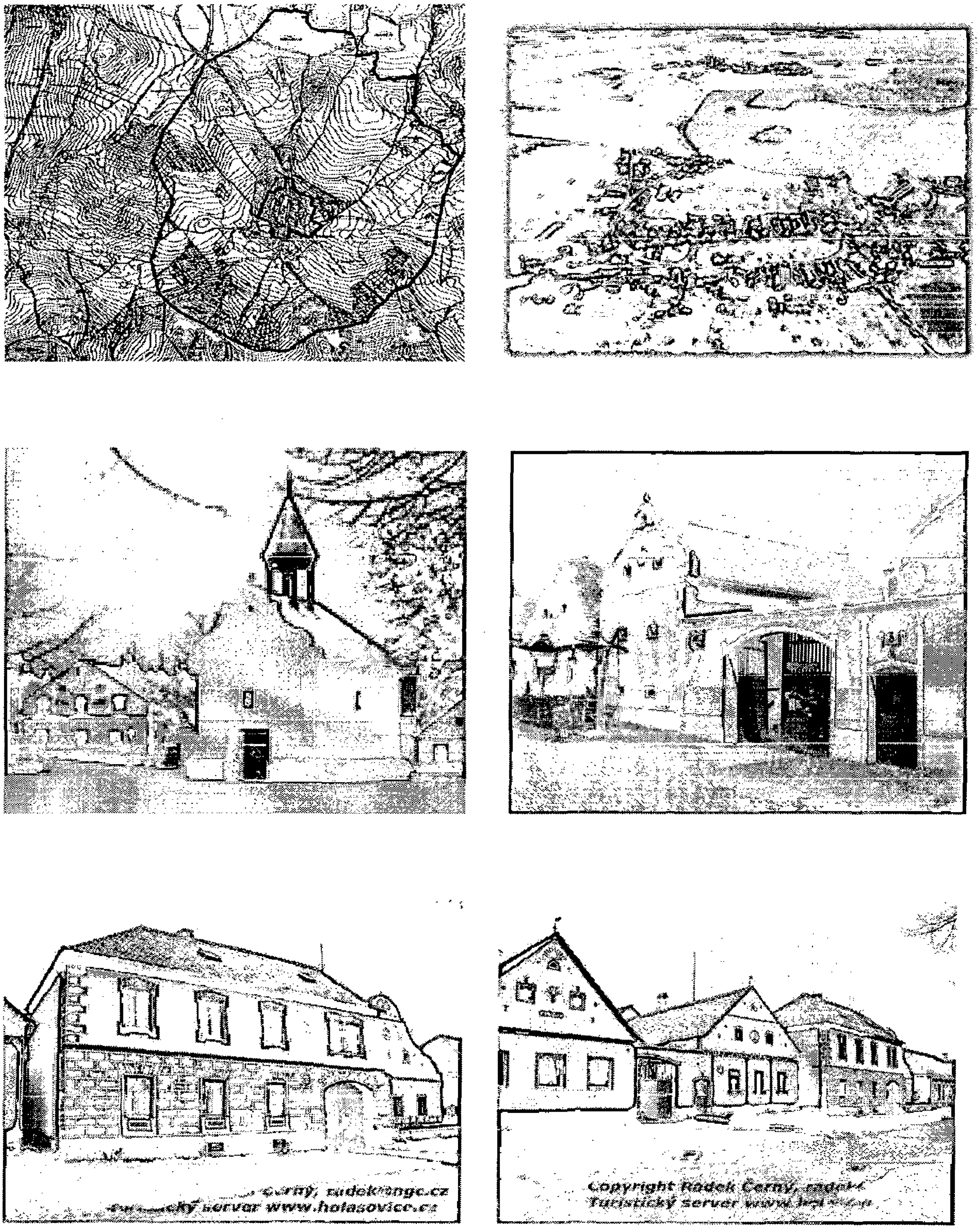


Fig. 5.1. Case Study 1: Holašovice Historical Village Reservation, Czech Republic

Fig. 5.2. Case Study 1: Holašovice Historical Village Reservation, Czech Republic

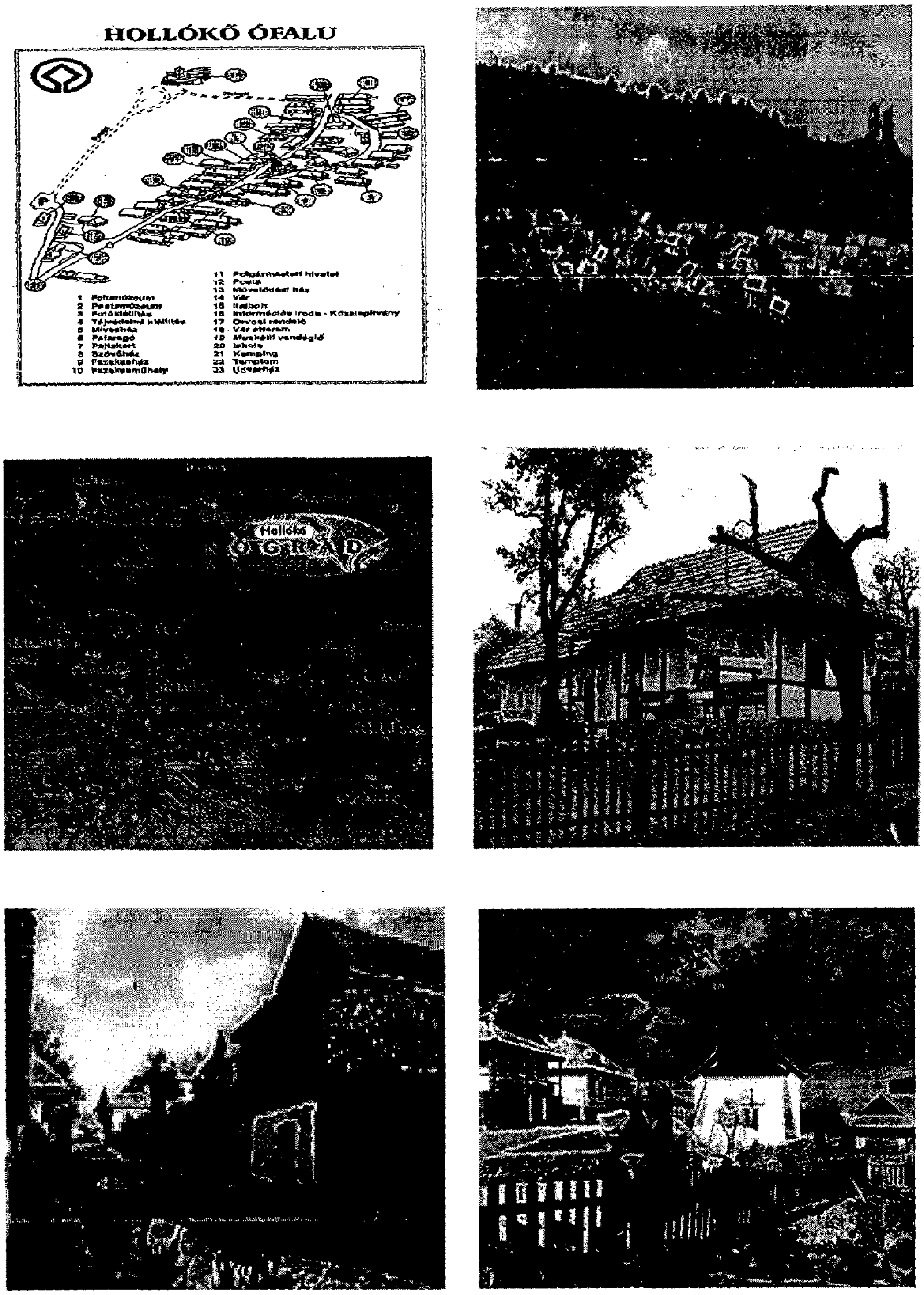


Fig. 5.3. Case Study 2: Old Village of Hollókö and Its Surroundings, Hungary

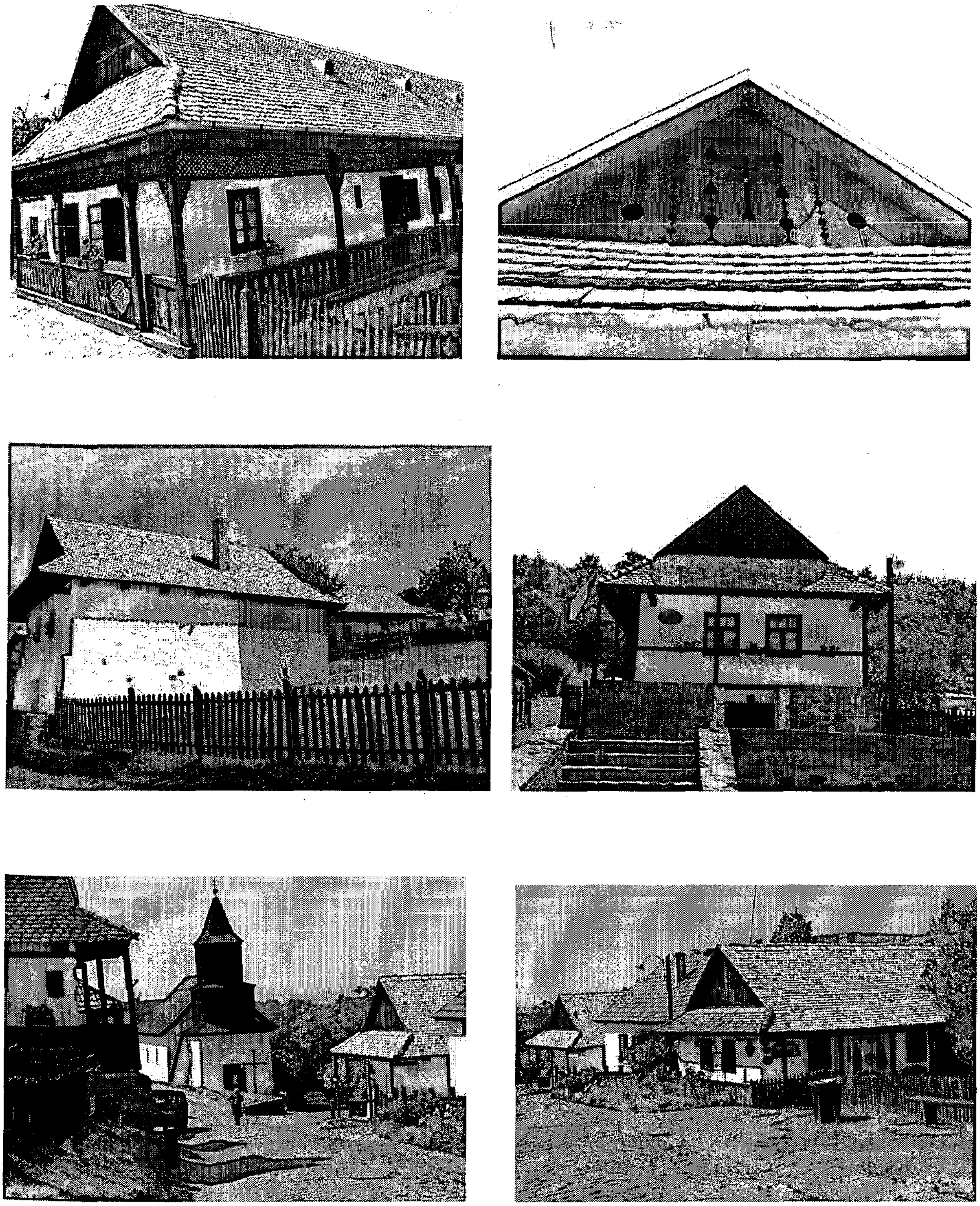


Fig. 5.4. Case Study 2: Old Village of Hollókö and Its Surroundings, Hungary

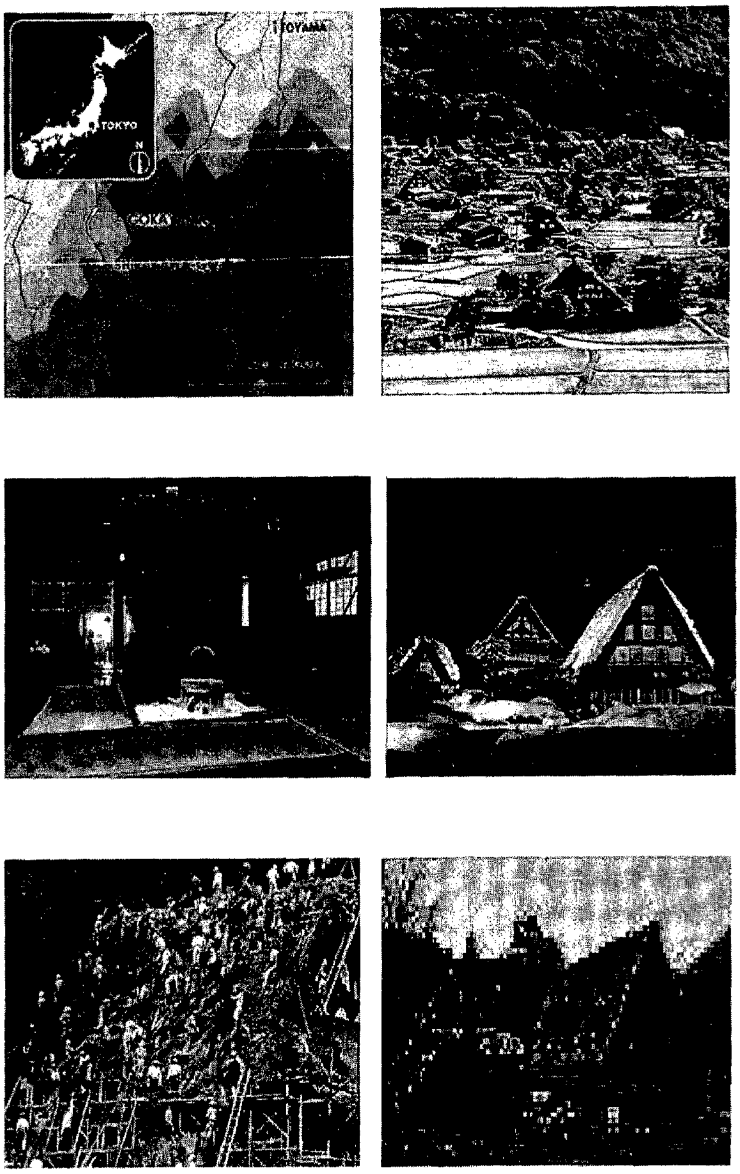
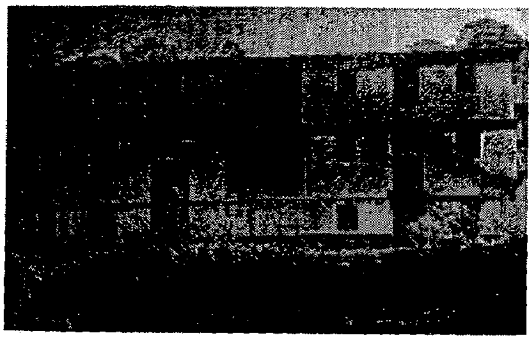
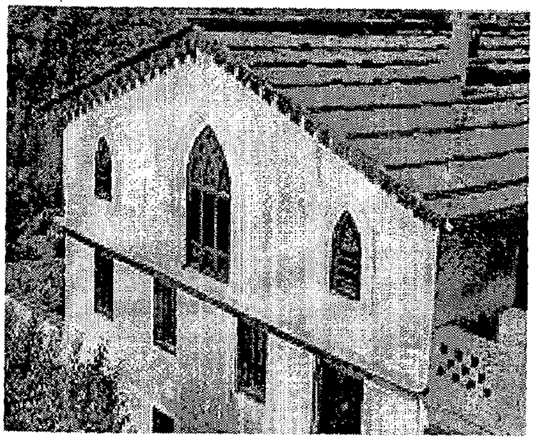
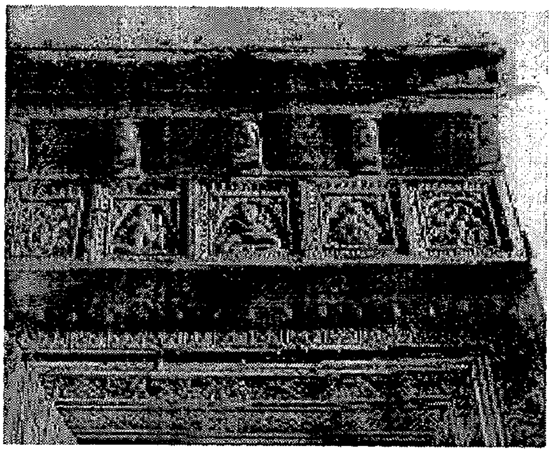
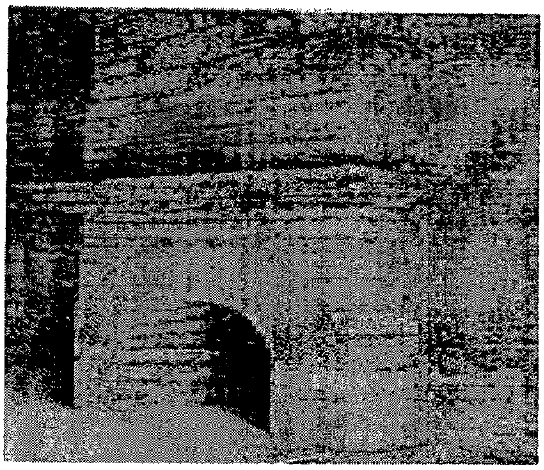


Fig. 5.5. Case Study 3: Historic Villages of Shirakawa-Go and Gokayama, Japan

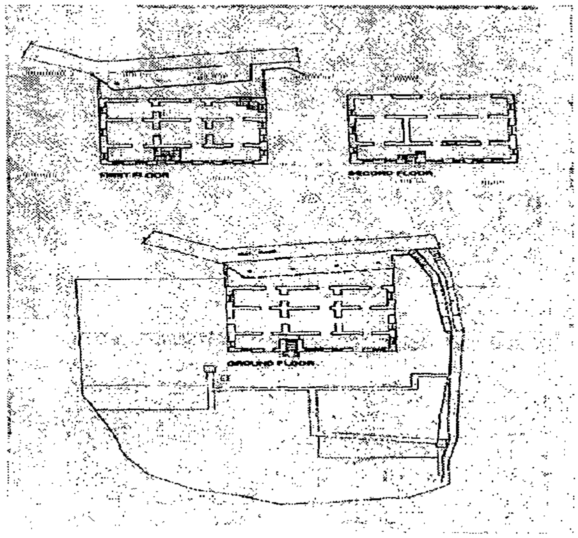
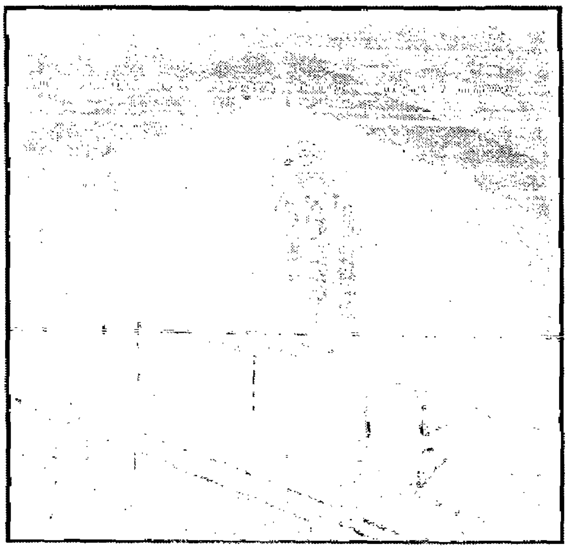








5.6. Case Study 4: Uttarakhand Paryavaran Shiksha Kendra, Uttaranchal

5.7. Case Study 4: Uttarakhand Paryavaran Shiksha Kendra, Uttaranchal

5.6. Summary

An overview of these examples of vernacular architecture involve the Holašovice Historical Village Reservation, Czech Republic; Old Village of Hollókö and its Surroundings, Hungary and the Historic Villages of Shirakawa-go and Gokayama, Japan and our local example is taken from Almora, the study area itself, gives way to the study of our research area, the hill town of Almora in context of Adaptive reuse dealt in the forthcoming chapter.

6.1. Introduction

Physical and culture diversity within the Himalyan range has resulted in varied vernacular architecture of different regions in Laddakh, Kashmir, Himachal, Garhwal, Kumaon, Assam and Arunachal. Kumaun Himalayan region of North India, bounded by Nepal on the east and Garhwal Himalayas on the west, has a unique geographic location between the plateau of Tibet on the north and Gangetic plains on the south. The physiographic, bio geographic and climatic transition from western to central Himalayas and from Indo Gangetic plains to Tibetan terrain is reflected in a discernible existence of a variety of Indian, Tibetan and Nepalese symbols and elements among its inhabitants and local Architecture. Kumaun hill region, though inhabited since pre historic times and visited by pilgrims since time immemorial, had been very sparsely populated till nineteenth century. The population of Kumaun, including that of its capital was predominantly agrarian till nineteenth century, though trade with Tibet started since early historic period. Carpentry and other crafts also developed with the flourishing of trade with Tibet during the Chand period, carpentry and other crafts also developed, which is evident in the intricate wooden craftsmanship found in the buildings constructed during the period. Examples of the traditional vernacular Architecture are found all over the region, in urban as well as rural areas, with the finest examples being concentrated in and around the historically important towns, namely, Almora, Champawat, Dwarahat and Bageshwar. Interestingly, even in the colonial hill settlements the market cum residential areas for the Indians were developed on the pattern of traditional Indian towns though the residential buildings for the Europeans and the public buildings were built in colonial Architectural style.

In response to the generic forces of a hill environment, the culture and micro climatic and physiographic contexts within the Kumaon Himalayas have resulted in a distinct domestic Vernacular Architecture of Almora, the historical capital of the region. The surface topography and hydrology have governed the landuse, settlement patterns, street patterns, location of kholas (the residential neighbourhoods), siting and layout, orientation and spatial organization of building clusters. Almora is relevant as an example of vernacular architecture because people here lived together within the embrace of an administrative and social system that continued for centuries. The physical structure of the town is a manifestation of the socio economic interdependence and hierarchical nature of a traditional society, planned in conformity with natural environmental forces, such as, location of natural water sources (springs), most essential aspect for physical locations on the crest of the hills. Architecture relates well to its visual context and possesses a common identity, as most of the social clusters, irrespective of caste, community and economic levels, have same design and configuration of spaces.

6.2. Origin & Development of Almora Town

Almora, a historical place, depicts the typical vernacular architecture of Kumaon hill region of which it was a capital and has remained a main town for more than three centuries since early 16th century, when the capital of Kumaon was shifted here from Champawat. In 9th century Katyuri king made the royal fort "Khagmarakot" (meaning the place where the bird was killed) on the right bank of river Suyal in Almora, as this area was full of natural water resources and forest, hence more suited for hunting rather than agriculture. On the basis of certain available limited historical records, local legends and folk songs, we tried to focus on the origin and development of Almora town. In the earlier stages of development, i.e. in the middle of sixteenth century the town was ruled by the Chands and followed by Gurkhas. After that in the early 19th century Kumaun as a whole became a part of the British Empire. Finally, the town developed rapidly in post-independence period. Keeping in view the different administrative set-ups of Almora town, the developmental history of the study town has been divided into the following four periods, which have been well recognized by historians.

A. The Chand Period (1563A.D.-1790A.D.)

B. The Gurkhas Period (1790A.D.-1815 A.D.)

C. The British Period (1815 A.D.-1947 A.D.)

D. Post Independence Period (after 1947 A.D.)

Chand Period

It appears through the historical records that the original settlement of the town was village 'Khasiyakhola' which was located on the north-eastern slope of the ridge. The main work of the inhabitants of this village was to clean the utensils of the temple of Baraditya or Viradhaditya Sun Temple which is located at Katarmal about 12 km from that village. This temple was built by Katarmal, a king of Katyuris dynasties. It is one of the most important sun temples of ancient India and has been noted for its architecture, stone and metallic sculptures, characteristic images of the lord Sun and beautifully and elaborately carved wooden pillars and doors etc. The village was famous for sorrel grass which was known as Chalmora (Rumex histatus). The grass was used at Katarmal temple for cleaning the utensils of the temple. The name Almora was derived from that wild sorrel grass. It is believed that Katarmal temple was built before 14th century A.D. and at that time the area was under Katyuri kingdom. Besides the village Khasiyakhola, the saddle shaped ridge was densely covered with forest till 1563 A.D. and some small temples were there on the south-eastern and north-western slopes. Before 1563 A.D., the capital of Chand's kingdom was at Champawat, Raja (king) Bhishma Chand realized that Champawat was situated in the corner of his vast kingdom in Kumaun. He therefore, selected the ridge of Almora for construction of a fort named 'Khagarakote' on the south-east slope of that ridge (Fig. 6.1.).

At that time, the king named the town as 'Alamnagar' but in records the name is mentioned as 'Rajapur'. After the period of king Bhisma Chand another story is popular regarding the origin of the town. It is said that once when Balo Kalyan Chand was hunting in the forests around the Khagmara hill, a hare appeared before him. Followed by the king it reached the top of the hill, assumed the form of a tiger and disappeared. The Raja consulted his diviners about the occurrence and was told that his enemies would find that they had tigers to deal with during war. He was advised to establish his capital on the hill where the tiger had vanished (District Gazetteer Almora, 1981). This was the reported time of origin of present Almora town when Raja Balokalyan Chand built a fort named as 'Lal Mandi' and he also built a market near the old 'Nial-Pokhar' which is presently known as 'Paltan Bazar'. For the purpose of development, the king selected four corners of the area i.e. Dyolikhan, Tyarikhan, Sitolikhan and Chinakhan. The area in between these corners became the center for the administrative and cultural activities of that time.

During the Chand Regime till 1790 A.D., Almora had reached a remarkable level of development. In their regime four main nuclei came into existence i.e. king Balokalayan Chand developed two places around the 'Lal Mandi' fort and Khasiyakhola village (Upretikhola of present days) and king Rudra Chand (1568 A.D.-1597 A.D.) developed the 'Malla Mahal' in 1590 A.D. alongwith a temple and a open pit type spring (naula). In this way till 1590 A.D., four main centers were developed in the form of two forts (Lal Mandi and Malla-Mahal) and two muhallas the Khasiyakhola and Synerakote, in different parts of the ridge of the hill. Among these four sites the Malla-Mahal site got enlarged in size with the addition of several functional and office-buildings. At the same time they gave much emphasis on agriculture and horticulture in the area. The elder brother of the king, Shakti Gunsai (1577 A.D.-1621 A.D.) encouraged agriculture and horticulture in the region. Due to this several places were brought under settlements and orchards (locally known as 'Bari'). At present, there are many localities (muhallas) which are named after Bari like, Narsing Bari, Bari Pandekhola, Bari Kapina etc. He constructed each of these orchards with a temple and a naula (spring) for supply of drinking water. King Bajbahadur Chand (1638 A.D.-1679 A.D.) preferred to develop settlements on the western slope of the ridge and named the localities as Jhijihar, Selakhola and Galli mohalla. These names were based on the original names of the villages of its inhabitants. The period of king Bajbahadur Chand is famous for construction of many buildings, temples and naula in different parts of the present town. In the history of Almora town a new area was developed in 1660 A.D. when king Narayan Tewari, the God brother of king Bajbahadur Chand constructed a temple of Lord Mahadeva to the north-east of Hiradungnri which is a part of present Almora town.

Like his predecessors, king Udyat Chand (1678 A.D.-1698 A.D.) played a significant role in the development of Almora town and constructed several temples and naula in different parts of the present town. He built the Talla Mahal in 1668 A.D., presently used as female hospital, Rang-Mahal of Deori in 1692 A.D., temple of Lord Vishnu, the Tripura Sundari temple, Parwateshwar temple (all within the Nanda Devi temple campus), Shai-Bhairab temple, the Sidha Narsing temple and the Sidha Naula near the Paltan Bazar of present days. King Deep Chand (1743 A.D.-1777 A.D.) built the temple of Patal Devi and a Dharmshala. King Mohan Chand (1786 A.D.-1788 A.D.), the last king of the Chand dynasty constructed the Bhairab temple in the town (Pande, 1936). During the period of Chands, the town experienced a variety of changes in terms of settlements, evolution and distribution. The period of Chand rulers is well recognized for the construction of religious buildings particularly temples which have been reconstructed or renovated in recent years. In that period various new sites were introduced for settlements and most of them were along the temple and naulas.

Gurkha Period

In 1790, the Chand empire declined and the Gurkha dynasty came into power. Gurkhas came from Nepal and occupied all forts of the previous rulers of Chand dynasty. The period of Gurkhas is known as the 'dark period' in the history of the region due to their destructive activities. As far as their contribution in the development of Almora town is concerned, it can be mentioned here that they did not carry out any developmental activities in this town. The population of the town decreased during that period and the town suffered much at the hands of the Gurkhas.

British Period

The British rule came into effect in the district with the 'Sigauli Peace Agreement' between Gurkha rulers and Britishers in 1815 A.D. British rulers also established their administrative headquarter at Almora. They developed new pathways and roads and also built European type buildings on both sides of the ridge. The Britishers mostly settled on the Hiradungari slope due to good climatic conditions (Fig. 6.2.). The main attraction of that site was the view of the snow clad Himalayan ranges which are clearly visible from there. A new campus was developed which was known as 'Mission Compound'. They established a Church with a clock tower and a jail in the same area. The Britishers used the Malla-Mahal area for residential bungalows and the courts after some modifications, whereas, the Talla-Mahal was kept for hospitals and Schools. They also modified and utilized the older constructions for administrative, military, residential, medical and educational purposes. Britishers always gave emphasis on child education and started a college known as Ramsey College on July 28, 1851 A.D. After some time due to growing number of students, they started Government Inter College in 1899 A.D. on the north-western slope. After that a town school was built in 1907 A.D. The Normal School and Adams School (near the Church) were developed later during the British period. At that time, the town was famous as an apex education center in the Kumaun region.

Due to the availability of good educational facilities, and employment opportunities, the town attracted more people to settle here. This resulted in construction of more number of residential buildings and in the expansion of market facilities in the town. Britishers introduced new services and amenities in the town and established a municipal board in the town in 1864 A.D. and municipal library-cum-reading room in 1870 A.D. Almora District Hospital, Post Office and T.B. Hospital were established in 1907 A.D. and Kundan memorial hall was built in 1934 A.D. At that point of time the district became an important center for trade between Tibet in the north and the plains of northern India in the south.

Till the Gurkha period Almora was connected to nearby areas by a footpath. When Britishers came to power, they constructed many motorable roads for better administrative control. Firstly, Almora was connected with Ranikhet (1873 A.D.) by a cart road, and with Nainital via Ramgarh by a bridle path. The first vehicle was brought to this town in 1920 A.D. After that, Hill Motor Transport Company, Kumaun Motor Transport Co., Nainital Motor Transport Co., Messrs. Narayan Das Hans Raj Transport Co. etc. started serving the town with regular motor services. Water being one of the basic needs for development, it was also provided to local people through better water management by the Britishers. Natural springs (Naula) were the main source of water for drinking and household purposes till 1884 A.D. In the year 1884 A.D., Almora town was provided with water supply through pipe lines from Shail village and in 1932 A.D. gravity water supply scheme from Shyahi Devi hill was commissioned. These facilities gave birth to new settlements in different parts of the town. The town was sub divided into four wards i.e. Murli Manohar, Ram Shila, Baleshwar and Nanda Devi, for better management.

Post Independence Period

The town has experienced remarkable growth and change as the country became independent (after 1947 A.D.). During these years, the town has considerably developed in terms of its area. Origin of new localities, construction of footpaths & roads, establishment of educational and technical institutions, setting up of different administrative offices, schemes of electrification and water supply and provision of post and telecommunication networks are the important features of development in this period (Fig. 6.3.). This has completely changed the morphology of the town and due to all these amenities and facilities, immigrants were attracted from surrounding villages. The market has been extended from Paltan Bazar to Nanda Devi temple on the saddle shaped hill in linear shape. The ground floor of the houses are used as shops and the upper stories are mostly utilized for residential purposes. It has become a center for supply of specific materials to several villages. The purely residential areas are generally located in the outer parts of the central town. The outer part of the town which was uninhabited in the past and was generally used for agricultural purposes, has gradually attracted settlements. Road network played a significant role in the development of this town. After the introduction of Almora Khairna road, lower mall road, Almora Paudhar road, Almora Chaittey road and the Ranidhara road, expansion of settlements took place along these roads at a phenomenal rate. Presently, the town is administered under 15 wards and 76 Muhallas. Considering the available geographical area in these wards about 14 percent increase in the built up area is possible. Range of expansion of built up area under each ward is also presented. (Fig. 6.4.) It can be concluded here that the morphology of Almora town has changed considerably with the upheavals of time. In the process of town building the environmental factors were completely neglected in tie recent past. In the present time, the town has several environmental problems which call for a sound development plan and its proper implementation to overcome these problems and to give a better and healthy environment to its inhabitants.

6.3. Physical Environment Of The Area

It is of prime importance to discuss the physical environment of any area before conducting any Environmental Impact Assessment (EIA) study. In this chapter the spatio physical attributes which have an influence on the growth and development of Almora town are analyzed and discussed.

The Area

The hill town of Almora is situated at 29°37'3"N latitude and 74°40'20"E longitude at a height of 1 646m above mean sea level in Kumaun region in the state of Uttaranchal at a distance of 65km from Nainital and 378km from Delhi. Almora town, the headquarters of Almora district is situated at a magnificent location (latitude 29°37'3" N and longitude 79°40'20" E) over a saddle shaped ridge of 6 km in length running from north east to south west (Fig. 6.5.). The town is spread over an area of 9.03 km2 including the cantonment area, which has been considered as a part of Almora town for the purpose of this study. This town is connected by metalled road with Kathgodam (the nearest railway station at about 90 km) and with a number of famous tourist centers of this region, namely Nainital (65 km), Ranikhet (48 km), Kausani (49 km) and Pithoragarh (about 120 km). Due to to its historical, physical and cultural identity the town is the core of Kumaon Himalaya.

In the medieval period this town was ruled by the Chands and Gorkhas and during the early 19th century Kumaon as a whole became a part of the British Empire. However, the town experienced the rhythm of freedom with national movement and breathed its independence with republic of India. At present the town is administrated under two local bodies, i.e. Almora Municipal Board (M.B.) and Almora Cantonment (Cant.). Almoora Municipaj Board is divided into 15 wards which are further subdivided into 76 localities (Mohalla) and Almora Cant, is administrated under twcf localities. Boundaries of these units are shown in Fig. 6.6.

Relief & Slope

Almora town is located on a saddle shaped ridge and its elevation varies from about 1500 m to 1800 rn above mean sea level (Fig. 6.7). The surrounding ridges Simtola (1877 m) and Kalmatia (1945 m) form a col known as Mount Brown which in the present time is known as Hiradungari (1684 m). The name Hiradungri is originated from the micaceous rock which shines like a diamond (Hira) in the morning sun (Atkinson, 1989). Another ridge known as Sitoli runs westward from Hiradungari to Salidhar and is situated in the north of the Almora town. The average slope of this town ranges from 5 degree to 35 degree (Fig. 6.8.).

The lower value of average slope is found on the ridge. The top of the ridge is crowded with houses from Paltan Bazar to Nanda Devi Temple. The slope gradually increases towards the west and east directions. Almora is located on the mountain ridge running NE SW and on the Eastern & Western slopes, having excellent panoramic views and pleasant climate.

Geology

The town falls in the lesser Himalayan zone of Kumaun Himalaya. Several attempts have been made to characterize the geological environment of this part of central Himalaya. After the pioneering work of Strachey (1857) and more recently by Valdiya (1979) and by Powar (1980) gave a detailed geology of this area. The geological features of the area are presence of Muscovite as dominant clay mineral in the soil. Geologically the town is located on the Almora Nappe of lesser Himalaya, which is delimited by the north and south Almora thrusts. The rocks are predominantly made up of crystalline rock group and granite rock group. The rocks of the area are mainly composed of quartzite, sandstone, mica granite, weathered muscovite schists; gneiss and chlorite etc.

Climate

In Almora town, temperature starts rising from February every year and reaches the highest values in May and June. In general, during the summer and rainy seasons (May to September) the temperature remains high. From mid September to November the temperature of the region is moderate whereas December to February are the coldest months of the year. The humidity is very high during rainy season (mid July to mid September) and during rest of the year it remains around just more than 45 percent.

Rainfall is maximum during monsoon season (July to September) and Almora receives about 75 percent of the total rains in this season. August is the month which receives maximum rainfall while in November and December the area receives negligible rainfall. In general, the main characteristics of the autumn and spring seasons are cloudless sky, transparent atmosphere, tranquil nights, heavy dew and great temperature variations. Pleasant nights and hot days are the principal characteristics of summer season in this town. General Climatology of the Town

The Meteorological Station

The station is located at Almora (latitude 29°37'3" and longitude. 79°40'20") within the premises of Vivekanand Parvatiya Krishi Anusandhan Shala (V.P.K.A.S.), a unit of Indian Council of Agricultural Research. Monthly averaged values were obtained from V.P.K.A.S.; these data were further analysed. For climatological calculations, data collected during the last fourteen years (1979-1992) have been considered.

Temperature Patterns

Under the present scope of work, monthly temperature data for 14 years were taken and average monthly temperatures (maximum, minimum & mean) were calculated. Himalayan ranges protect all regions located on its south from polar air masses. It is reported that under normal conditions, reduction in temperature with increase in altitude is 6.5°C per 1000 meters. Almora town is located at about 1640 m above mean sea level due to which it experiences moderately cold winters. The climate of the town can be discussed under three main seasons, i.e. winter (December to February), summer (April to June) and monsoon (July to September). Besides these three seasons, it has spring (March) and autumn (October & November) seasons also but of shorter durations. The surface temperature patterns of the town are, therefore, discussed only for the three main seasons of the year.

Average Monthly Mean Temperature

The monthly mean surface temperature data from year 1979 to 1992 was averaged for calculating this parameter.

Winter Season (December to February):

In Almora town, average mean monthly temperature in the winter season ranges from 9.40°C in Jan. to 10.83"C in December (Fig. 6.9). January is the coldest month of the year. Variations in mean temperature during winter months is well below 1.5°C which indicates uniformity of climate during the winter season in the area.

Summer Season (April to June):

The summer season in higher altitudes is really pleasant in comparison to hotter plains and foothills. Variations in the mean summer temperature ranging from 19.05°C in April to 23.19°C in June, is a clear indication of pleasant climate during that season. June is the hottest month of the year as in the other parts of north India. Variations in the mean temperatures are of the highest order (4.14"C) in comparison to all other seasons.

Monsoon Season (July to August/ September):

In Almora town, monsoon season starts in the month of July and ends in August to mid September. Average monthly mean temperature remains almost constant (22.25"C to 22.61°C). In September, air temperature generally remains same as in August but decreasing trend is quite visible (Fig. 6.9). Autumn and spring seasons in Almora town are of two and one month durations respectively and temperature variations during these two seasons are similar.

Average Monthly Maximum Temperature

The monthly maximum temperature of each month was averaged for a period of 14 years from 1979 to 1992; this is presented in Fig. 6.9. Discussion of seasonal variations of the maximum temperatures of Almora town is presented in following lines.

Winter Season (December to February):

During this season average monthly maximum temperature varies from 14.79°C in January to 16.58°C in December. Difference in maximum temperatures is 1.79°C which is very low. It indicates almost similar conditions during all the three months of the season.

Summer Season (April to June):

Summer temperatures in the Himalayan region, particularly in high altitude areas remain pleasant all through the season. The average maximum temperature of 28.27°C is observed in the month of June. The difference in temperatures during this season is

2.95°C. In the past 14 years, only on 3 occasions, the maximum monthly temperature of the town has exceeded 30°C.

Monsoon Season (July to August/September):

The maximum monthly temperature was nearly the same in this season. The variation was recorded as low as 0.27°C. In September, the temperature changes slightly towards lower values and a decreasing trend can be seen (Fig. 6.9).

In the autumn and spring seasons (October, November and March), maximum temperature varied between 20 and 25"C. There is a sharp decrease in temperature in November. Rains are generally over by October and this month is well known for its potential as a second tourist season of the year.

Average Monthly Minimum Temperature

In this region where cold climate dominates among all the seasons of the year, monthly average value for minimum temperature is very important.

Winter Season (December to February):

Minimum monthly temperature is a critical parameter for the winter season during which the nights are very cold. In January, the lowest temperature of 4.01°C was recorded. Slightly higher values were observed during December and February. The night temperature in the town was never found below 2.90°C in the past 14 years.

Summer Season (April to June):

Lower values for the minimum temperature are observed during night time. Summer nights in hilly areas are quite pleasant with monthly temperature changing from 12.78"C in April to 18.11°C in June. Range of variation is quite high (5.33"C) which indicates sharp increase in night temperature as the summer season progresses. This change was not observed in average maximum temperature for the same period. Micro meteorological conditions are responsible for these changes in minimum temperature to a great extent and this could be a possible reason for these different temperature patterns.

Monsoon Season (July to August/ September):

Night temperature in the monsoon season is generally found quite high due to cloudy conditions. Values of average night temperature of the town are recorded to be higher than for the night temperature during summer. In the months of July and August, night temperature were nearly equal (18.78 and 18.79°C, respectively) with nearly zero variation. In September, the night temperature has shown some decreasing trend. In autumn season, temperature changes in the night are quite high (12.00°C in October to 8.16"C in November) and this period can be mentioned as the transition period between monsoon and winter. Spring season (March) generally has moderate night temperature of 12.78"C.

Rainfall Patterns

Orographic precipitation is formed by topographic barriers to moving air masses. This form of precipitation governs the rainfall in the Himalayan region. Distribution of land and water influences the rainfall patterns of middle and higher altitudes to a great extent. Mountain barriers divert the concentration of precipitation on their windward side. This is mainly due to forced ascent of moist air masses on these slopes. Leeward slopes receive relatively low precipitation. The concept of 'normal rainfall' is a hypothetical one which is related to horizontal distribution and duration of rainfall. Sub-Himalayan regions more frequently receive above normal rainfall.

Seasonal Variations in Rainfall

In Almora town (altitude 1646 m above m.s.l.), the rainfall pattern is greatly influenced by south-west monsoon. The annual average rainfall in the town, for the past 14 years, is 1042.14 mm. In India, monsoonal variations are quite significant and mountain barriers have certain impact on the amount of rainfall in the rainy season. In Almora town, the months of July and August fall within the peak of rainy season and more than 40 percent of total annual rainfall occurs during these two months (Fig. 6.10.).

In Almora town, the variations in the rainfall pattern for different months of different years are found to be quite high and more than 10 percent variations are recorded for annual average. This indicates that the degree of dependability of rainfall at Almora town is not very high. The rainfall patterns of Almora town for the years 1991 and 1992 were studied. The number of days of rainfall in each month is plotted (Fig. 6.11.).

Total rainy days in 1991 and 1992 are 69 and 66 respectively. October is the only dry month in 1991 whereas in 1992 in April and December there was no rainfall in the town. Intensity of rainfall is defined as ratio of precipitation and time during which it fell.

In Almora town, the records of the past 14 years indicate that maximum rainfall intensity of 616 mm was recorded in 1988, in the months of July and August. Minimum rainfall intensity for 2 months was observed in October and November, 1986 as 1.4 mm. Records of average, maximum and minimum rainfall intensity in a year are shown in Fig. 6.12.

Variation of Relative Humidity

In Almora town, variation in the relative humidity was studied using monthly average of its values collected over a period of 14 years (1979 to 1992). As per the general trend, mid latitude mountains should have maximum relative humidity in summer but at Almora (Fig. 6.13.) the maximum values are observed in the month of August.

This is due to amount of excess water present in air masses during the monsoon period. The variation in the average monthly values of relative humidity is quite high at Almora town. January and May are found as the period of low humidity. Only for four months in a year, relative humidity exceeds 50 percent mark. In January, though the temperatures are quite low, minimum relative humidity values are recorded. This is due to dryness of winter season in this area. In May, high temperature and low rainfall are responsible for lower values of relative humidity. Less humid climate of Almora is responsible for evaporation at a greater rate from its water sources which in turn reduces total availability of fresh water for domestic needs. Analysis of climatological parameters of the town indicates that the summer season in the town is quite pleasant and in winter months, air temperatures were never found below zero degree centigrade in the last decade. In general, the town experiences moderate rainfall during eight to ten months in a year but the distribution of precipitation is uneven. It was observed that more than forty percent of total annual rainfall has occurred in two monsoon months (July and August). This rainfall has very little influence on the recharge of water perennial springs of the town; due to impermeable nature of urban land surfaces. In dry periods about six to eight months in a year), all these springs are used as supplementary source of water for domestic purposes.

Drainage

The drainage patterns of entire town can be characterized by many small seasonal streams flowing on eastern and western slopes. The town is situated on a hill top which is the origin of all the streams. The drainage system of the area is constituted by two major watersheds on both sides of the hill, viz. eastwards flowing streams and the westwards flowing streams. The western portion is drained by Jamthara Gad, which is the main stream of this watershed and after flowing about 3 km towards west it merges with river Kosi. The eastwards flowing streams are Malgaon stream, Khagmara stream, Sarsyon stream, Chinakhan stream and Palri Gad scream which join the river Suyal at different locations. These streams play a significant role in the distribution of natural springs (locally known as Naula); most of the natural springs are located along these streams (Fig. 6.14.). The drainage pattern is generally of Dendritic type. Geological structure, human settlements, micro-climatic conditions, difference rock types and its erosional history are the major controlling factors of the drainage patterns of the area.

Occurrence of Springs

The most remarkable feature of Almora, a rare occurrence in Himalayas, are a number of springs and their nearness to the crest of the hill. According to Batten, in 1844, there were more than 100 springs within 300' of the crest on either side of the crest and generally at 150' from the top. In Almora town all these characteristics exist which are responsible for the occurrence of a number of springs within the town boundary (Fig. 6.14.).

The geological formations of Almora group i.e. Garnetiferous mica schists interbedded with thin bends of quartzite and interbedded granitic gneiss and nonfoliated granitic rocks act as the barrier to the groundwater flow and it results into the origin of springs. Fractured mica schists covered with thin layers of top soil provide permeable recharge zone for groundwater. In addition to that, the town is located over a saddle ridge which is surrounded by a high hill on the northern side. This saddled shaped ridge and the hill act as recharge area for these springs. Any human activity in this area which can influence the surface characteristics will also affect the quality and quantity of groundwater. Development of the township over the ridge is one such activity which may influence the quality of spring water.

Vegetation

Altitudinal variations and landscape ecology reveal the natural floral habitats in the urban catchment and its surrounding areas. The sub tropical pine (Chir) and Deodar are found around the town. Due to extensive construction activities in the town area, vegetation is poorly represented. Throughout the area scattered tree species are found except a few patches of Pine (Ranidhara, Setoli, Pandey Khola, Karbala), and deodar

(Cant. area). The characteristic species found within the town area are Finns roxburghii (Chir), Quercus leucotrichophora (Banj), Toona ciliata (Toona), Cordia vestita, Ficus roxburghiana (Timal), F. religiosa (Pipal), F. palmata (Badu), Pistacia integerrima (Kakari), Bauhinia variegata (Kweral), Celtis tetrandia (Kharik), Grewia oppositifolia (Bhimal), Ehretia laevis (Khoda), E. acuminata; Embelica officinalis (Aomla), Cedrus deodara (deodar), Prunus cerasoides (Paya), Grevillea robusta, Robinia pseudo-acasia, Bombax ceiba (Semal), Populus nigra var. *italica*, Cupressus torulosa (Surai), Ricinus communis (Arandi) Dendrocalamus strictus (Bans), Butea frondosa, Berberis asiatica (Kirmora), Rubus ellipticus (Hisalu),Prinsepia utilis (Jhatalu), Pyracantha crenulata (Ghingaru); Urtica parviflora (Suin)etc. Among the fruit trees Prunus ceracifera (Padum), Citrus limon (Chook), C. aurantifolia (Kagji Nimbu), C. hystrix (Jamir), Punica granatum (Darim), Prunus persica (Aru), Mangifera indica (Aam) and Juglans regia (Akhrot) are characteristic species (Fig. 6.15.).

6.4. Demography

Study of human population is one of the most important aspects of Environmental Impact Assessment (EIA) studies, because man is an active factor who influences all the natural systems.

Population Growth

Almora was one of the most populous towns of the region having 8596 persons in 1901 A.D. It was the district headquarter even at that time. Now Almora town has a population of 28,051 persons (Census, 1991) which makes it as a Class III town and as per area considerations (8.03 sq. km), it also falls under Class in category of cities in the country. The total population of the town (Almora M.B. and Almora Cant.), as recorded in 1981 was 22,705 persons, which has increased by 23.55 percent during this decade (1981-91). Successive growth trend (1901 to 1991) of population has been given in Table 4.1. The town marked high growth rate (30.14%) during 1951-61 followed by 1961-71 and 1981-91, possibly due to the considerable increase and overall improvements in urban amenities after independence.

Table 6.1. further reveals that the growth rate was comparatively high in the past except in 1971-81 having only 8.74 percent growth rate. The period 1911-21 has shown a negative growth rate. In general the growth of population is controlled by two main factors, i.e. natural population increase and net immigration from rural areas. In case of

Almora town, net immigration from rural areas can be considered as an important factor. Being a district headquarters maximum facilities viz, educational, administrative offices, medical and other services are available in the town which have attracted immigrants from surrounding localities.

Distribution & Density

According to census report of 1991, total population of Almora town is 28,051 persons which is distributed in 76 localities (muhalla) and cantonment area. Similarly in Almora, the entire town population distribution has been directly influenced by the business activities. The central part (from Paltan Bazar to Lala Bazar of about 1 km in length) of the town is densely populated. This part of town has relatively homogeneous characteristics both with regards to human activities and geographical set up. This zone had better conditions for human habitation in the past. The outer side of town has low population density. Table 6.2 reveals that since 1951 A.D. to 1991 A.D. the population density increased from 1585 persons/ km2 to 3485 persons/ km2 whereas the number of residential houses and households both increased by nearly three times. A successive growth trend of the residential houses, households and population density (1951-1991) is given in Table 6.2.

Literacy

Education plays a significant role in the implementation of any development plan. The technological progress and improvement in quality of life can only be achieved through education. Almora town has been famous for educational facilities from the British times. In 1951 the literacy percentage was 62.51 which has increased in 1991 to 77.09 percent. It is much more in comparison to the state and national average. Here, it is noticeable that the percentages of literacy and education among the males and females have not shown much difference. Male literacy level is reported as 80.14 percent and literate females are 73.16 percent (Table 6.3.).

Table 6.3. further reveals that there is a continuous increasing trend in literacy level of females. This is possibly due to the urban environment and increased number of educational institutions (there are three Inter colleges and one degree college for women) in the town.

Occupational Structure

According to census report of 1991, the total workers in the town were 9294 persons which constitute about 33.13 percent of the total population. Decade wise (1961-1991) percentage of workers (percent of total population, percent of male and female to the total male and total female and percent of male and female to the total workers) is given in Table 6.4. In Almora town, most of the working population is engaged in secondary and tertiary activities. It is a district headquarter, therefore, all the administrative offices are located and the administrative nature of the township is reflected in the occupational structure. Thus, the other services category of the workers is the most important sector for employment. There is very low industrial activity the town and workers in the trade and commerce category is next to other services. The population of workers (total, male and female) is given in Table 6.5.

In this table, a comparison for the period between 1961 and 1991 has been presented. In case of female workers in the year 1961, cultivators (47.99%) were the highest, whereas in the year 1991 the highest percentage of workers were engaged in other services (mainly in the educational sector and different offices). This low percent of cultivators in 1991 is mainly due to the fact that the cultivators sold their land for new construction and there was no land available for agriculture. The next category embraces marginal workers engaging 601 persons. The number of female marginal workers is higher (456, out of total 601 persons) than that of the male. The demographic structure of the population of Almora town clearly indicates that it has a growing population rate which is mainly controlled by the immigration from nearby rural areas. This is reflected in the observed rapid increase in the construction activity, consequently the agricultural land has been reduced. This could be a reason for recorded decrease in the population of cultivators. The literacy rate of town population is better than state and national averages. The town inhabitants are therefore expected to be well educated about environmental problems.

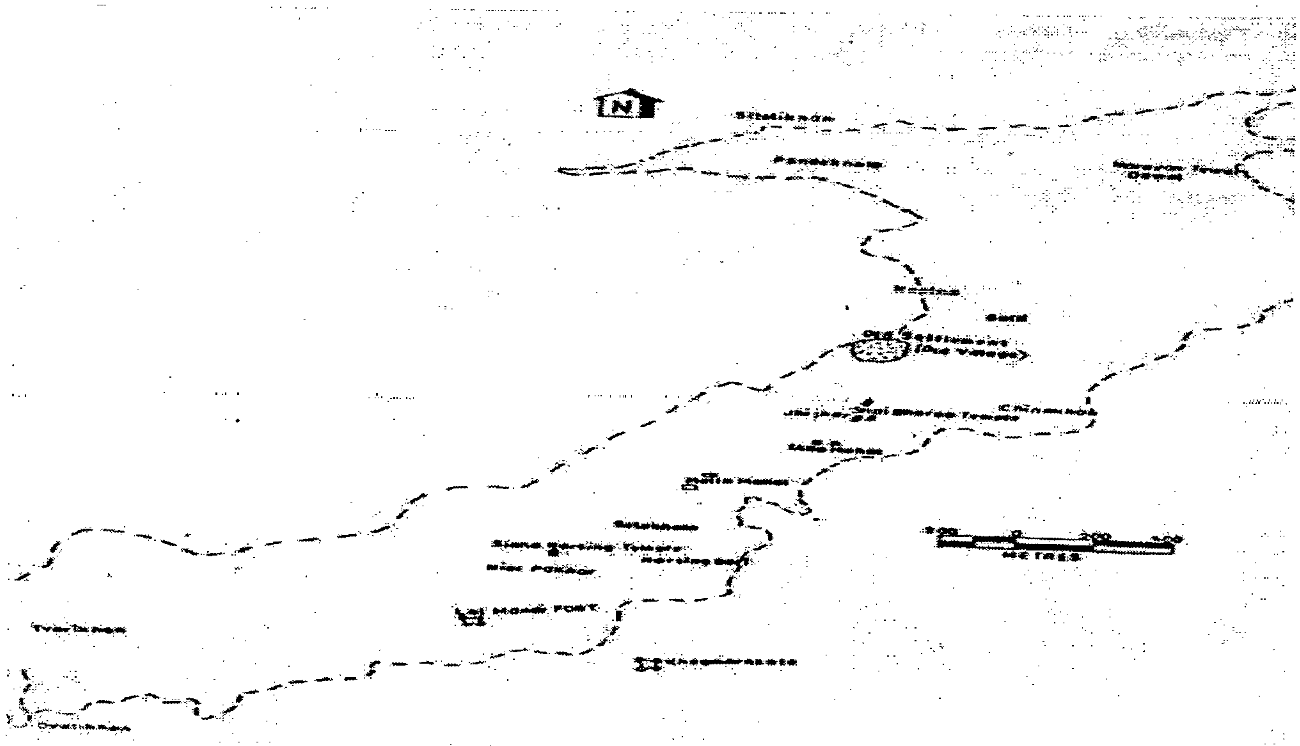


Fig.6.1. Almora town under Chand dynasty (1563 A.D.-1790 A.D.)

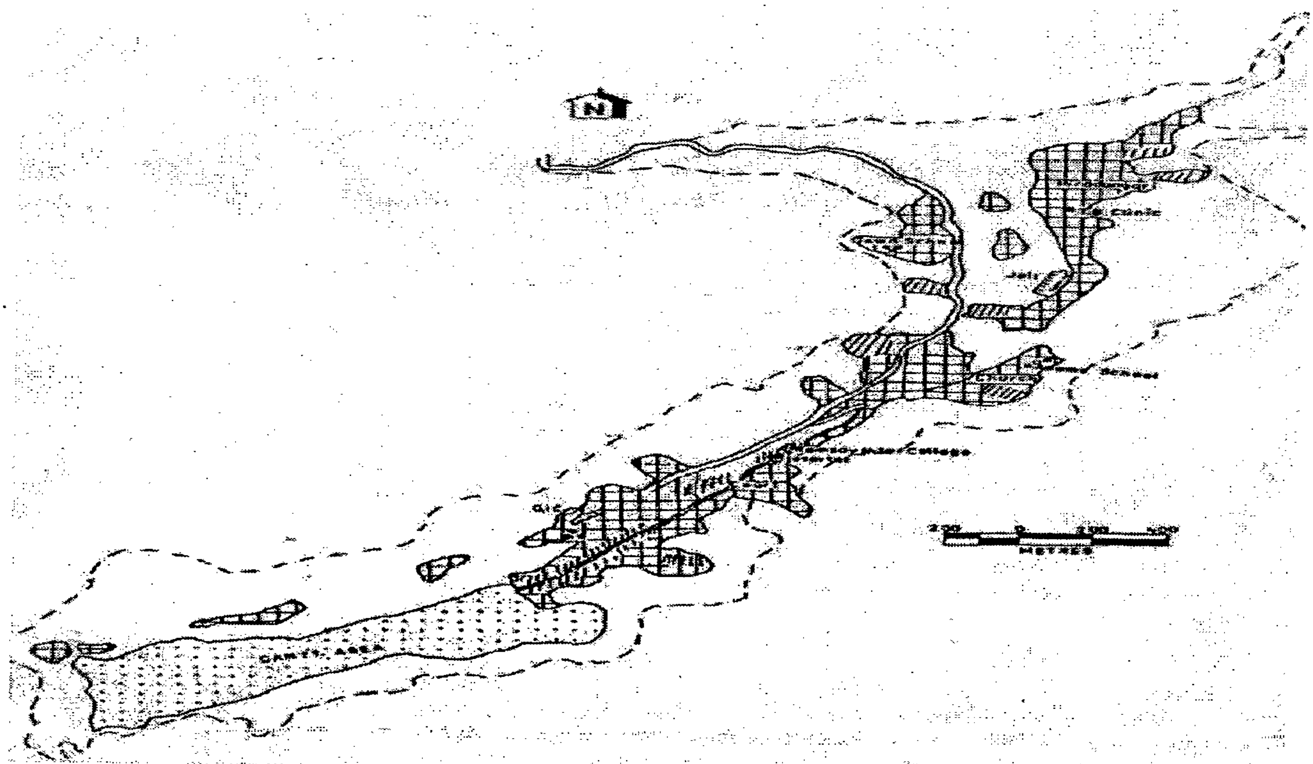


Fig.6.2. Almora town under the British rule (1815 A.D.-1947 A.D.)

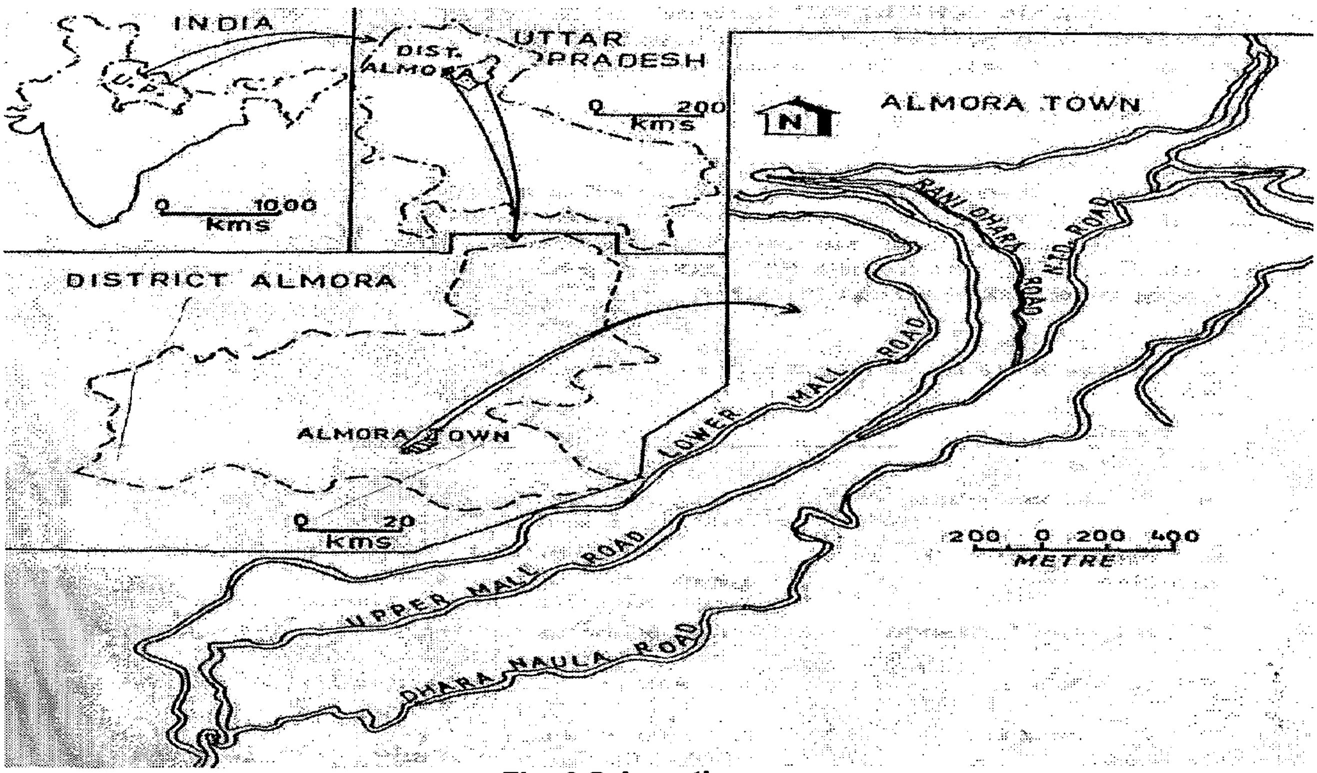


Fig. 6.5. Location map

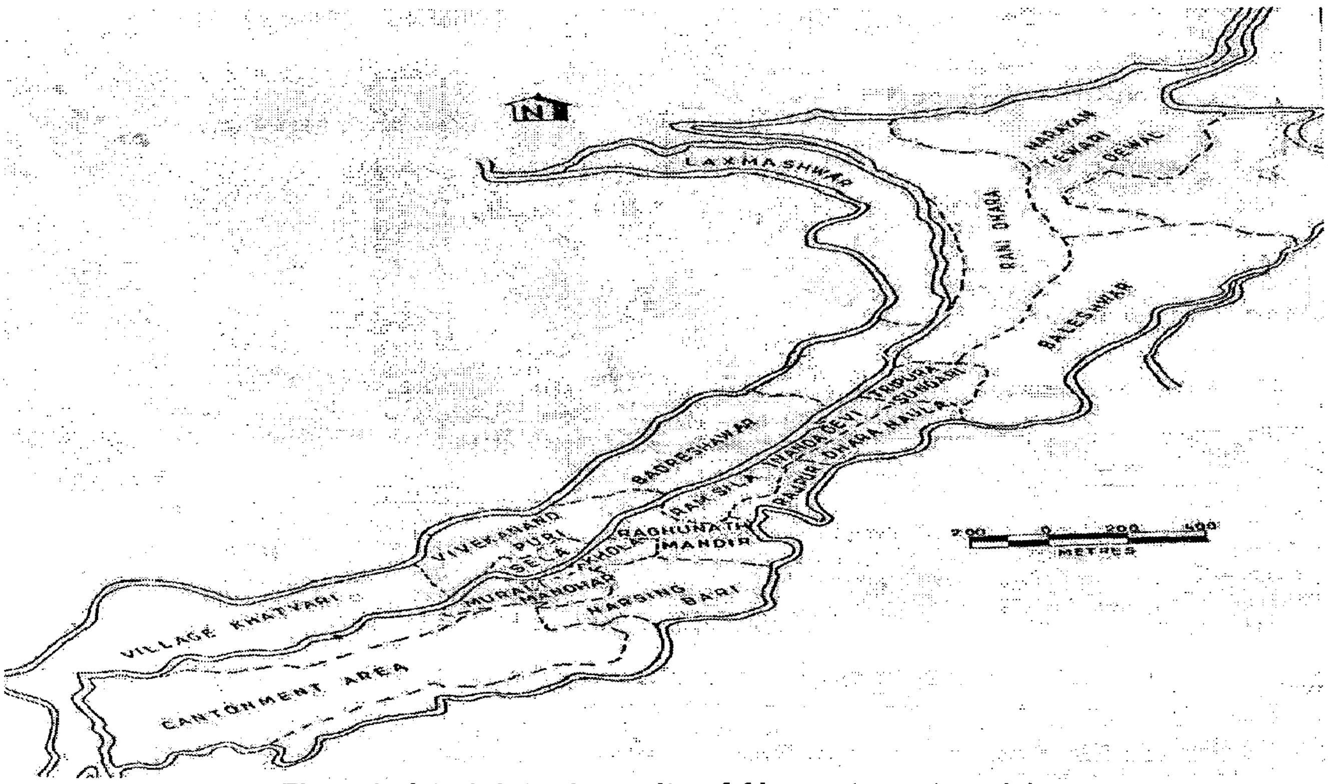


Fig. 6.6. Administrative units of Almora town (wards)

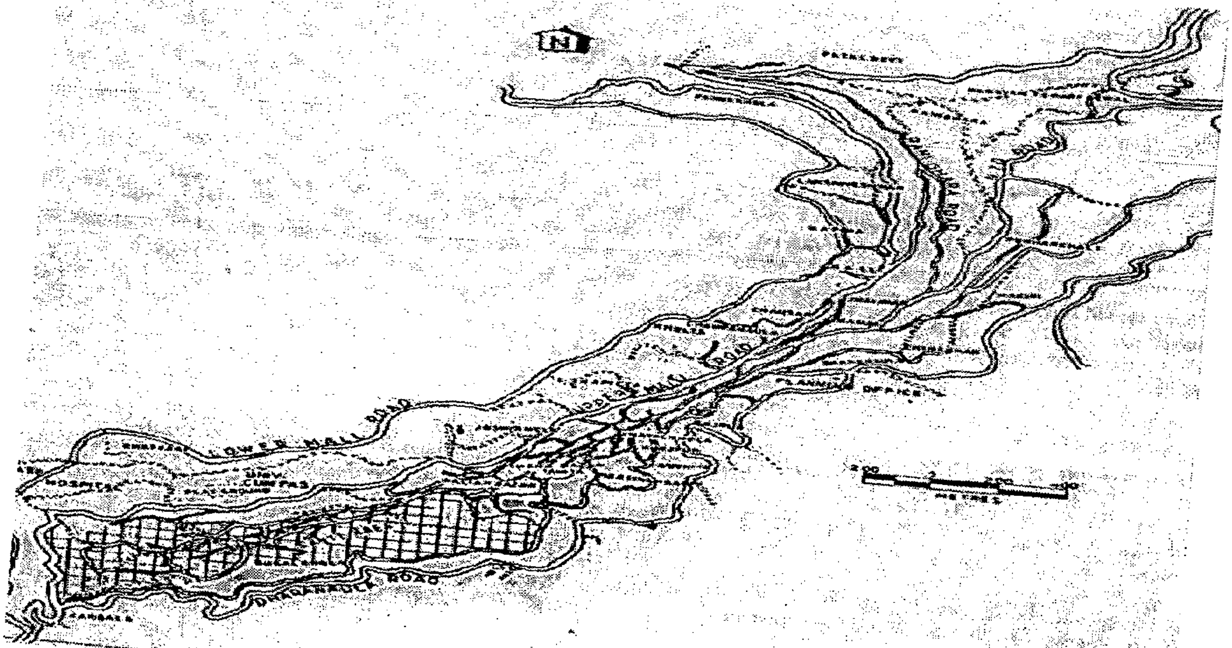


Fig.6.3. Almora town after Independence period (1947-1993)

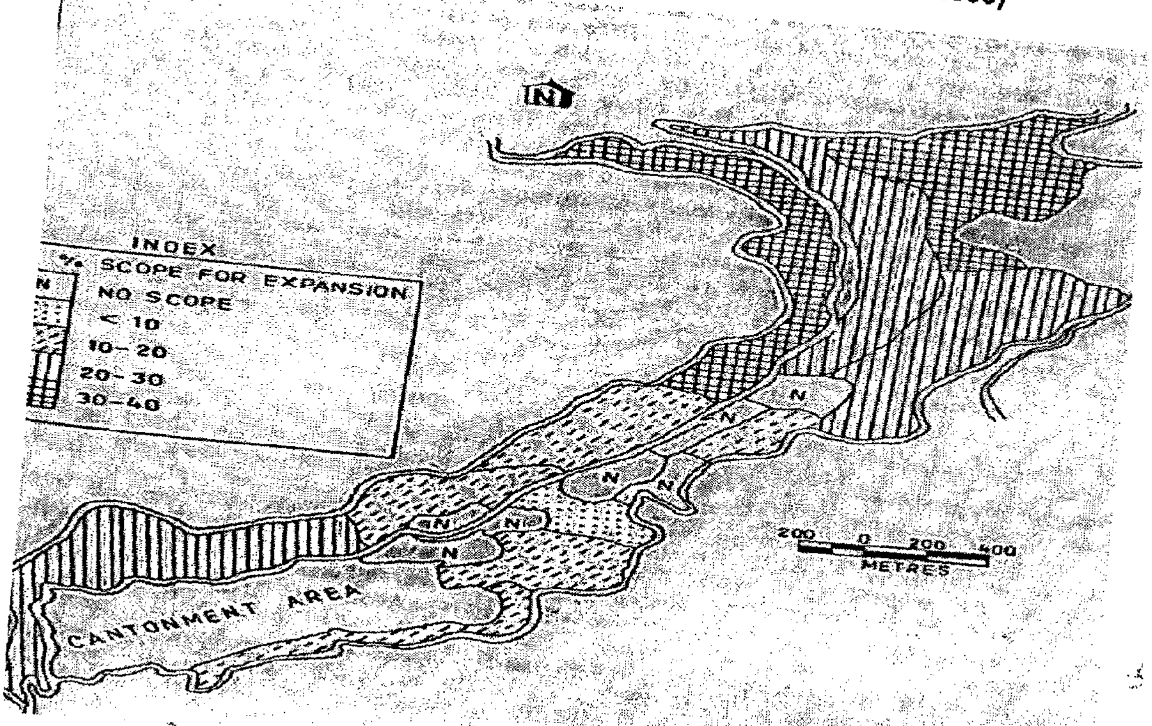


Fig.6.4. Scope for expansion of built-up area

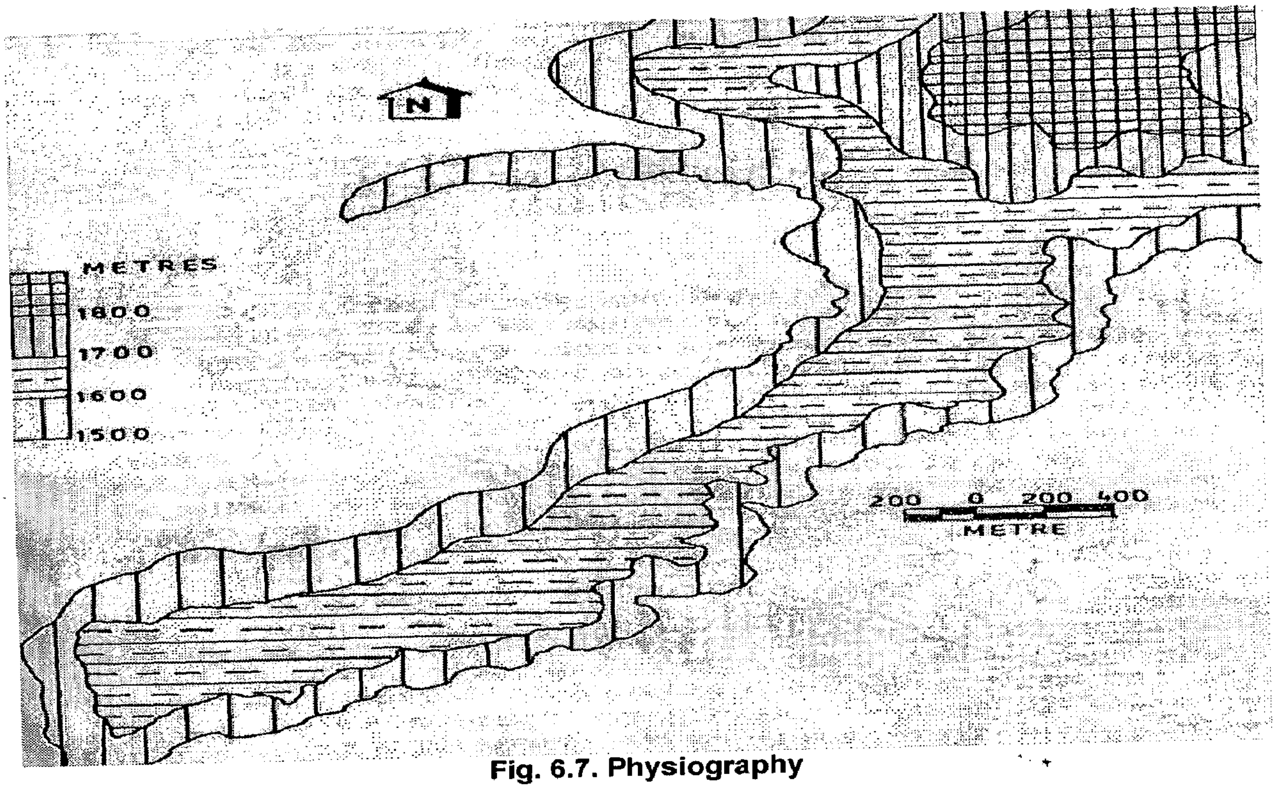


Fig. 6.7. Physiography

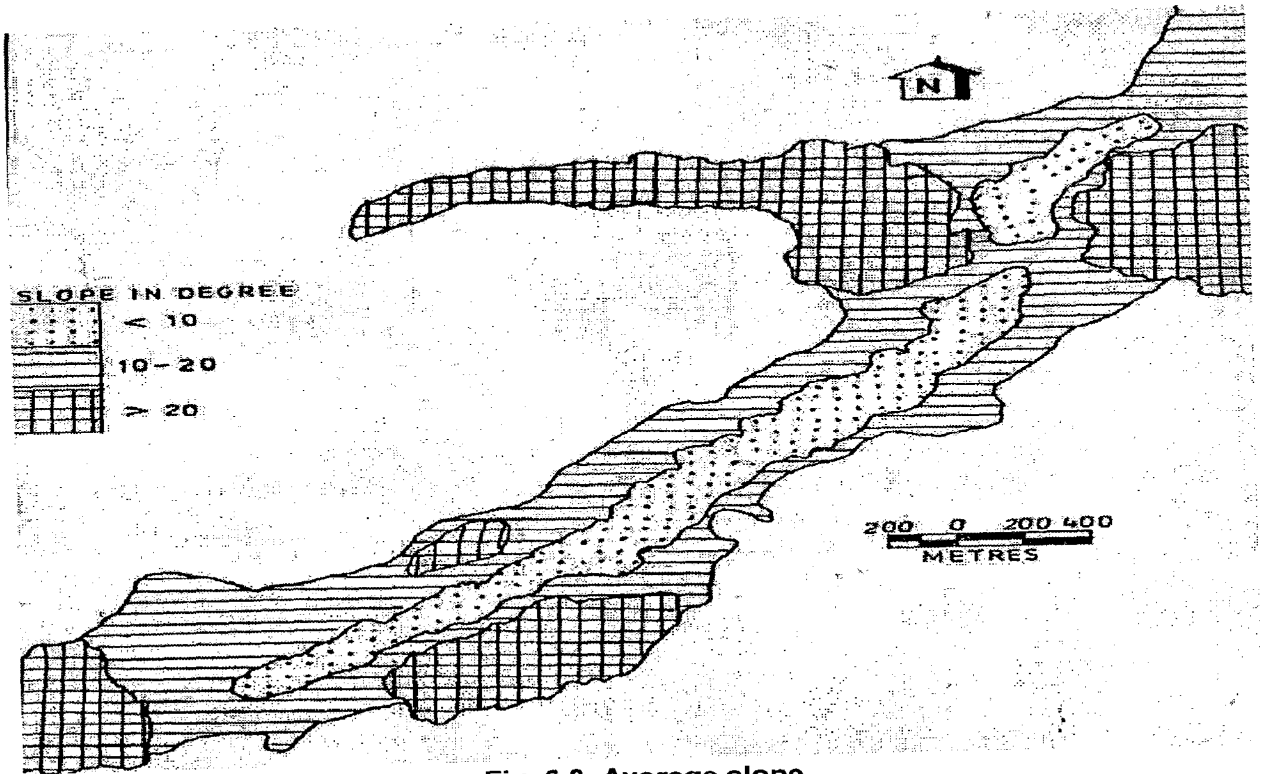


Fig. 6.8. Average slope

Average temperature, degree °C

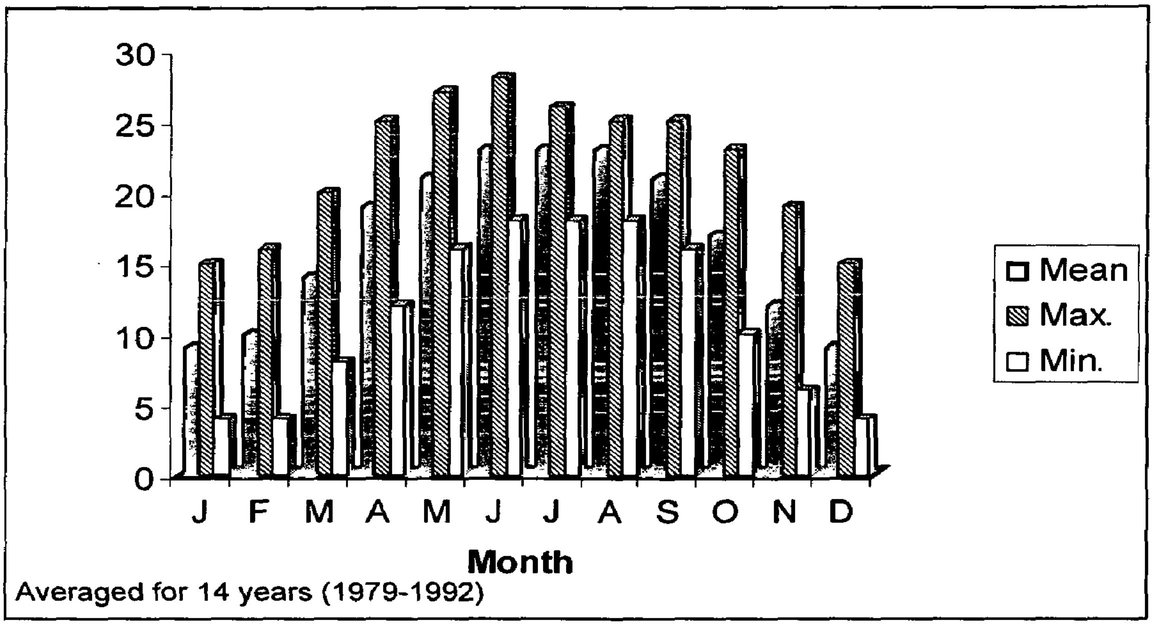


Fig. 6.9. Air temperature patterns of Almora town

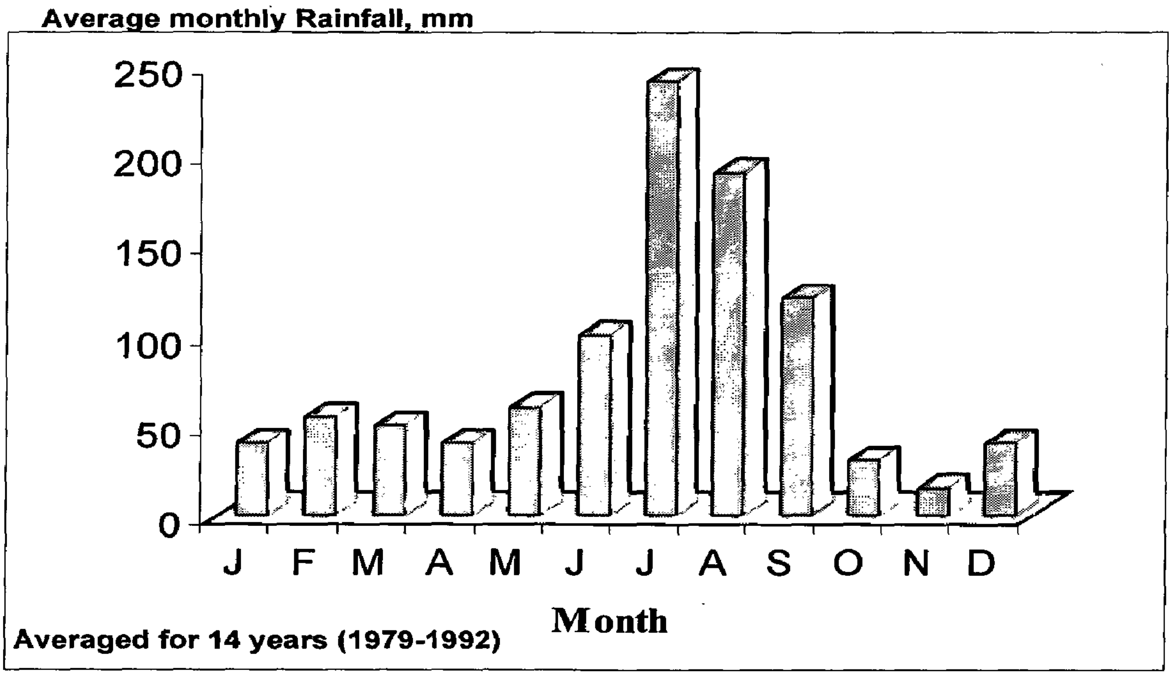


Fig. 6.10. Monthly rainfall patterns of Almora town

No. of Rainy days/month

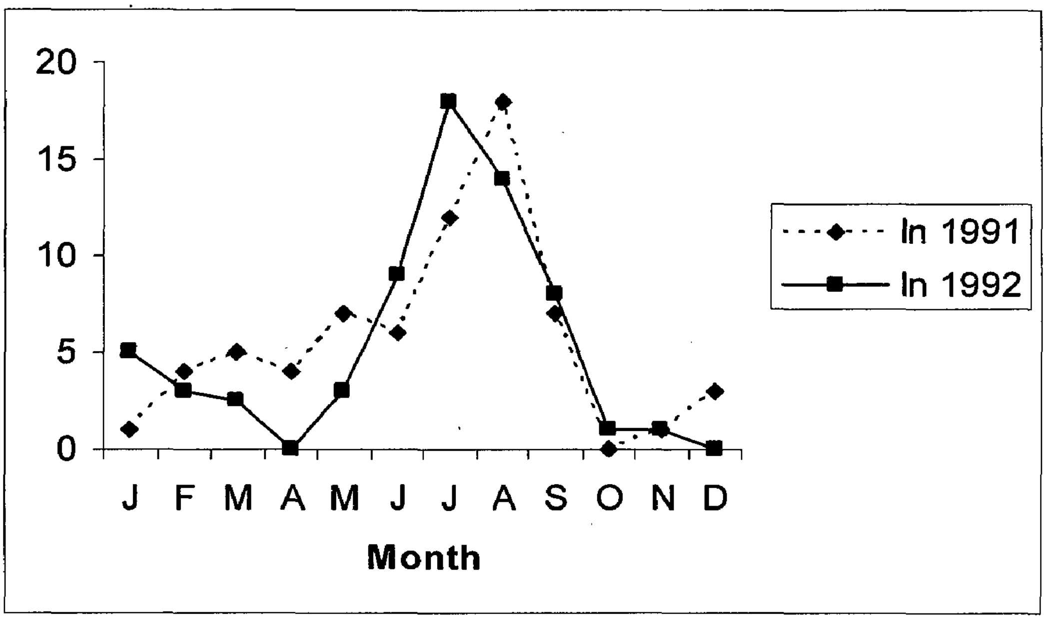


Fig. 6.11. Frequency of rainfall in Almora town

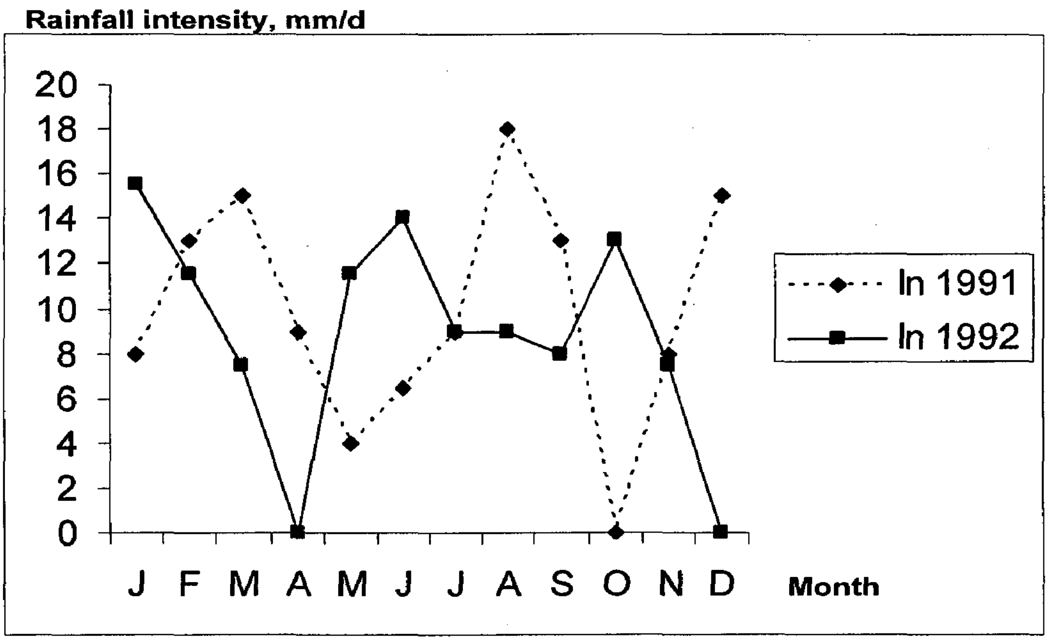


Fig. 6.12. Intensity of rainfall in Almora town

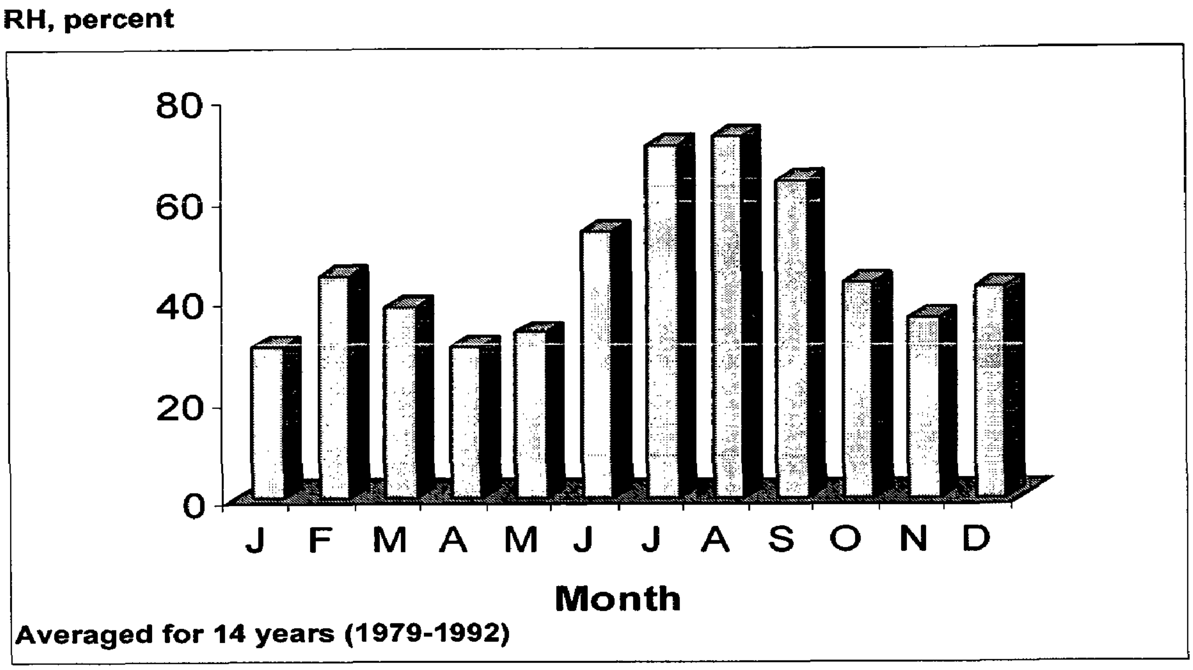


Fig.6.13 Monthly average of relative humidity (RH) for Almora town

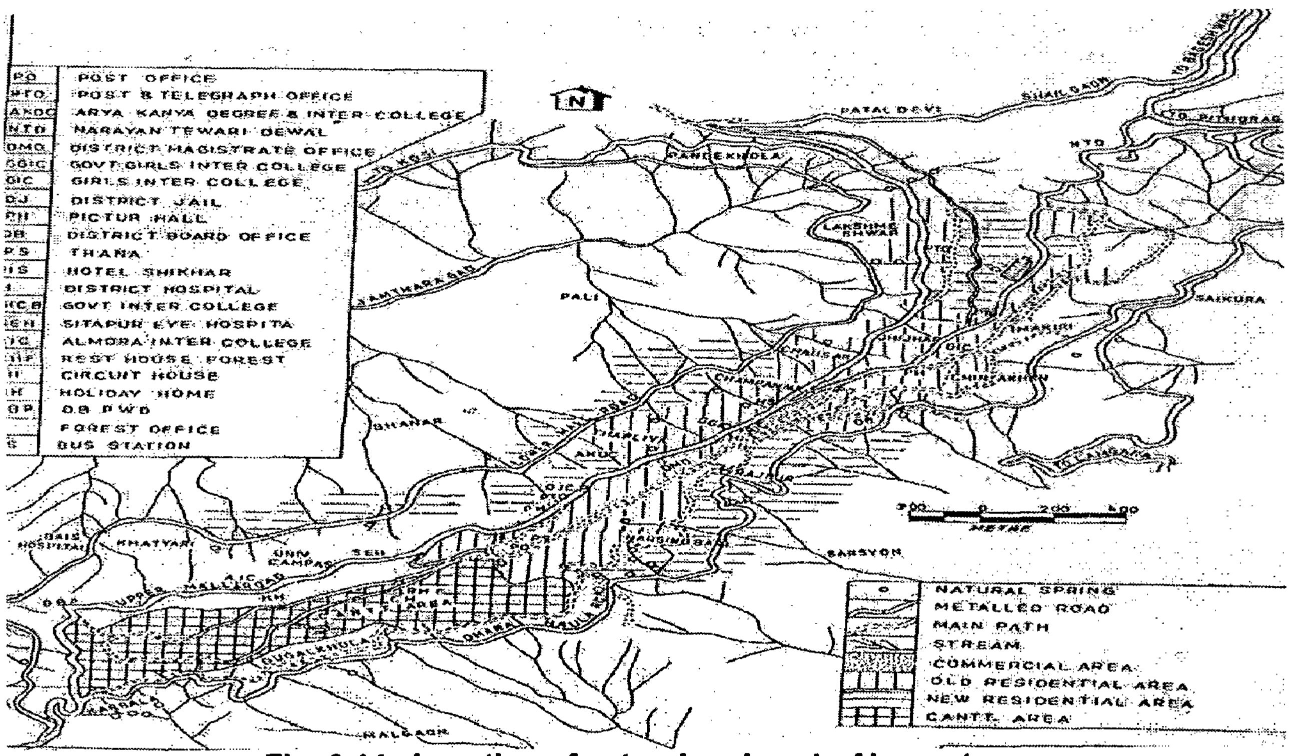


Fig. 6.14. Location of natural springs in Almora town

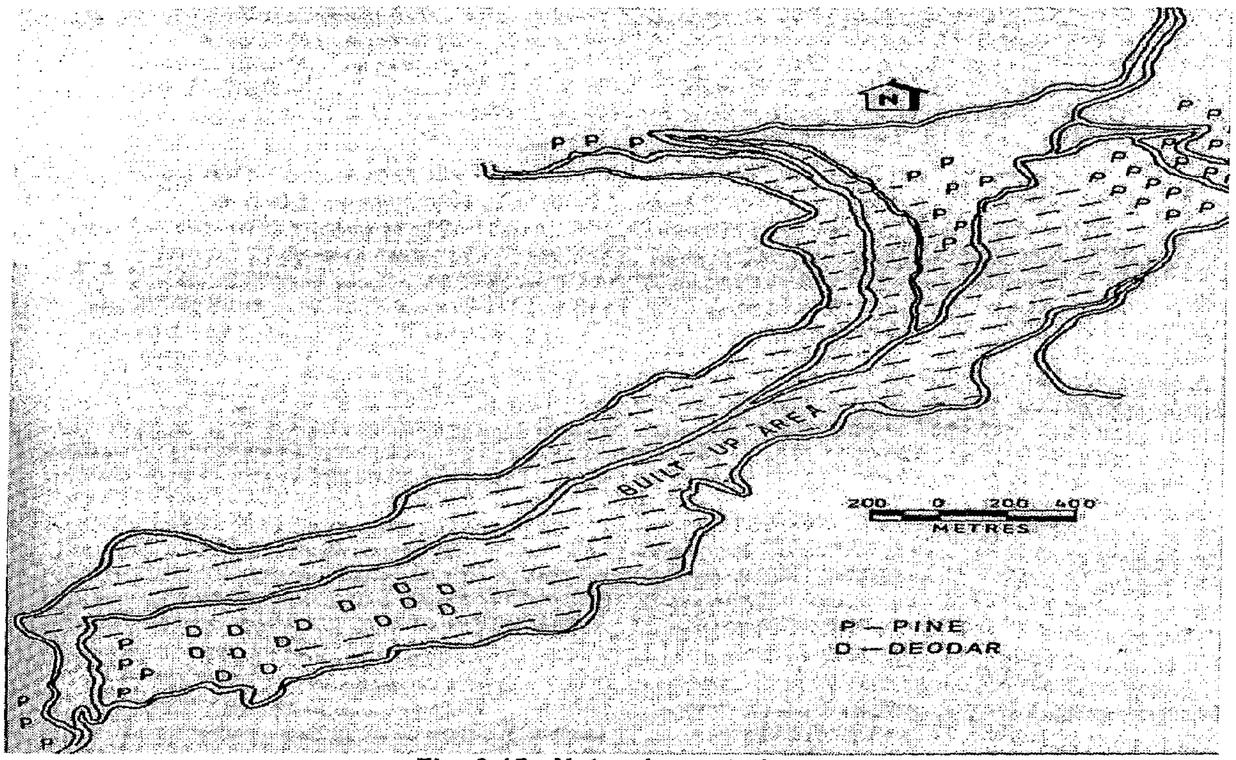


Fig. 6.15. Natural vegetation

Table 6.1. Population growth (1901-2001)

Years	Total population				
	Almora MB	Almora Cantt.	Almora	Net variation	% Decade variation
1901	8,596	-	8,596	-	-
1911	10,560	-	10,560	1,964	22.84
1921	8,359	-	8,359	2,201	15.90
1931	8,715	973	9,688	1,329	13.49
1941	10,229	766	10,995	1,307	16.03
1951	12,116	641	12,757	1,762	30.14
1961	16,004	598	16,602	3,845	25.77
1971	19,671	1,210	20,881	4,279	8.74
1981	20,758	1,947	22,705	1,824	23.55
1991	26,001	2,050	28,051	5,346	-

Source: (i) Census of India, District census hand book, 1951,61.
(ii) Census of India, District census hand book XB, 1971,81.
(iii) GISTNIC, Almora, 1991.

Table 6.2. Number of residential houses, households and population density (1951-2001)

Years	Houses	Households	Density/km^2
1951	1941	2279	1585
1961	3553	3802	2062
1971	3566	4184	2594
1981	3852	4821	2820
1991	5618	6140	3485

Source: Census of India, District census hand book, 1951,61,71,81,91 and GISTNIC, Almora, 2001.

6.5. The Settlement

The town is located on a saddle shaped ridge running north east- south west and river Kosi and Suyal flow on the west and east of the town respectively. The town spread over 9 sq km area is developed in a linear pattern on the ridge and its eastern and western slopes. All the administrative and commercial areas, that is, the King's fort and the market were initially located on the ridge with the fort occupying the highest location. The king's fort/palace was located strategically at the highest location and the shops, workshops (Almora is famous for copperware) and houses of traders are located along the main spine running on the ridge. All the administrative and commercial areas, that is, the King's fort and the market were initially located on the ridge with the fort occupying the highest location. The location of Mohallas was determined largely by the location of water springs (Naulas), most of them being in private ownership of Brahmins, who were the trusted men of the king. The Western side of the ridge, known as Shaliphat (the cold side), having gentle slopes is inhabited by the houses of Brahmins, which later developed into mohallas. The Eastern slopes of the ridge known as Tailphat (the warmer side) having steep slopes and less number of Naulas near the ridge, are inhabited by other communities.

Most of the mohallas were Brahmin dominated though few were of Khsatriyas and rest were mixed and were known either by the names of communities of the place from where the inhabitants came. The other streets meeting the main spine at the ridge are across the slopes and are either parallel to or over the natural drainage courses and become stairway whereever slopes are too steep. During the early period of town development, a traditional Indian pattern of three storied commercial cum residential buildings evolved on both sides of the street located along the ridge, with ground floors being used as shops and upper floors for residences. Residential areas were concentrated along the ridge and its adjacent areas on both sides. The Eastern slopes, known as 'tailphat', the warmer side, was inhabited by lower castes, lesser privileged communities, and had more compact physical development. The western slopes, known as 'Shailphat', the colder side, had scattered houses of Brahmins, the priest class, who owned the natural water springs, naulas, that were essential for survival in a settlement located on the ridge.

The Residential neighborhoods, Kholas, located on either side of the ridge in general have a linear arrangement of building units varying from 3 to 10 under one roof. The building blocks are built along the contours in stepped terraces and are provided with a common 6m to 9m wide stone paved terrace in front on the valley side and a waste

Table 6.3. Literacy and education (in %) 1951 – 2001

Table	% of total population	% of total male	% of total female	% of total literacy	
				Male	Female
1951	62.51	70.49	50.71	67.26	32.74
1961	70.04	76.99	60.34	64.04	35.96
1971	72.11	79.47	61.31	65.54	34.46
1981	78.33	84.13	7078	60.70	39.30
1991	77.09	80.14	73.16	58.50	41.50

Source: District census hand book, 1951,61,71,81,91 and GISTNIC, Almora, 2001.

Table 6.4. Details of workforce (1961-2001)

Table	% of total population	% of total male	% of total female	% of total workers	
				Male	Female
1961	30.40	45.49	9.35	87.16	12.84
1971	29.01	45.59	4.69	93.45	6.55
1981	30.23	48.32	6.72	90.32	9.68
1991	33.13	50.61	10.65	85.95	14.05

Source: District census hand book, 1961,71,81,91 and GISTNIC, Almora, 2001.

Table 6.5. Occupational structure (%) 1961 and 2001

Activities	1961			1991		
	T	M	F	T	M	F
1. Cultivators	7.41	1.43	47.99	0.09	0.04	0.38
2. Agricultural Laborers	-	-	-	0.03	0.04	-
3. Livestock, Forestry, Fishing etc	3.01	3.46	-	5.08	5.45	2.83
4. Mining and Quarrying	4.32	3.86	7.42	0.38	0.43	0.07
5. MAF and Processing in H.H. Industry	7.13	8.16	0.15	0.86	0.79	1.30
6. MAF and Processing other than H.H.I.	-	-	-	4.64	4.86	3.29
7. Construction	3.19	3.66	-	6.50	7.34	1.38
8. Trade and Commerce	13.08	14.96	0.31	19.80	22.25	4.83
9. Transport, Storage and Communication	5.33	5.98	0.91	4.88	5.52	0.99
10. Other services	56.53	58.49	43.22	57.74	53.28	84.92
Total	100.00	100.00	100.00	100.00	100.00	100.00

T – total, M – male, F – female.
Source: District census hand book, 1961 and GISTNIC, Almora, 1991.

face East or West or south. Most of the traditional houses are two or three storey high, with the first floor being used for living, the lowest floor for cattle and storage and the attic for cooking and prayer.

The typical house consists of a Kholi, an entrance with stairs in the center of the unit, which over of time got converted into two separate units. On both sides of the stairs on the ground floor are Goth, small cellar like rooms meant for cattle, hence the name, fodder and storage. On the first floor Chakh, a sitting area, is provided on both sides of the stairs behind which is Majhala, the middle room, a square dark room, which is a multipurpose room. It is mainly used as bedroom and for storage but it is also used as a cooking area in two storied houses, whereas, in the three storied houses, the kitchen is placed on the top floor, attic. The kitchen on the attic is ventilated through the holes in the roof slates and at times through the ventilators on the roof. The attic is approached by a ladder. The area above Chakh on the attic level is a loft and small Khotharis, or stores, are located under stairs landing on the ground level. Whereas the Chakh is rectangular, Majhala is invariably square in shape, and has a wooden pillar in the center of the room. The average size of Majhala is around 4.2m by 4.2m and that of Chakh is 2.4m by 4.2m. The size of Majhala varies from 2.4m square in smaller houses to 4.8m in bigger houses. Window openings in the traditional houses are generally limited to the front side, except for a small window on the side wall in Majhala. Windows are generally kept small for reasons of climatic desirability and social privacy. The window openings in traditional houses are crescent shaped in general and the wooden columns are short, tapering and fluted which became straighter, more round and simpler over period of time. Women and children are often seen hanging out of the small window opennings of Chakh that have intricate wooden carvings. The floor heights were kept very low, 1.8m to 2.6m to conserve natural warmth in winters, especially for the Goth, kitchen in the attic and the lofts. Houses are made of 45cm to 60cm thick stone walls, bonded and plastered with mud. The floors are made up of mud and wooden planks and very occasionally of stone slabs. The roofs are made up of 230 mm to 300mm wooden rafters, purlins and ridgepoles. Bhita, a layer of split pine laid over the wooden rafters and the Patals, slates, are embedded in mud over it. The intricate wood craftsmanship and the sloping slate roofs give coherence and unity to the vernacular Architectural character. Bright blue and green colour used for door frames in many houses makes them distinctly visible, though dark brown colour is also common. The characteristic wood carvings are found on the entrance Kholi and windows. At times even the ceiling, in the houses of the rich are disposal drain, karadi, on the rear. Even when the units are scattered informally each unit has its individual stone paved open terrace, which is used for miscellaneous household chores during the day time. Houses are consciously placed to face south, west and east cardinals so as to receive a maximum advantage of the sunny sides of the terrains. Height of building and spacing between them is purposely graded to ensure that the building block gets a direct sun penetration in the building behind as well.

Vernacular Architectural Character

The limited distinctive stone and wood multistoreyed buildings remarkable in appearance have survived many earthquakes in his seismically active zone. Houses are simple two and three storeyed structures with slate roofs, built separately or in clusters. Keeping in view the uniformity of the architectural pattern of most dwellings, they must have been constructed following a careful worked out plan, and are precisely designed using local raw material, and purely traditional indigenous knowhow and technology. Today the traditional houses are not common sight in Almora because of dearth of timber and stone slates and high cost of construction and repair. Some local craftsmen still survive who had constructed these buildings in the past, and who have inherited the tradition of craftsmanship from their forefathers. Therefore for the present study some of their families were interviewed to understand the methods and techniques employed in construction. Besides this detailed architectural plans of each floor, sections and elevational images are made to reconstruct the arrangement of the basic building structure.

Vernacular Architecture of Kumaun is characterised by the intricate wood carving and use of huge stone slates for roof and wood for structural and decorative purposes. The most unique aspect of Kumauni vernacular Architecture is the similar pattern of internal space organisation irrespective of the socio economic class of the owner and the locational context of the buildings. The difference in the social and financial status of the owner is reflected only in the decoration of the entrance, 'Kholi', the wood carvings and a slight variation in the sizes of the rooms. Consequently the plan form of the houses irrespective of the owner being rich or poor and the location being in urban or rural area, in the center of town or on the outskirts, is exactly the same. Even when numbers of units are placed together there is no modification in the house design and the dwelling units are placed in the same orientation in a linear pattern. Likewise, the house design remains the same irrespective of the slope aspect and the building orientation, that is, whether they material for walls, huge stone slates for roof and pine or deodar timber for structural as well as decorative purposes. The most unique aspect /feature of vernacular architecture of Almora is the similar pattern of internal space organization and design irrespective of the social and economic class of the owner, the only difference being in the decoration of the entrance (kholi) and very slight variation in the sizes of the rooms and the wood carvings. There is no variation or modification in the house design and even when more than one unit are placed together they are in the same orientation and are placed in a linear-fashion. Most of the houses in mohallas are 2-3 storeys, 3-storey blocks being frequent in bazar area. Houses built are compact and rectangular, with multipurpose rooms reached by a central stairway. Wooden beams form a frame which carries the weight of the building, and transfers it to stone or brick piers around the perimeter to which they are joined. They are laid so as to form prominent wooden bands at the level of each floor, and support joists and floor boards. Transverse beams carrying the weight of interior partition walls articulate with the perimeter frame, and intersect where interior walls meet. Pre-stressing of the walls with wooden beams allows some of the force of an earthquake to be spread. In addition the bonding between the stones is made relatively soft and weak, not rigid, so that the shock may be further spread throughout the building without causing it to collapse. Life is organised vertically within it. The typical house consists of a "kholi", i.e., an entrance with stairs in the centre of the unit, which later got converted to two separate units on both sides of stairs. The ground floor rooms "Goth " are meant for cattles, fodder and storage. Human living areas are raised to the first floor level, with sitting area in front (Chakh), a middle room (Majhala) which is a multipurpose room with a central wooden non-structural pillar supporting an eccentric wooden beam. The kitchen is placed on the top floor (attic) and is approached by a wooden ladder and ventilated through the holes in the roof slates and at times through the ventilators on roof. A hearth and a drainage channel have been made on the back wall. Area above the "Chakh" is a loft and small "Kotharis" (stores) are located under stair landings. Each storey is divided into two parts, each consisting of a pair of inter-connecting rooms. Except for the central staircase from the ground floor to the first, specially designed wooden ladders connect the upper floors through apertures cut in the ceiling/floor on one corner of the room. The ground floor is divided into two parts, each consisting of two rooms, as described above. There are two very low entrances at the front, each opening into a pair of rooms. This floor has not been provided with ventilators. The back chambers store grain and other commodities. The two outer rooms, have been designed for keeping animals, agricultural implements, fuel and intricately carved. Whereas iconography of Gods and Goddesses-are found in the houses of earlier period, houses constructed during the later period have floral and geometrical patterns. In addition, the decorative hand made patterns on the entrance, on the walls adjacent to the doors and on floor, particularly in the area used for prayers, in form of Aippan, the traditional art made from rice powder paste and vegetable dyes, to welcome important events, in most of the houses add richness to the vernacular Architecture.

These compactly planned buildings evolved over generations to suit the life styles and values of the particular society and climate of the region are apparently the and contextually the most appropriate Architectural solutions to the generic forces that have been adapted to their geographic environments and are visually interesting. Nevertheless, they lack in few basic necessities, such as, adequate light and ventilation in different rooms and a proper relationship between interior and exterior spaces, apparently because of introverted and cellular compactness of living or utility spaces.

Architectural traditions are now under strains owing to increased commercial and residential demands that do not fit into the conventional practices. Over a period of time certain inevitable additions, alterations and substitutes have therefore taken place, which were very minimal and slow almost till about sixty years ago. But the physical changes in the Architecture have been very rapid and drastic since independence, particularly, due to changed functional retirements for spaces and allied facilities, new building materials which do not necessarily have local bearing, and new construction techniques being adopted. Many of these new constructions do not integrate well to the local hill environment and social contexts. Rapid growth of assorted buildings blocks are causing serious damage to environment, ecology and landscape which are now seen in siltation and the drying up of Naulas, the natural water sources. Absence of adequate regulatory measures for growth and development of the town, particularly the conservation of traditional buildings, increasing cost of maintenance and acute shortage of skilled craftsmen are also responsible for the loss of rich Architectural heritage of the region. In such situations physical developments should be seen within the context of traditional wisdom of life and environment relationship on an infinite continuum of spaces and time matrix.

There is a need for strong conservation policies to ensure a definitive continuity of the local Architectural identify, so that building morphism of hill settlements is encouraged to enrich its vernacular traditions of Architecture as a part of hill culture and heritage. The character of local architecture is dictated by the use of stone as building progression results into only eighty one (9 X 9) variations of four rooms per floor combinations, for nine roomed combinations there was a choice of seven hundred and twenty nine (27 X 27) varieties. These floors were then arranged into two or three storeyed structures. Thus the four rooms per floor combinations stacked one over the other gave way to either eight roomed dwelling units, as the smallest houses available or twelve roomed dwelling units. Similarly the nine rooms per floor combinations shelved successively into eighteen roomed or twenty seven roomed houses, as the most lavish. This gives way to a theological totality of dwellings ranging from one hundred and sixty two (81 X 2) four rooms per floor units till one thousand four hundred and fifty eight (729 X 2) nine rooms per floor structures, seemingly not a big variety of choices. These houses were either dispersed individually or flanked one against the other with common walls into angular open ended clusters, like the alphabets C, E, F, H, J, L, T, S, X and Z . Symmetry was much respected in the evolution of elevational treatments. Accordingly, openings were either symmetrically or eccentrically punctuated over the external facades, but openings on the internal walls were eccentrically places for maximum space utility and functionality (Fig. 6.15.).

Structures

The height of a dwelling is normally between 1.75 m and 2.25 m. In order to achieve this height and provide stability to the structure, a foundation trench 1 m deep was dug and filled with flat dressed stones. To know more about the nature of the foundation, a portion of the structure exposed, was found that at the front of the building the foundation rested on bed rock and was built up to 0.75 m above ground level. It seems that this must have been done to provide a strong support for the building. The remaining portion of the trench was filled with mortar (a mixture of clay and stone fragments) and the whole levelled up to form a plinth. The foundation wall was then capped with flat double wooden beams on all four sides. From the platform, the entire structure was raised. In course of construction, the double walls, with a total thickness of 75 cms were first raised from the plinth level to a height of 1.75 m; then further capped with intermittent single beams and lintels of almost the same length as the wall. This process continued until the double walls, reinforced with intermittent beams and lintels, reached the roof. At the front two wooden doors were provided for the main entrances into two separate compartments of the dwelling. Small windows, were punctuated in the wall masonry. Another interesting structural feature is the absence of toilets.

fodder. The first floor, is also divided into two separate parts, each consisting of two interconnected rooms of the same dimensions as those on the ground floor, and each provided with a small ventilator. The inner room is intended for multipurpose living areas, and outer for sitting. The attic floor, is used for cooking and storage. It too is divided into four rooms of the same dimensions as before, and with very small roof ventilators. Kitchen occupies the inner right side. Wooden shelves have been attached to the walls for storing household articles.

Over walls 50 cm thick wooden beams are spanned by massive timber floor joists. The floor height is kept very low, specially for the Goth, the kitchen in the attic and the lofts to conserve natural warmth in winters. The floors are made up of mud and wooden planks, and very occasionally of stone slabs. Window openings are very small for reasons of climatic desirability and social privacy. The most characteristic feature is the intricate wood craftsmanship on the entrance doors are sometimes on windows which along with sloping slate roofs give coherence and unity to the vernacular architectural theme. These buildings compactly planned and designed are visually interesting, nevertheless, they lack in few basic necessities, such as, adequate light and ventilation in different rooms and a proper relationship between interior and exterior spaces, apparently because of introverted and cellular compactness of living or utility spaces.

The buildings are built along the contours in stepped terraces, leaving a waste disposal drain on the rear and a big terrace in front of the building. Houses are consciously placed to face south, west and east cardinals so as to receive a maximum advantage of the sunny sides of the terrains. Height of buildings and spacing between them is purposely graded to ensure that the building blocks gets a direct sun penetration in the buildings behind as well (Fig. 6.16. to Fig. 6.25.).

Evolution Theology

The planning and design of each dwelling is essentially derived from the regular quadriteral taken as the unitary module. The local masons and craftsmen incorporated the use of three basic lineations of about 2.25 m, 3.375 m and 4.5 m respectively to permute and combine nine (3 X 3) formulations of regular quadrilateral room sizes, essentially square or rectangular, ranging from minimum dimensions of 2.25 m x 2.25 m as minimum till 5 m x 5 m as maximum. height of each unit was retained at about 1.75 m to 2.25 m low. Now these nine variations of room sizes were again conglomerated into floors, each containing a minimum of four to maximum nine rooms. While successive

Isolated Dwelling

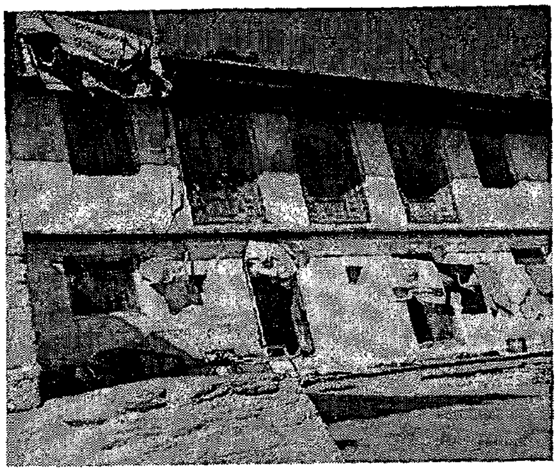
EXTERIOR FAÇADE DETAILS

Fig. 6.16. Images of Almora

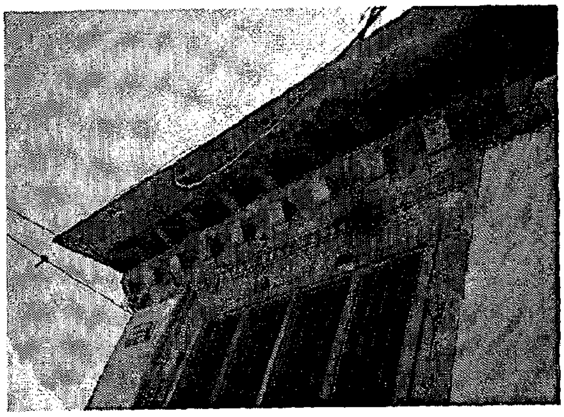
The entire four double outer walls are further reinforced within by stone partition walls, that run from one side of the building to the other in each direction, intersecting at the centre on each floor. Thus on each floor the interior was divided into four regular quadrilateral parts. These correspond with the floor joists supporting the floor boards in each floor of the building, which can be seen in the photograph as well as in the section. After carefully studying the internal arrangements of beams it may be said that the framing of the structure with continuous beams was done deliberately with the intention of strengthening the entire structure. The front elevation and section of the building both clearly show that the provision of the beams within partition walls is designed to act as a reinforcement, and during an earthquake the beams take the entire load of the structure. This technique has made the houses highly resistant to recurrent earthquakes.

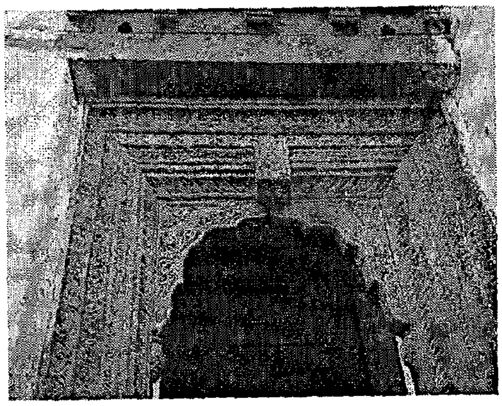
The traditional construction practice of buildings in Uttaranchal is mainly in the form of random rubble stone masonry using undressed stones. The wall is made of two separate sections, outer and inner widths. The space between two widths is filled with stone rubble. Another practice is masonry work and slate wafers. The dressed stones and slate wafers are stacked lightly with very little or no mud mortar in between. This type of wall has a tendency to split and buckle into two separate widths due to lack of interlocking. However, the masonry wall with slate wafers performed better than those with random rubble masonry. Masonry works in buildings with lintel bands of wood performed in a better way. Folk wisdom places great emphasis on quality of construction. Apart from the proper selection of sites, the foundation was laid using the interlocking technique (Jor-tor) in which stones were wielded with one flat stone and the space between was fitted with fine rock pieces. Similar attention was paid to the corners.

The inhabitants constructed their houses with the designed anti seismic arrangement. They might be the sufferer of earthquake in the past, hence they applied indigenous technique of house construction. The building weight was distributed into different components with horizontal and vertical wooden beams embedded into the stone masonry wall. Due to this design some of the triple storied traditional buildings successfully survived several seismic shocks in the last century.



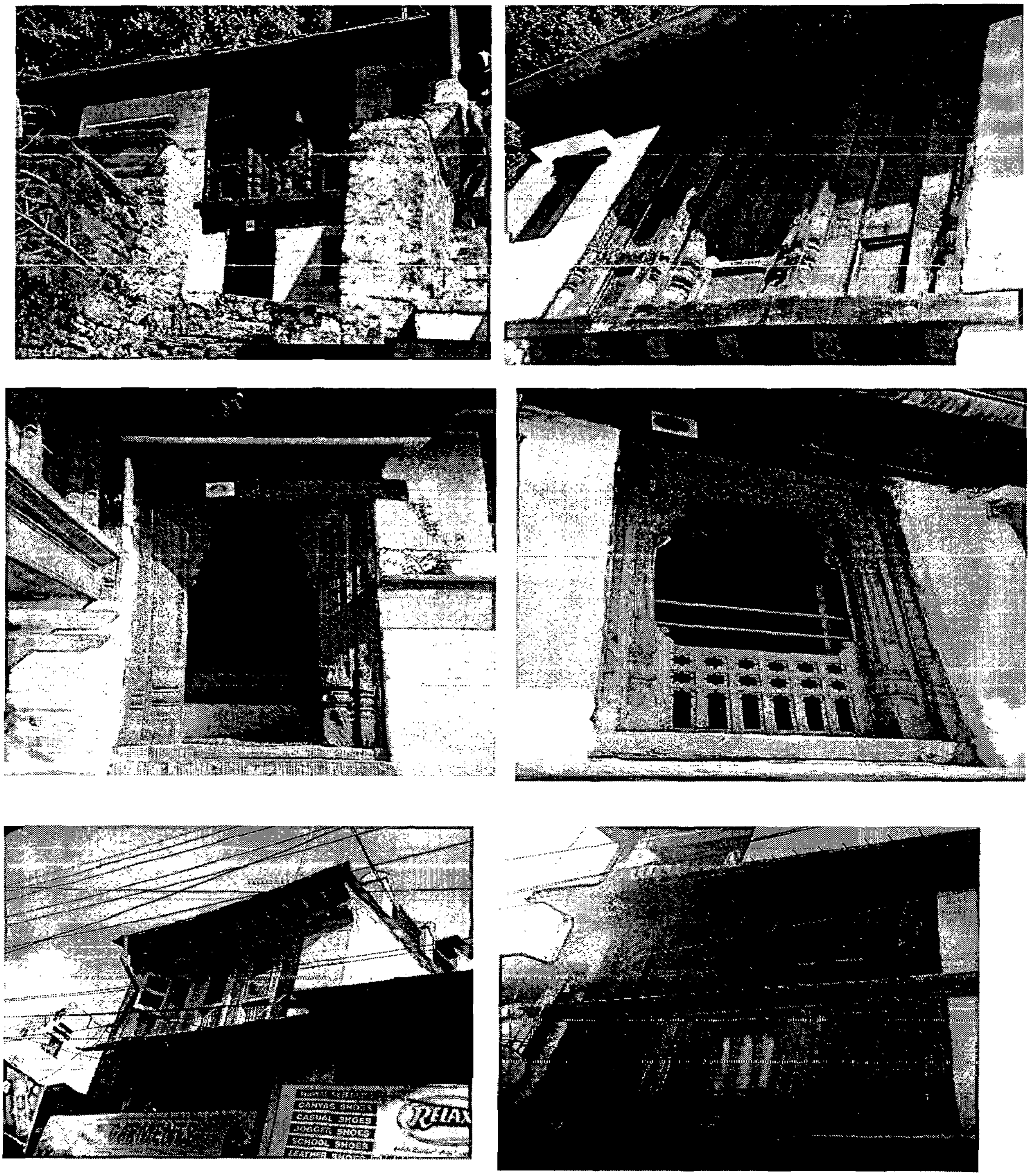
Row houses



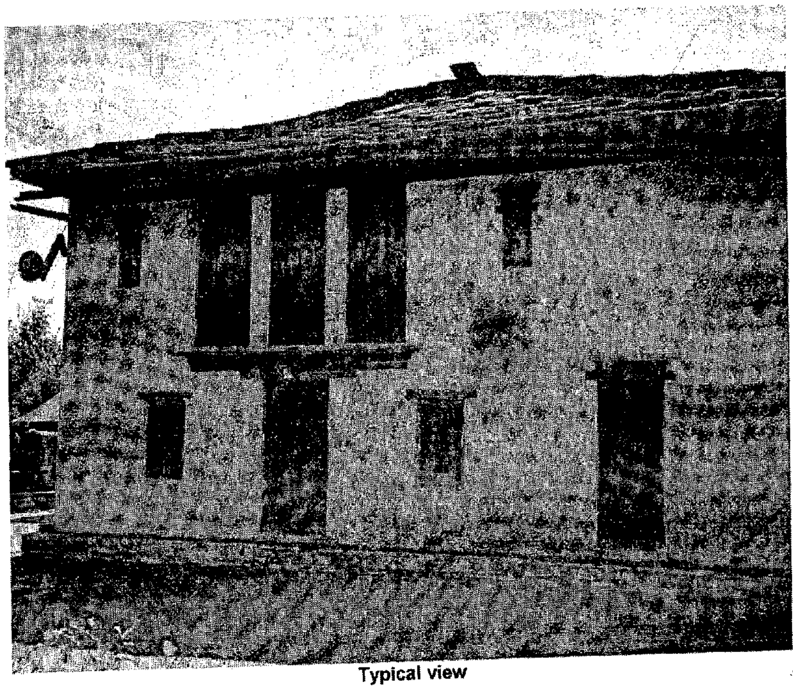


Exterior Façade Details

Fig. 6.18. Images of Almora

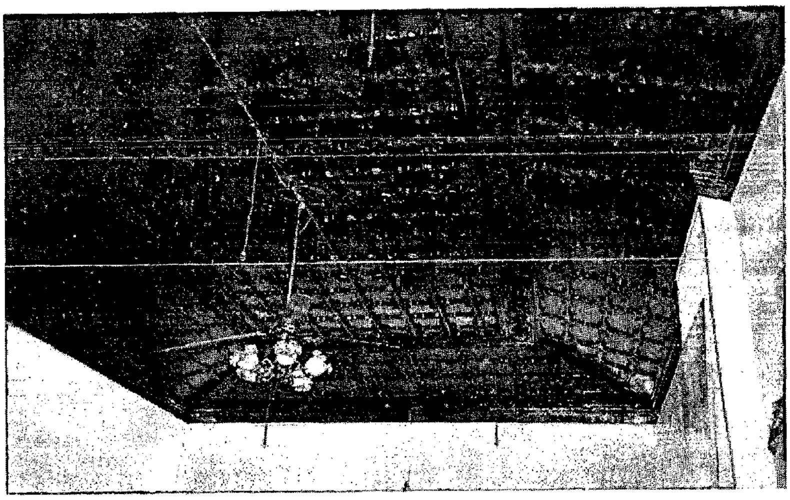


Market place dwelling with shops below
Fig. 6.17. Images of Almora



Typical view

Fig. 6.20. Images of Almora



Wood Carving On Ceiling

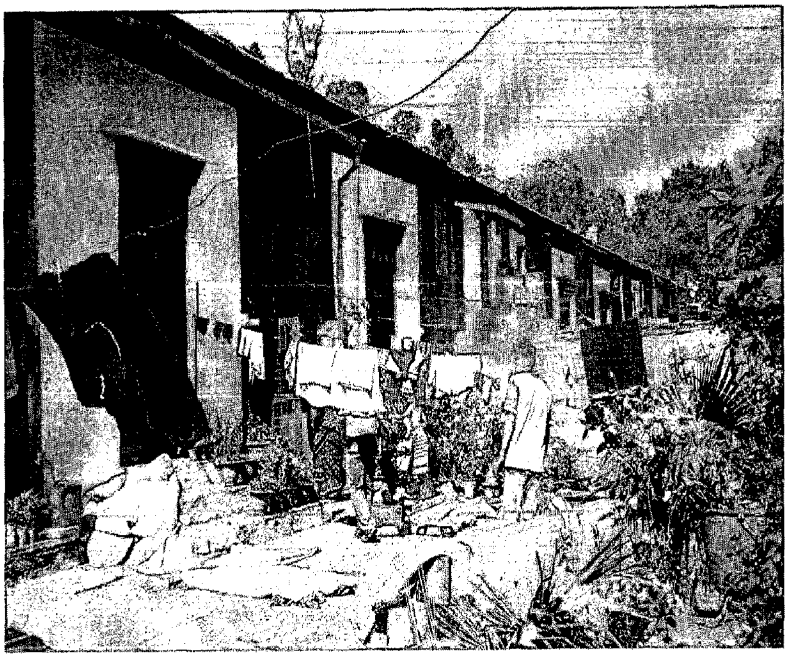


Fig. 6.19. Images of Almora

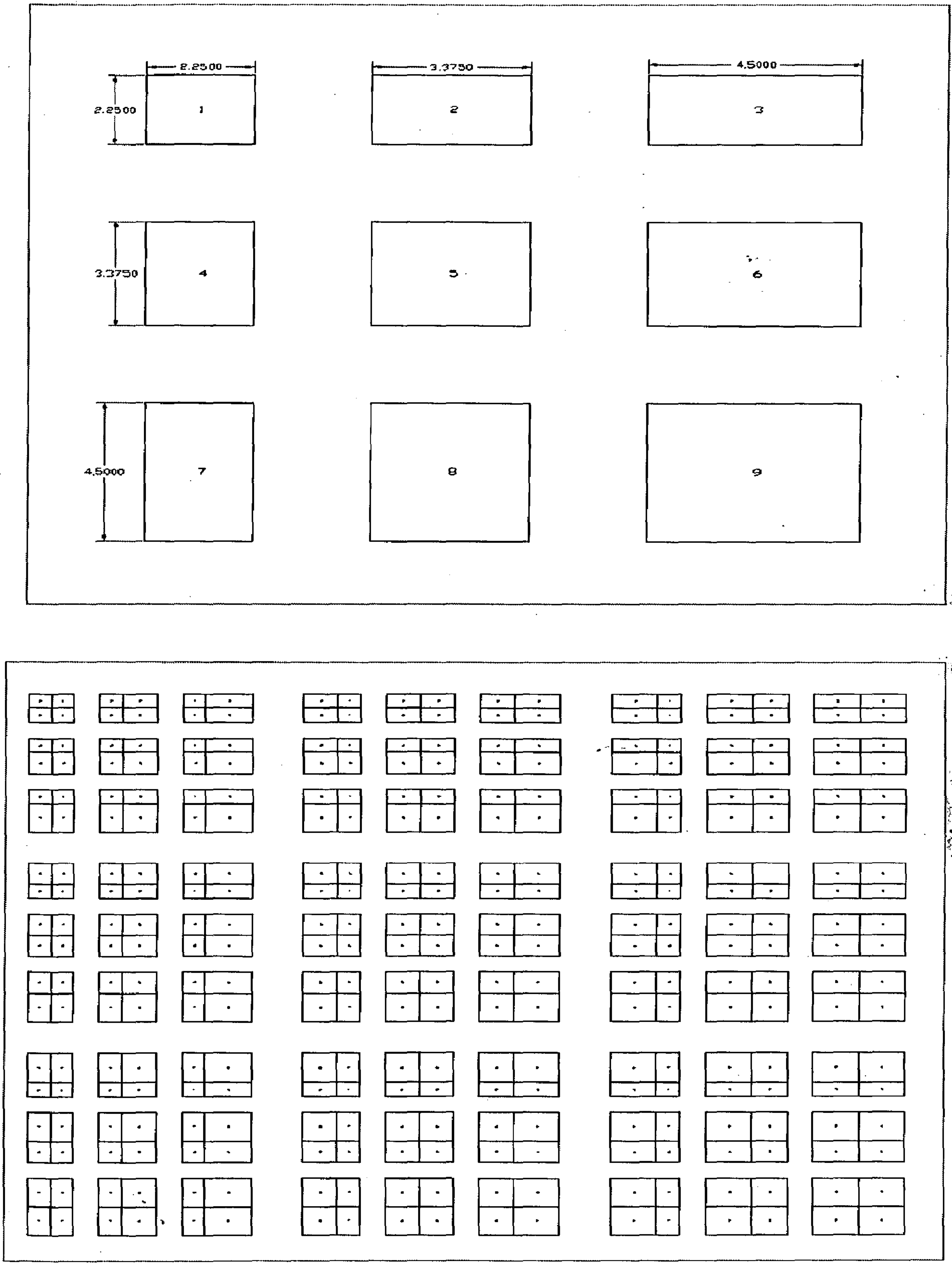


Fig. 6.22. Images of Almora

Fig. 6.21. Images of Almora

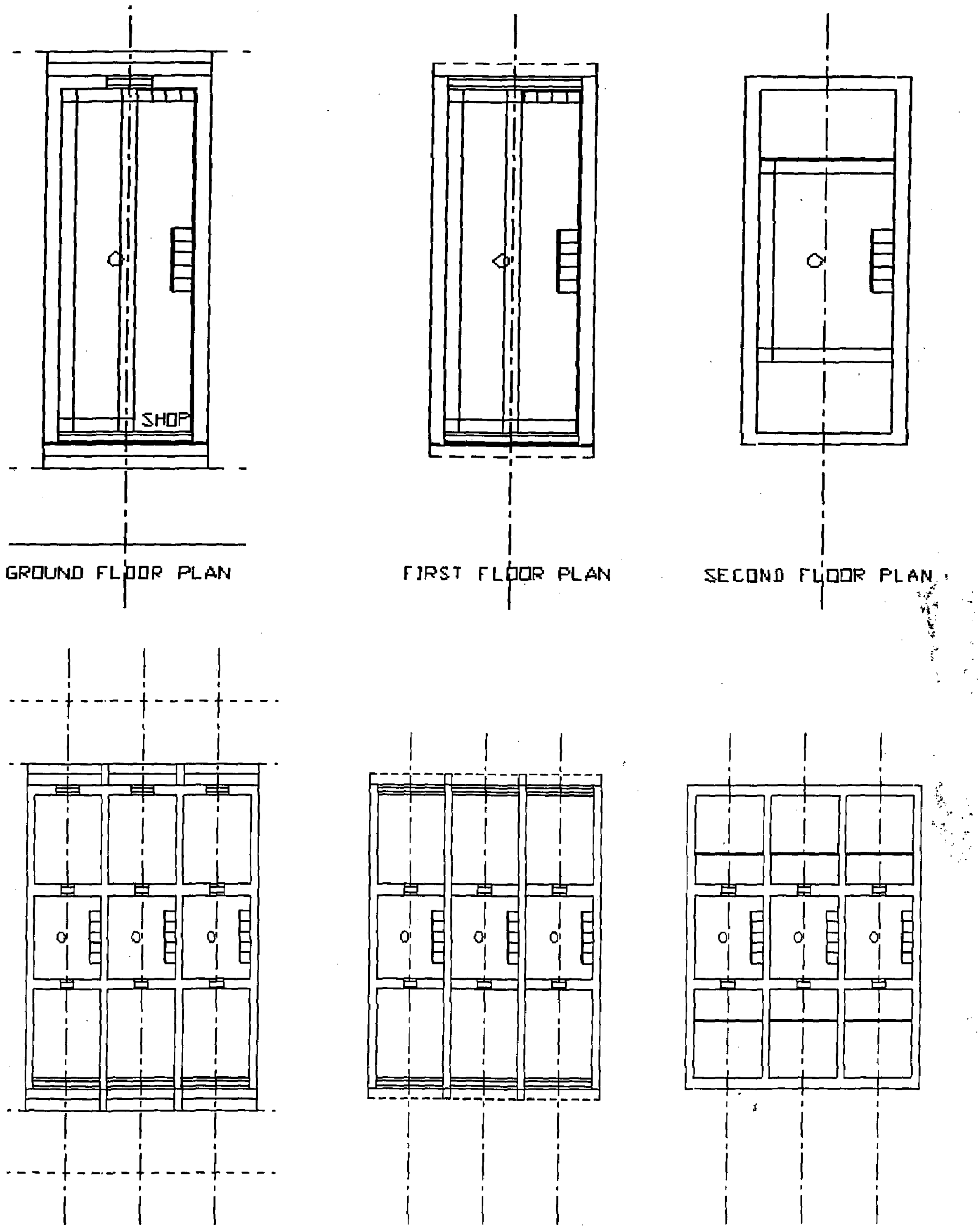
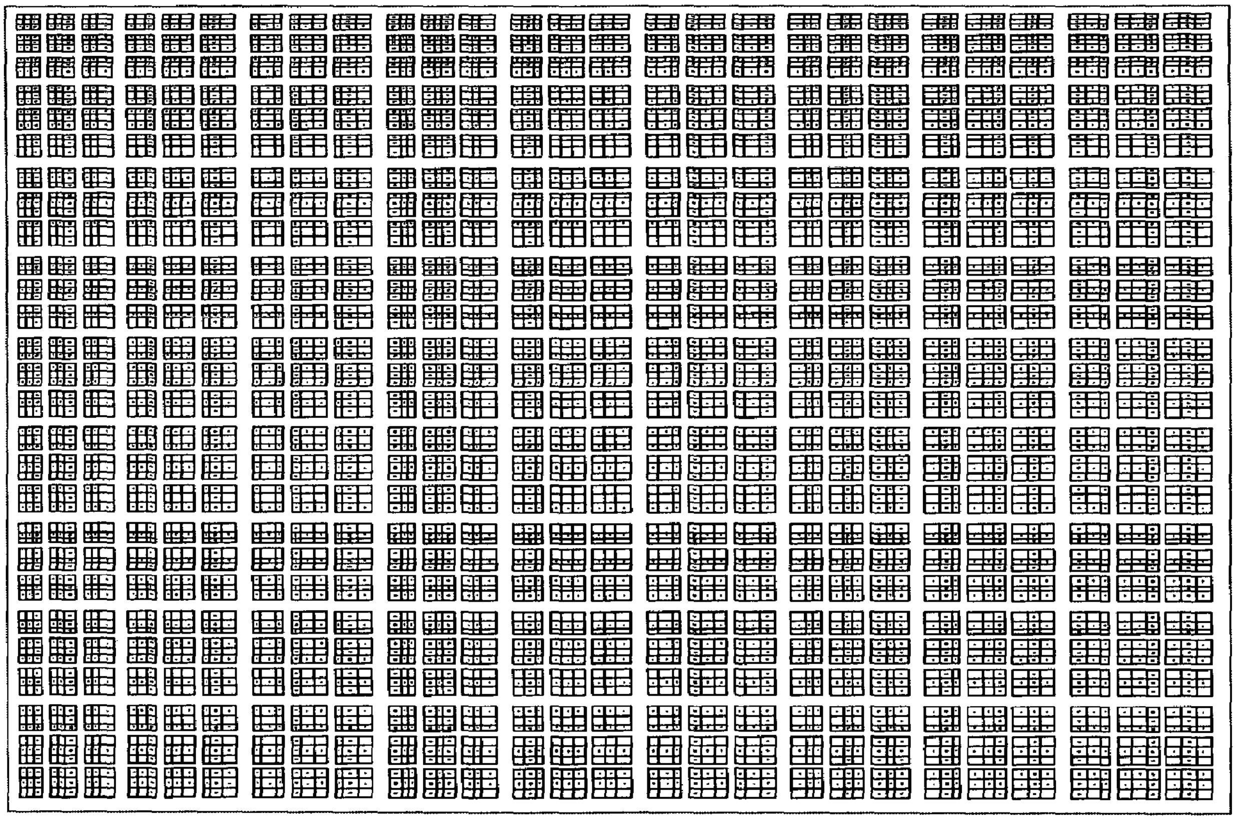


Fig. 6.24. Images of Almora



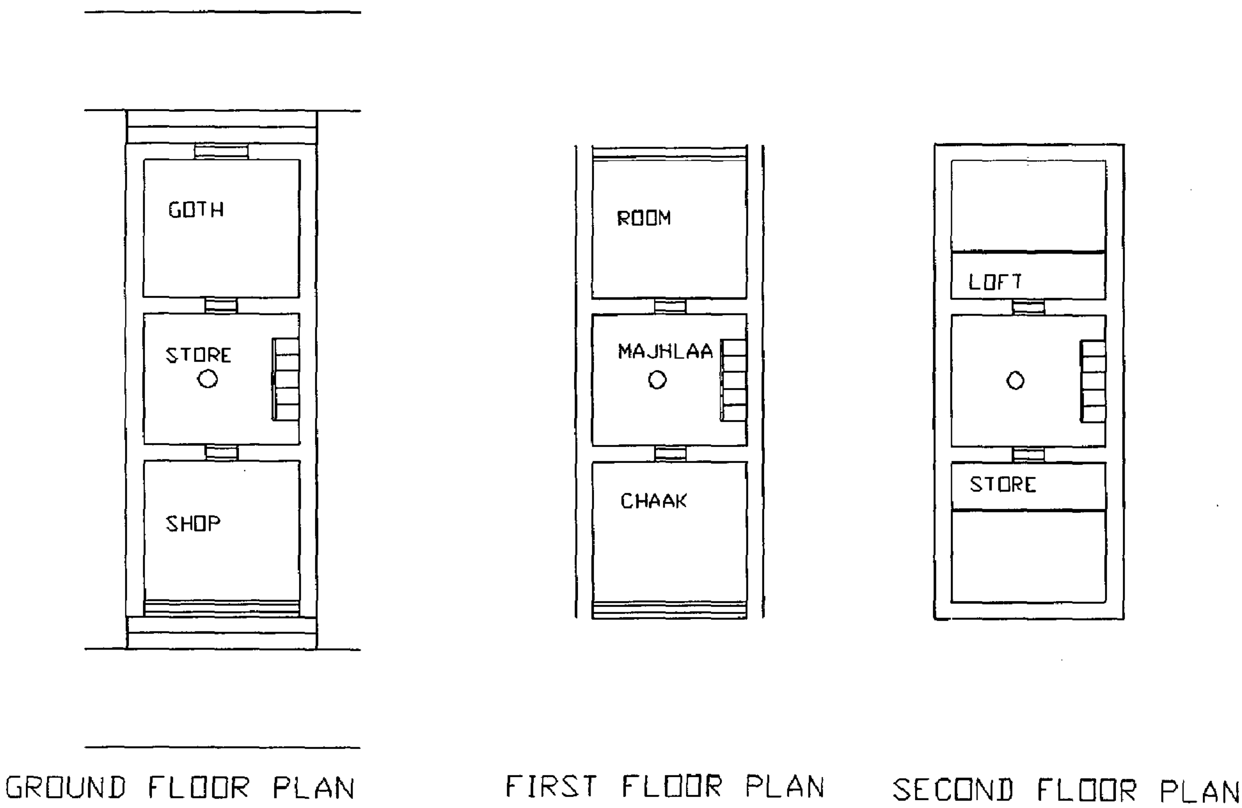


Fig. 6.23. Images of Almora

6.6. Conclusion

The Vernacular Architecture of Almora, exemplifies the highly specialized, earthquake resistant building techniques that appear to have been indigenously developed for constructing defensive houses and high buildings generally in the Himalayan earth-quake zone. This is a long established tradition in the region which, is seldom used today, but deserves to be put on record for both its local and its regional importance. It is part of a more widespread tradition variations of which have been noted from Nuristan in the extreme Northwest of Pakistan to Eastern Himachal Pradesh, and Nepal, and which may well extend further in both directions. It is a subject deserving of further research from a number of points of view, both locally in the Kumaon valley, and more widely throughout the Himalayan/Karakoram earthquake zone, and also in terms of the antiquity of these building techniques in the region as a whole. The earthquakes are reported to have caused large scale destruction owing to their high intensity, however, it was interesting to discover that the indigenous structures in Almora have not suffered any damage, and are still intact even after experiencing the quake of this magnitude. These examples which have survived the various episodes of earthquake during the last two hundred years reconfirm the viability and relevance of indigenous technology in constructing the buildings in the earthquake prone zone of Kumaon Himalaya.

The initiation of these traditional buildings of Almora needs to adopt various interventions prior to any suggestive Adaptive reuse measures. These follow in the next chapter.

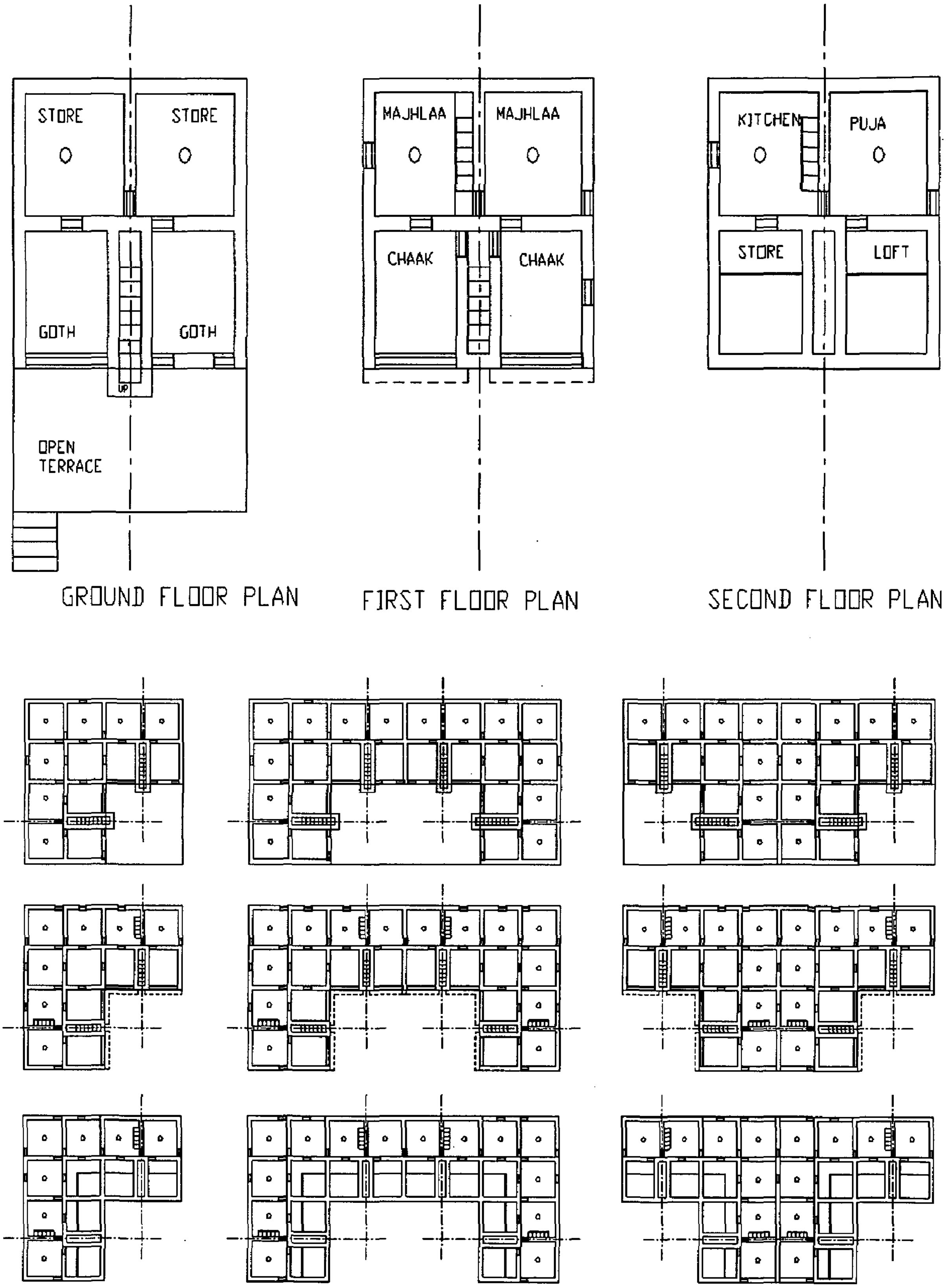


Fig. 6.25. Images of Almora

6.6. Conclusion

The Vernacular Architecture of Almora, exemplifies the highly specialized, earthquake resistant building techniques that appear to have been indigenously developed for constructing defensive houses and high buildings generally in the Himalayan earthquake zone. This is a long established tradition in the region which, is seldom used today, but deserves to be put on record for both its local and its regional importance. It is part of a more widespread tradition variations of which have been noted from Nuristan in the extreme Northwest of Pakistan to Eastern Himachal Pradesh, and Nepal, and which may well extend further in both directions. It is a subject deserving of further research from a number of points of view, both locally in the Kumaon valley, and more widely throughout the Himalayan/Karakoram earthquake zone, and also in terms of the antiquity of these building techniques in the region as a whole. The earthquakes are reported to have caused large scale destruction owing to their high intensity, however, it was interesting to discover that the indigenous structures in Almora have not suffered any damage, and are still intact even after experiencing the quake of this magnitude. These examples which have survived the various episodes of earthquake during the last two hundred years reconfirm the viability and relevance of indigenous technology in constructing the buildings in the earthquake prone zone of Kumaon Himalaya.

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7.1. Introduction

This chapter discusses the various structural interventions to the various structural elements of the historic buildings at Almora, essentially beams, trusses, frames, walls and foundations. Thereafter, causes of decay in materials and the structure are analysed like, climatic, earthquake, botanical, biological, microbiological, insects and pests, besides manmade causes. Internal environment of the buildings are assessed. Thereafter building repair and special techniques are suggested. Adaptive Reuse suggestions are proposed on the type of functions to be introduced within.

7.2. Structural Actions of the Historic Dwellings

The commonest dynamic load is wind, but earthquakes are essentially dynamic loads acting horizontally on all parts of the structure above ground as the result of vibratory displacements of the foundations. Traffic, while producing comparatively small dynamic loads, can have major long-term effects. Active loads such as the weight of people, furniture and goods, vehicles on a street or water against a wall have to be balanced by the resistance of the structure and these, together with the dead weight of the structure, have to be passed on, and balanced by, the opposed resistance of the soil below the foundations. Changes in temperature and humidity or even the setting of cement can produce expansions or contractions which, if restrained, produce large active loads. Whether there is an adequate reserve margin of strength and stiffening in all the structural elements of an historic building and their interconnections to resist live and dead loadings is often a matter of judgement. Where the structure permits of only one pattern of equilibrium it is statically determinate, but if more than one pattern is possible then the structure is statically indeterminate and the loads will take the path through the stiffer routes and by-pass those parts that give way more readily. The calculation of stresses in complex indeterminate structures is an extremely difficult task. These old structures tended to be massive and indeterminate since they were built of relatively weak materials. An indeterminate structure has the possibilities of many readjustments within its form and can absorb new loadings, settlements and distortions. In statically indeterminate structures, deformations lead to the establishment of one of many possible patterns of equilibrium. Further deformations reduce the number of choices left to the structure, which tends to become more and more nearly determinate in the process of time. The total deformation that an indeterminate structure can absorb is a matter of judgement which must depend upon consideration of analogous situations, while bearing in mind that analogies must not be pushed too far. These small buildings are more liable to suffer from neglect, carelessness and changes to unsuitable uses.

Materials Used

Let us consider the two main structural materials found in these historic buildings—timber and masonry. Members of timber systems can resist tension as well as compression, and the joints can resist tension, but the strength of the total system is limited by the strength of the joints. The span is limited by the length of timber available. The length of wooden beams is limited by the length of available timbers. The known timber structural systems include, for walls, solid timber tree trunks set horizontally, simple post and lintel systems, and for roofs, simple trussed beams, framed trusses, rafters and ties. In contrast to timber the total strength depends more on the compressive strength of the material rather than on the joints. In the case of stone, its strength, quarrying facilities, lifting and transportation were also vital considerations. These historic buildings carry their loads by massive and stiff forms. Although the strength of materials is of interest in extreme cases, generally it is not of major significance unless decay of the material affects the strength of a structural element, otherwise such decay is only of secondary importance.

Structural Elements: Beams

Post and lintel, column and beam and slabs made of beams side by side, resting on continuous walls, are the most elementary form of building construction in both timber and masonry. Just as a beam conceals within itself the action of an arch, so slabs contain the actions of shells and membranes. The directions of principal stresses, as shown earlier in **Figure**, of compression (thick lines) and tension (dotted lines) are known as isostatics. These give a picture of typical situations that will enable visible evidence to be understood and interpreted. A simply supported beam (free to rotate about the supports at its ends and to expand or contract longitudinally) is an element acting in bending, compression and in shear. In carrying any particular sets of loads, a, b and c, it is equivalent to a family of arches (compression) associated with an orthogonal family of catenaries (tension). These internal arches and catenaries adjust themselves within the beam to each change in the loads. When the beam cracks due to weakness in tension, as often happens with stone, the situation changes and the beam then acts mainly as an arch and produces outward thrusts. Moreover, in this condition it is safe provided the abutments can resist the lateral thrusts which the cracks generate.

Decay and Repair

Decay in timber columns usually occurs as a result of dampness and insect attack close to the ground. Decay in timber beams usually occurs where they are embedded and subject to fungal and insect attack. Penetrating rain also can cause decay and a beam may collapse as a result. Cracks in stone columns and beams can be injected with epoxy resin and strengthened with dowels of stainless steel or bronze.

Trusses and Frames: Analysis and Assessment

Because trusses and frames require tensile strength for their function, masonry is excluded from this section which focuses on timber construction and its repair. The development of effective triangulation in timber trusses was hampered by difficulties in jointing, as the joints themselves are generally the points where trusses fail. Wood used for trusses creeps as a result of the tensile stresses imposed by the structure and movements caused by variations of humidity. When subjected to bending stresses the longitudinal fibres may be stretched by tension and squashed by compression; if this process occurs repeatedly, the wood may deteriorate in a manner similar to fatigue in metal. Where subject to tension the timber may lengthen, and splits and clefts formed during seasoning may widen. Likewise, metal nails may loosen their hold and as time goes on the wood fibres contract and leave a void into which atmospheric damp penetrates and condensation occurs, causing corrosion of the nails. Putting varnish or grease into screw holes, is the best practice. The shrinkage and compression of timber also leads to the loosening of wooden structural joints; the resulting play between them, due to movements induced by wind, may quickly cause the whole structure to become dangerous, especially with extra loadings caused by snow. Because joints offer ledges and cracks where pests can lay their eggs, these vulnerable points are often attacked first and most intensively. Joints are also vulnerable as they trap water or condensation, thus starting the rot/beetle attack sequence. Joints may fail in tension (e.g. tenons may pull out or dowel pins fail) or may fail owing to distortion of the structure and to having to withstand forces never envisaged by the designers. Failure in a joint may set up a chain reaction.

The most common causes of failure in roof carpentry construction are poor structural design, poor quality or lightweight timbers, alterations made after the initial construction such as cutting through tie beams, loss of strength owing to aging of timber, breaking of joints, sagging and spread due to rotting of ends of beams, rafters and wall plates or movement of supporting masonry. Purlin joints are often found to be fractured. To repair a timber framed structure, first the structural system must be studied, for example to determine whether it is the early box framed type of construction (possibly with jetties and exposed timbers) or the later balloon framing with hardwood or softwood studs. Posts, girders, summers, principal rafters and braces should all be traced and the timbers inspected to ensure that they are intact and the joints secure. When the original frame has been discovered, it should be surveyed and drawn in every detail. Often it is necessary to strip out parts of the building in order to do this: plaster, inserted floors, ceilings and partitions. The inspection may show severed tie beams, decay caused by leaking roofs and pipes, and fractured floors and walls without proper means of support except loose bricks or plaster lath. Shakes in old timber may not matter, but where there are large knots one may find indications of incipient breaking which must be repaired. Large shakes are often found in old oak beams. Inspection must decide whether these materially weaken the timber. These shakes can offer the female pests a convenient crevice in which to lay her eggs, they also allow moisture to penetrate and reach the heart of the wood. It used to be the custom to fill these shakes with putty mixed with hair, but such a filling has little ability to expand and contract with seasonal movement of the timber, and caulking with tar and hemp as is done on ships' decks has been suggested. The use of artificial rubber sealing compounds would appear to be more satisfactory, as these are adhesive yet flexible, although their colour may be a problem. Large shakes can also be filled with pieces of matching timber cut to shape and slipped into position and then gunned with sealing compound. The repair of timber framed structures can be attempted by in situ scarfing, but this is often clumsy and unacceptable. It is therefore generally necessary to dismantle a timber framed building section by section, recording every action archaeologically; then each joint can be reconstituted with the minimum use of new material and reassembled according to the original design, but with no attempt to eliminate distortions caused by time. The repair of timber frames has two further aspects, first, rot at or near ground level due to rising damp and rain splash, and secondly, open joints and attack by wood boring beetle throughout the frame. To avoid damp penetration into the timbers, the tenons on the posts should be cut to face upwards where possible and holes in the upper surface of horizontal members should be avoided or the joints should be designed to drain; rot and beetle attack generally starts as a result of moisture standing in these undrained joints. If the filling masonry is loose and the external plaster has been taken off, new sills may be inserted and together. The dead weight of the superimposed masonry generally cancels out any tendency for vertical tensile forces to occur from wind loading, except in light structures such as spires. It has been said that the failure in timber systems is not so likely to be due to structural causes so much as to the decay of the material itself, particularly where it enters into or is close to the ground. This decay can lead to the failure of the masonry structural elements by causing new stresses to be imposed upon the remainder of the structure; for example, the rotting of embedded beams in foundations can cause cracking of the walls like any other defect in the foundations. The rotting of timber piles exposed to different conditions by the lowering of the water level is another example. The effect of the decay of timber roofs on load bearing walls below can be equally disastrous, particularly where the walls are pushed outwards. The rotting of one end of roof beams can cause multiple collapse, because the other end of the falling beam may lever sound masonry out of position. Likewise, if the walls themselves move because of foundation settlements, or for other reasons, they can have an equally adverse effect on the roof construction. In mixed structures, the wooden elements are liable to shrinkage in all dimensions and also are vulnerable to decay from fungi and insects. As has been said, the joints of the wooden elements are the weakest parts and if these fail there is a danger of thrusts developing on the walls, which they were not designed to resist. The investigation of defects in walls and their appropriate repairs are topics dealt with after the next section, as are the particular problems associated with mud walls.

Investigation of defects in walls

Cracks in wall elevations may be of three types. Those, over the point of settlement, sloping toward the centre of gravity indicate a failure of the centre of the wall, and those opening outwards towards the extremities indicate settlement at the ends of the wall. Causes for such cracks should be investigated in the foundations. A further type of crack is vertical and may be the result of weak material, shrinkage or thermal movements. Vertical cracks, wider at the top, can mean that a wall is moving outwards or rotating on eccentrically loaded foundations. Cracks may also result from the phasing of building work and therefore it is highly desirable to know the construction sequence of a building so as to assess the date of a crack and whether it is active or static. Cracks and settlements due to initial defects generally occur within the first 20 years of the building's life. Walls are less vulnerable to eccentric loads in the plane of the wall as these can easily be distributed along its length. Open joints due to thermal movement, aging and vibration damage are the most common defects. Spalling of stone is comparatively rare, particularly if the bed joints are reasonably thick, as is most posts can be repaired by splicing. Joints may be pulled together by irons; old oak dowels or treenails can be drilled out and renewed, and faulty timbers can be replaced using scarfed joints. Lastly, all sapwood and areas affected by beetle attack should be cut back and a durable preservative applied after any gluing.

Walls as Structural Elements

Stone masonry walls all form part of the same system of enclosure of space and support of the roof. The load bearing wall is probably the commonest type of building construction element. The importance of soft thick mortar joints in allowing small movements to take place without consequential damage may not be fully appreciated. It has been observed that many masonry structures can settle up to 100 mm or more, depending upon the quality of the mortar and the thickness of the joints, without showing the movement by cracking, for the movement is absorbed by compression of the mortar. There may be a time lag of weeks or months between the actual movement and the showing of fresh cracks. Thin mortar joints may cause cracking and spalling of individual stones. As thin mortar joints are surrounded by stone, the strength of the mortar is of less importance and the mortar is often overstressed, when it may break up into powder and tend to fall out of the joints. Shear and tensile cracks are quite common in masonry walls, the former resulting most often from settlements and the latter from inherent design defects. Diagonal cracks indicate shear, generally resulting from unequal settlements. Local settlements may cause cracks soon after the building's erection, possibly due to faults in the ground such as an old tree, a midden or bog hole or well. Cracks may also be caused by the building having been initially put up over a 'pipe' (a hollow void) in chalk or in gravel subsoil or by a local patch of sand or other material under the foundations. In some cases, archaeological remains have contributed to the cracking pattern by giving the foundations unequal bearing capacities. Compressive cracking consisting of close fine vertical cracks in an individual stone is rare, as the walls of most historic buildings are generally strong enough to resist this force. Sometimes, however, it occurs in the form of spalling along the outer edges of stones which have been bedded on too thin a mortar joint, or with a hollow bed, which throws all the weight on to the outside edges. Also, if the joints in the external facing are fine and the blocks of stone are large there is a danger that the core will consolidate, leaving the skin to carry the loads in full with resulting pressure cracks, spalling and even bulging. Thus a quite small horizontal tensile force can cause large cracks through a massive wall. For this reason masonry is suspect when it has to take any horizontal tensile force, unless all the stones are cramped testing with water.

The condition of masonry can be investigated by using a diamond drill to take cores say 75mm to 100 mm in diameter at not less than 75 mm from the surfaces and in the centre of the wall. These cores should be inspected carefully, as how well the sections hold together indicates the condition of the mortar and stone. After taking the core, a lamp and mirror on a stem can be pushed down the hole and large cracks and voids can be seen with the aid of this apparatus, as it is rotated.

Water can be passed into the core hole through a sparge pipe. By limiting the outflow of water to groups of holes in the pipe, some indication of the pattern of fissuring can be obtained. Such a water test is very useful in determining the general quality of the masonry and should be used before major grouting work is proposed, but caution is advised because with masonry in very poor condition such treatment might lead to an unfortunate collapse.

General repair of walls

Walls can be repaired by cutting out the defective parts piece by piece and so renewing the wall, but if it is in very poor condition it is advantageous to grout it first. Grouting work cannot be guaranteed; all it can do is to consolidate work temporarily by filling voids. Grouting cannot renew worn out materials. Indeed there is a danger that grouting may accentuate defects by filling vertical cracks with a hard material that does not bond to either face. When repairing a very thick wall, it is often possible by rebuilding a section to carry out the repair a half thickness at a time, but care must be taken to ensure that the two halves of repair are properly bonded or tied together. If this procedure is used, the wall need not be completely supported by needling and shoring, although any opening will need temporary struts. If a large area of wall has to be rebuilt, the new work should be prestressed after the mortar has hardened sufficiently by using flat jacks to ensure that the new wall carries its share of the total load. Walls may have to be cradled with steel and timber bolted tight together wherever the opportunity presents itself, so as to make a rigid entity prior to structural works. To prevent the crushing of the masonry by scaffolding, packing pieces should be of hardwood, although there is a danger of damaging old walls from raking and flying shores if the wedging is too tight. If needling is necessary, seek out old putlog holes. One advantage of tubular steel scaffolding is that it does not need putlog holes, but can be fixed to the face of the wall using stainless steel ties drilled into the masonry at inconspicuous spots. After serving its purpose, all shoring must be removed with usual in ancient construction of ordinary buildings. Cracked stones are due to local pressures or bad construction such as inadequate bonding or the junction of works executed at different periods. Bulges due to weak masonry or overloading are difficult to detect, although not uncommon. They can indicate that a wall is near collapse. Bulges may occur in weakly bonded masonry buildings, particularly if they have been refaced with a different material. Such bulging may be caused by the cumulative effect of thermal movements which causes the facing to expand, creep or drift while the core remains more static. Ultimately, quite large bulges and cracks will form behind the facing. Walls may have other defects besides cracks. In exceptional circumstances walls which have leant outwards may be pushed back into position, if this does not mean altering the design of the building. If this course is taken, the cause of the previous movement must be cured or compensated for in the repair works, for instance by putting in a new foundation concentric with the actual loads. To carry out this rather drastic realignment procedure, the wall is cradled on both sides in a framework of timbers that provides horizontal strength and rigidity (steel joists with timber packing may be used for greater strength). The vertical and horizontal timbers should be bolted together through openings in the masonry of the wall and diagonal braces are necessary to keep all in position. When ready, a suitable cut is made at the base, as in felling a tree, so that the wall will rotate into the correct new position with the whole wall in its cradling being pulled over by winches. If it is in poor condition, the wall should be consolidated with grouting and reinforcement before such a drastic treatment.

Voids in stone walls

Although voids are often found in the walls of historic buildings, it is reasonable to assume that the walls were originally solidly constructed. The size of voids is unpredictable, but $0.1 m^3$ to $0.3 m^3$ is not uncommon and the total may well amount to 5% of the volume of the structure. The initial crack and the subsequent void are both significant in terms of structural analysis. Whereas cracks and slipping can be detected by visual observation, suitable methods of detecting the size or location of voids are problematical. Ultrasonic methods may be successful in some cases. As for all wall defects, simply tapping with a hammer and listening to the note can be helpful. Voids of 75 mm to100 diameter can be found with atomic isotopes, using plant weighing three quarters of a ton. Ultrasonic detectors are much handier but unfortunately do not appear to be able to distinguish between cracks and mortar joints and so have limited usefulness. Thus, so far there seems to be no simple, efficient method of detecting voids except by drilling 25 mm (1 in) holes and great care.

Repointing masonry

Portland cement pointing should never be used for stone, as it is too hard, too rigid and too strong, and being too impervious it promotes frost damage. The strength and porosity of the mortar for stonework should be related to the strength of the stone itself. For instance, for stone with a crushing strength of 55 500 kN/m^2 a mortar with a crushing strength of about one-third of the stone is ideal. Although the use of stone dust is often advocated by practical masons, this may have dangers: first, the fines must be sieved out, as otherwise the surface of the pointing is too much like putty; secondly, in the case of some stones the remaining coarse particles may decompose in time and thus spoil the mortar. On the whole, therefore, this practice is not to be encouraged and reliance should be placed on getting the colour and texture of the sand right and adjusting the whiteness of the mortar by using white Portland cement if necessary. A sharp crystalline sand with a little sparkle is desirable. The basic mix is 1 part of cementacious material to 3 of sand, but in exposed positions the mix may be 1 to 2 or 2 1/2. Ideally, the cementacious material should be a warm-coloured hydraulic lime, but as such a material is practically impossible to obtain nowadays, a premixed coloured lime cement mortar may be used, with 3 to 9 parts of hydrated lime to 1 part of cement by volume. In time the colour and texture of the sand will dominate.

Repair of fractures

Vertical fractures in masonry walls are repaired by working up from the bottom to the top and bonding both sides together. If wall thickness allows, narrow precast concrete bonding beams can be cut in and faced within the thickness of a stone wall.

Forming openings in walls

It is generally much more expensive to cut holes in stone walls, because of the size of the blocks and the greater difficulty of needling and shoring stonework with large irregular coursing. With stone masonry the outer skin should, if possible, be snapped off in say 80 mm thickness by using feathered steel wedges. The surface can then be reinstated exactly using the original facing stones when the works are completed. The difficulty of cutting holes for needles can be overcome if a diamond coring drill is available, as this machine can cut a neat circular hole of 150 mm or 250 mm diameter through most types of wall without damage or vibration. Then a steel joist can be inserted as a needle, and concreted into position. After the concrete has set, struts with hydraulic or screw jacks can take the load of the wall via the needles; then the opening can be formed. In this way stress redistribution and settlement by compression of the shoring are avoided and structural disturbance is minimized. In repair work, too much cutting out of stone, particularly if the stones are large, should not be undertaken as this may well shake the whole wall and cause damage which will only show in the fabric many years later. Tools usually used in cutting holes are the hammer, chisel, crowbar, Kango electric hammer, and compressed air drills and augers with a variety of bits.

If new openings have to be formed in a wall during alteration work and the wall is thick enough, the execution of the work in two halves using twin beams or arches can be both kinder to the old fabric and more economical in cost, because needling and shoring may be unnecessary. An alternative method is to insert, in a row, precast concrete blocks with preformed holes for reinforcement wires. When all the blocks have been inserted one by one the reinforcement is pulled through the holes, post tensioned with hydraulic jacks and then grouted into position. In this way a beam is put into the thickness of a wall without major structural redistribution of the forces and the wall below the beam can be cut away safely without needling and shoring. Care must always be taken when cutting openings into old walls to ensure that the end bearing of the beams is sufficient, and if this is not the case a reinforced frame should be inserted, surrounding the whole area being cut out. Where there is also a danger of adding a concentrated load to a poor soil, an advantage of this method is that, by forming a complete four sided frame, the load is spread much as before without the risk of altering the existing below ground bearing. As has been said, new work rarely bonds perfectly to old, and therefore a mechanical key or the use of non rusting metal dowels may be necessary. The old work should always be well wetted to encourage adhesion, for new mortar will not adhere to dry and dusty surfaces. Provided they are not subject to damp conditions, special resin based bonding agents can be used to improve the adhesion of new to old. All old material that can be re used should be set aside and cleaned. Concrete fill for restoration work is improved by using crushed brick in the aggregate and, following the old practice, mortars may also have ground brick together with sand added to the mix. The final pinning up of new work in an opening needs great care, and is usually done by driving in two pieces of slate to act as wedges; then any voids should be grouted. A cement based expanding grout can be used if it is kept back from the surface some 75 mm and the joint pointed with a lime mortar. Flat jacks inflated by hydraulic pressure are a sophisticated way of dealing with this problem.

Repair of rubble walls

Rubble is irregular random masonry with an undressed face. Before being grouted rubble walls should have their cavities washed out from top to bottom. Pointing should be carried out round each stone with a flush joint and then finished with a dry brush so as to bring out the sandy texture. The primary object of pointing is to keep storm water from running into the building, but it will also contain the grout which is inserted as described elsewhere. Rubble walls are weak at their angles and, to counter this, corners are often built of dressed freestone. Because this dressed stone might have been imported and thus was expensive, quoins are often of inadequate size or are poorly bonded and therefore come away from the wall. In this case, they must be tied back to the rest of the rubble walling by drilling in ties or dowels of non rusting metal such as stainless steel or delta bronze. The charm and interest of rubble masonry lies in the ability of the observer to detect each individual stone, but the aim is not a rustic effect. Modern plaster technique raises a difficulty in that it obscures the contours of the stones and is often applied too thickly to be received by the projecting quoins. Old plaster techniques can be successfully imitated by using very fine clean sand washed at least six times in distilled water and a 1:1 lime mix.

Rebuilding masonry walls

When any part of a masonry building has to be taken down for reerection, a system should be devised for marking each stone as it is removed. For simple cases a marked elevational photograph would suffice, but for a whole building, courses should be numbered from the foundations upwards and stones numbered from left to right on each elevation and all openings lettered, with each of the stones forming the dressed surround numbered in association with the key letter, the drawings being used as an index. Taking down a large area of rubble wall presents special difficulties as it is virtually impossible to employ a code. What must be aimed at is to record the character of the wall face by both black and white and coloured photographs and, if possible, a sample of the old work should be left to guide those concerned with reconstruction. When repairs in stone work have to be concealed, the facing stones should be snapped out as mentioned earlier.

Substitutes for stone in repair

Reconstituted synthetic stone was formerly made with white or coloured Portland cement and ground stone dust, latterly with resin binding agents instead of Portland cement. Unfortunately, synthetic stone on a large scale looks like synthetic stone and often weathers poorly and too uniformly, with surface cracking and crazing. Its life is limited and in nearly every case has failed one way or another after some 30 years. It is inexpensive, however, and in limited applications—for small scale dentistry, weathering of concealed surfaces and making casts of decaying sculpture—it has valid uses. The problems to be overcome are the amount of cutting back and dovetailing required, as in dentistry; the matching of colour and texture; and the question of porosity, which must be equal to or slightly greater than that of the original material. The material is moulded on to a rustless armature which is pinned securely to its base. Natural stone, when laminated, can be repaired by pinning and grouting with resin inserted by a hypodermic needle. Loose plaster can also be consolidated by similar resin injections.

Disadvantages of Portland cement in repairs to historic buildings

Portland cement, in its various specifications, is a magnificent material for modern structures which require its strength and quick setting qualities. It is useful in reinforced concrete, with suitable aggregates, to strengthen and consolidate the structure of an historic building, under professional guidance. On the other hand, Portland cement is not designed for use in mortars or plaster on historic buildings, which do not require its specific good qualities, but which suffer from its defects and side effects on traditional materials. Its disadvantages are as follows:

(1) Its use is not reversible. To remove it damages all historic building materials, which cannot then be recycled.

(2) It is too strong in compression, adhesion and tension, so that it is not compatible with the weak materials of historic buildings. It is a paradox that such weak materials have the greatest durability.

(3) Because of its high strength it lacks elasticity and plasticity when compared with lime mortar, thus throwing greater mechanical stresses on adjacent materials and hastening their decay.

(4) It is impermeable and has low porosity, so it traps vapour as well as water and prevents evaporation. Consequently it is no good for curing damp walls. In fact, the reverse is true, for if used it only drives moisture upwards. When used as mortar its impermeability accelerates frost damage and increases internal condensation.

(5) It shrinks on setting, leaving cracks for water to enter, and because it is impermeable such water has difficulty in getting out. Therefore, it increases defects caused

by moisture.

(6) It produces soluble salts on setting which may dissolve and damage porous materials and valuable decoration.

(7) It has high thermal conductivity and may create cold bridges when used for injections to consolidate walls.

(8) Its colour is 'cold' grey and rather dark. The texture is too often smooth and 'steely'. These characteristics are generally judged aesthetically incompatible with traditional materials.

Portland cement should not be used for mortars or plasters in historic buildings, but as a last resort a small proportion of Portland cement, preferably white cement, although this costs more, should be added to the lime, but not more than 10% of the volume of the lime should be added without expert advice. The traditional methods of burning and slaking lime are best, but have been lost in many countries. Traditionally, lime mortars in the mix of 1 part lime to 3 parts of coarse sand were used. The sharper and more varied in size of its particles, the better the sand. Its colour determines the ultimate colour of the mortar. Its texture can be improved by light spraying to remove 'laitance'. In thick walls and to accelerate setting, some pozzuolanic material should be added. Because it is modern, efficiently marketed by advertising and is readily available, and because it is indispensable to the modern building industry, many people think that Portland cement is ideal, but to sum up—unless it is correctly used, Portland cement mortar is the enemy of historic buildings.

Foundations

The history and methods and materials of foundations are generally the same as the walls which they support, although in some cases new structures have been built upon old foundations. Foundations are that part of a building which distributes the loads from roofs, floors and walls on to the earth below. This is generally done by a widening of the wall into a footing which bears on to the soil under the building; however, in many early buildings no such widening was practised. The major factor in the permanence of a building is the sufficiency of its foundations and if this is lacking there is no sense in spending large sums of money elsewhere on superficial restoration work.

Ground movement is not at all uncommon. Geologically it occurs continuously and in extreme cases causes earthquakes. Heavy rain can also induce landslides, while underground streams, especially in chalk and gravel, can cause potholes and caves under buildings. Conversely, blocked underground watercourses may cause the water table to rise. The absolute movements of a building—with the exception of earthquakes—are of less concern than differential or relative movements which may be caused by different types of ground under the building or uneven loading of different parts of the building. The geology of the ground upon which a building stands and which carries all the dead and super-imposed loads can have short and longterm effects. Ground movements must be considered normal for all buildings with long life, but for important historic buildings it is necessary to record these movements, as a time will come when preventive action must be taken. There are gradual geological movements in most countries which may affect the water table and underground drainage patterns. Heavy buildings planted near an historic building can alter the ground stresses and cause movement, and their foundations may block underground water movement. Ground failures do not always appear suddenly. The soil, particularly if of low permeability, may well creep even when below its actual shear resistance. The structure above accelerates the effect of ground failure as this induces eccentric loadings and turning movements. The rate of movement may die away with time as soil resistance builds up due to its compression, or alternatively it may accelerate towards collapse. These settlements may be aggravated by inconsistencies of the bearing capacity of the soil under the foundations which turn straightforward overall settlement into differential settlement, causing distortion and cracking of the superstructure. Very high loadings, up to 800 kN/m^2 have been applied to foundation soils, and loads of 4000 kN/m^2 are not unusual in piers.

Investigation of foundations

Before carrying out major foundation works it is desirable to monitor any movements by establishing a system of measurements related to an accurate and reliable datum point, if this can be found not too far away. Besides monitoring structural movements, it is highly desirable to measure alterations in the level of the water table. Deep ground water is another factor not to be neglected. This situation, combined with dynamic influences such as traffic vibrations, deep construction and tunnelling, causes settlements. The success of a building foundations depends upon the nature of the soil on which it is built. As soils are infinitely variable, each problem of foundation failure must be individually examined. The nature of the soil depends upon its grain structure and the geological way the soil was laid down; there are two general types—cohesive soils consisting of clays and silts composed of fine particles and non-cohesive soils consisting of sands and gravels composed of larger particles. With noncohesive soils, eccentric loads can decrease the factor of safety very rapidly. The settlement of foundations can change the direction and relative magnitude of thrusts from roof and vaulting, setting up new stresses and thrusts in the fabric which the original scheme of counterbalancing of thrusts was not designed to meet. Cracking and consequential damage are caused by differential settlements, which are largely due to unequal loading which can only be eliminated by enlarging those foundations that are overloaded. Ideally, in a building, all foundations should be subject to the same pressures, provided they are on ground which has the same load bearing capacity. If inspection reveals cracks and fractures that can be attributed to ground settlement, or if the structure is leaning, the probability is that stabilization of the foundations will be necessary. Such endangered structures are very sensitive, so great care is necessary in the execution of the work. The scheme for stabilization must be prepared after a full investigation; then the execution of the work must be considered together with what temporary works are needed. Often these latter considerations will modify the design proposals. Before finally choosing measures for stabilization, these should be the subject of in situ tests.

Defects in foundations may be indicated by a drop or sag in the line of the string course or plinth of a building that may be presumed to have been built horizontal, or in more extreme cases by cracks and even shattered stone. First, the movements of the building should be measured and recorded. The inclination and deformation of the building should be studied for as long as possible. Inclinations are measured with plumb bobs, optical plumb bobs, theodolites and inclinometers. Ground slopes should also be carefully recorded near leaning towers and walls. Ground water variations at different geological levels should be checked with piezometers. All possible sources should be searched for plans and other relevant documents, and measured drawings should be made of the whole building recording all cracks and deformations. The possibility that the foundation walls may themselves have decayed due to the chemical action of salts in the ground should not be overlooked. If walls rest on wooden piles, these must also be checked, for often they have decayed due to alteration—past or present—in the level of the water table. Finally, the actual size and position of the foundations must be discovered, together with any archaeological hazards that may affect them. Lowering of the water table is generally caused by pumping either for building works or for mining, in which case it will probably affect a wide area. Percolation into deep drains can also affect the water table. A change in this level of the water table can alter the bearing capacity of the soil and may have other side effects, i.e. the raising of the water table may soften clay, or the lowering of the water table may cause drying and shrinkage of clay, or the washing away of fines out of gravel and ballast subsoils. Records show that the water level varies slightly with annual rainfall. Raising of the water table occurs gradually in river valleys, particularly those that have silt laden floods. If the water table land has been raised by some extrinsic cause this will show by dampness in cellars and increased capillarity and moisture content in walls. These are serious problems. After the whole building, its site and setting, including adjacent buildings, have been inspected, then the soil and the underground environment must be studied. Simple methods of exploring foundations are in digging holes and/or measuring and probing with augers at an inclined angle. Soil can also be examined by taking cores with hand augers. General soil conditions can be obtained from government agencies. Detailed information is obtained by boring and retrieving cores for inspection and undisturbed samples for laboratory analysis including standard soil mechanic tests such as triaxial tests for different types of soil. The object is to find the bearing capacity of the soil and to understand its characteristics based upon its stratification. The quality of the soil can be further explored and tested at great depth by driving heavy piles or pressure piles, which will indicate the load-bearing capacity of the soil.

Structural interventions to improve foundations

From inspection of the building and its environment and from the tests outlined above, it should be possible to make an assessment of the causes of structural damage, and for a specialist to produce calculations of the earth statics and to devise preliminary proposals for conservation of the structure through correcting faults in the foundations. Methods of consolidation of foundations depend naturally on local conditions, and often several alternatives can and should be considered. The underground soil may be improved by chemical grouting, modern methods having been developed using boreholes 50 mm diameter at 500 mm centres involving pressures up to 200 atm to create piles with a bearing capacity of about 10.2 t each. Overloaded earth pressures may be reduced by surface excavation, or uplift pressures may be balanced by a surcharge on the lightly loaded parts. If the soil is thick and compressible, adjustment of the ground water drainage will take a long time and is difficult to control. Only an experienced expert in soil mechanics can advise upon such esoteric matters. Foundations can be improved by enlargement, or deepening, or the use of levers and anchorages and containment. Underpinning should be avoided in enlargement because of possible damage from local settlement during execution. The most elegant way to enlarge a foundation is to provide the increased area in reinforced concrete and then to needle through the wall and prestress the new foundation using flat hydraulic jacks. The classic way of deepening foundations is by underpinning, but more modern methods including pressure piles, vertical bored piles, root piles at an oblique angle and many other types of pile give better results and improve load-bearing capacity. When piling, it is imperative to choose a method that does not produce vibrations, so bored piles are essential. Levers can be constructed so as to apply a back turning moment and so reduce the effects of foundation failure on the opposite side. The moment can be applied by weights sliding inside a hollow caisson, or by a hydraulic jack or by tension anchorages fixed to piles. Tension rods which by prestressing can counteract the eccentric loads caused by foundation settlements require counterforts or anchorages sufficient to resist their tension. A suitable combination is a tension anchorage with micro draw piles. Containment by simple sheet piling may be sufficient if the structure can withstand the vibration resulting from such a driving process.

Before projects are begun, field tests on the site should be carried out using the favoured methods of repair, all such tests being carefully monitored by measurements.

Temporary work relating to foundations

The question of whether temporary support is necessary must be carefully considered, bearing in mind that any works to foundations may cause further movements and induce increased danger until the works are finally completed. Schemes which are conceived in stages, so that results can be assessed step by step, have the advantage that they allow a minimum intervention to be practised. The same measuring procedures that were used for the initial assessment should be retained during the works and continued for some years afterwards in order to monitor the effectiveness of the work. A temporary support always looks unsightly and creates its own foundation problems, particularly if the ground is poor. For such supports to be effective they should be set on hydraulic jacks which will ensure that the correct amount of support is applied. Such hydraulic jacks can also be used to provide an active back turning moment to an inclined wall or tower. Temporary anchorages can be made using micro pressure piles. Freezing of the ground may also provide temporary support but careful consideration must be given to the dangers of frost heave if this proposal is adopted. Cradling of the whole structure comes within the scope of temporary works when dealing with foundations (it is also a technique used to prevent damage from mining subsidences). Besides cradling, elements can even be supported on cables in order to enable works to be carried out. Lowering of the ground water level for a short time by local pumping is often sufficient but sometimes cofferdams or rings of well points are necessary. Such continuous pumping must be watched carefully, as lowering of the water table may induce active springs and quite violent water movement which is dangerous to the structure being repaired if any sand or silt is abstracted. In this case the work must be stopped immediately. Freezing the ground either wholly or into blocks can overcome these difficult conditions, which of course should have been foreseen by initial soil mechanic studies. Excavation for foundation work must be properly planked and strutted and any underpinning must be needled and shored. Strutting can be done using screw type props or the newer hydraulic props, which are safer as they can share loads equally and have less risk of individual failure. Timbers used for temporary structures, such as planking and strutting, should be treated with preservative as a precaution against wet or dry rot. Where loads are heavy and near the ultimate bearing capacity of the soil, and particularly if these loads are eccentric and on a clay subsoil, there may be a risk of some heave or uplift of the adjoining ground. This will place a restriction upon the area which can be opened up for foundation works at any one time. It may well be necessary to replace the weight of the soil excavated by an equal weight of sand in rot proof sandbags. In an area that is critical, it is wise not to expose more than say one sixteenth of the total, but this will depend upon the circumstances.

Repair of foundations

If it is decided to enlarge the existing footings, these new foundations can be bonded to the old ones, using post tensioned reinforcement. When new foundations are added to the old, it is likely that the new parts will not take up loadings until further settlements have taken place, but this problem can be overcome by the use of compression pads and inflatable flat jacks. The latter can be used to depress a compression pad into the earth, and if the pressure is controlled carefully the exact load on the new foundation can be calculated and the stresses can be equalized with those on the old. Such a process must be carried out slowly by stages, with smaller increments as the pressure increases. If the pressure is applied too quickly, there is danger of punching shear and not giving sufficient time for the subsoil to adjust itself to the new loadings. After prestressing, the jack space is filled with grout to give a permanent connection with the new compression pad; the jack can usually be salvaged for reuse. The most traditional method of repair to foundations is underpinning, i.e. the removal of defective footings and their replacement by new and enlarged ones. In this method, short lengths of walling are cut out and propped up while the larger foundations are inserted. The phasing of such work must be arranged extremely carefully, bearing in mind the problem of shift of load from one part of the structure to another during the course of the work. Underpinning should also include the use of flat-jacks in order to prestress the loading. A device known as the Pynford stool is most helpful for underpinning. This consists of an upper and lower steel plate of approximately 30 mm to 50 mm thickness supported on tubular legs of approximately 800 mm length. Each of these is capable of carrying loads of up to 102 t and they can be cut into position and grouted and wedged through the masonry, above and below, using an expanding grout to make sure the joint is tight. The wall above can thus be carried temporarily while new foundations can be inserted by being cast into position with the reinforcement passing through the four legged stool. The success of underpinning depends however on the strength of the masonry above and if this is not sound, difficulties might occur. When underpinning foundations, the opportunity to insert a damp-proof course should be taken whenever possible.

7.3. Climatic causes of decay

Previous sections have dealt with the effect of gravity, one of the principal causes of structural decay. This section deals mainly with geographical causes, i.e. with climate and its side effects. Earthquakes are given a separate section. Climate, in all its aspects, is one of the fundamental causes of the decay of buildings, through failure of their materials which in turn affects the structure. The resistance of building materials to climatic agents of decay decreases with their exposure and age. Water, in all its forms, is the agent that promotes chemical actions and gradual deterioration of building materials and actively damages buildings when heavy rainfall overflows gutters and rivers rise in flood. Whereas the macroclimate of the world has been classified according to the growth of different types of vegetation or annual rainfall, this information is only of indirect value to the architect examining an historic building. The active components of macroclimate that affect a building particularly are radiation from the sun, seasonal temperature changes, rainfall, particularly storms which may cause flooding on both a micro or macro scale, wind and the transportation of ground moisture. The siting of a building and the soil it stands on affect its microclimate which can modify the macro climate considerably and so increase climatic hazards. It has been shown that cities modify the macroclimate, being warmer in winter and also much more liable to heavy concentrations of atmospheric pollution. Other examples of microclimatic effects are frost ponds, shading by hills or mountains, and the ameliorating effects of water on temperature extremes, as well as that of the moisture content of the soil. The architectural form and structure of a building will influence the microclimate of its parts.

Solar radiation

Light, especially the ultraviolet component, is a destructive agent, particularly to organic materials such as wood, textiles and pigments, and causes fading, embrittlement and loss of substance. Unprotected wood can erode at the rate of 5mm to 6 mm per century due to the combined attack of ultraviolet light and rapid moisture exchange.

Temperature and thermal expansion

Building materials are heated by solar radiation in three ways: by direct solar gain from external radiation; by indirect internal solar gain through windows, the 'greenhouse effect'; and by indirect heating via the external air whose ambient temperature is raised by the sun. The shaded part of a building stays relatively cool and immobile, being mainly affected by the seasonal average temperatures. All building materials expand when heated and contract again when cooled, this expansion and contraction being called thermal movement which is a major cause of decay in buildings. The colour and reflectivity of the material alters the radiant heat input, which is the main factor inducing temperature increase. Dark, matt materials, for example, absorb more heat than other materials. The extent of thermal movement depends upon the temperature range resulting from the heat input and modified by the thermal capacity of the structure, the thickness, conductivity and coefficient of expansion of the material. Building materials with high absorptivity may reach temperatures much higher than that of the ambient air. Thermal movement is reduced by the restraints the structure can impose. A study of temperature ranges of stone surfaces shows that they reach temperatures much hotter than the atmosphere. It takes time for heat to penetrate, and at a depth of 50 mm or so the temperature of the stone is close to the average. However, a repeatedly heated and cooled skin cannot resist indefinitely. The stresses induced in building materials by temperature changes are dependent on the following five factors:

(1) The magnitude of absolute dimensional change in the material, which is the product of its dimensions multiplied by the coefficient of expansion and temperature differential and the effects of changes in relative humidity.

(2) The elasticity of the material.

(3) The capacity of the material to creep or flow under load.

(4) The degree of restraint to the movement of the material by its connection to other elements of the structure.

(5) The change in moisture content by evaporation.

The amount of solar heat gain in a structure is determined by the angle of incidence of the radiation to the receiving surface and by the thermal properties of the receiving surface (some surfaces are reflective or are made so by being painted white, whereas others are absorbent). Heat gain is modified by evaporation of moisture in porous masonry and also by the effect of exposure to wind. As well as affecting the temperature of the material and internal air volume, solar gain can affect the internal temperature of the building by radiation through windows.

Thermal movements

Depending upon the nature and elasticity and plasticity of the mortar (hard cement mortar aggravates thermal movement decay because of its lack of resilience), thermal movements in masonry are not generally acute unless the building is longer than 30m to 50 m. Since the upper portions of a building are not shaded by its surroundings and are further away from the earth with its almost infinite thermal mass, they are liable to be subjected to greater solar gain and therefore to expand and contract more. The usual sign of thermal movement in a building as a whole is cracking of the upper portions or the loosening of the stones in their joints. As expansion of masonry is not necessarily followed by equal contraction, small annual thermal movements can build up to a considerable extension over a period of years. This is called creep or drift. Let us consider thermal movements under three sections: (a) the movement of a block of stone set in a wall; (b) the movement of the wall itself; (c) the movement of a building as a whole.

Thermal movement of a block of stone set in a wall

Considering a notional block of stone set in the external face of the wall, the structural forces which are applied to the five embedded sides should be for practical purposes constant, as wind loads and variation in live floor loads have little effect on massive construction. Foundation settlements may occur which would vary these forces, but these are dealt with elsewhere. Here we will consider only those thermal movements due to heat gain by day and loss by night on the sixth exposed face of the block. Heat is transmitted through the stone by the process of conduction, but there is a considerable time lag in the flow due to the thermal mass, low conductivity and moisture content of the stone. This means that a steady state is never achieved within the block of stone. Depending upon the season, there will be an inward or outward flow of heat through the stone. In late spring, summer and early autumn there is a net gain, whereas in late autumn, winter and early spring there is a net heat loss. Temperature differential across the block of stone is likely to be greatest in the early afternoon of a hot day, but because of the time lag the temperature gradient will not necessarily be in a straight line. If the restraint is greater than the stresses engendered by thermal movement, the stone will not move. If the bedding of the stone is imperfect, causing the outer edges to be exposed to higher stresses, the edges may spall or crack at the arrises, especially if the joints are thin in relation to the dimensions of the stone, and more especially if the stone is large and heavily loaded. Cracking may be aggravated if the stone is shaped so as to produce a fine narrow joint on the outside face, while behind the face it rests on a deeper mortar bed, for even without thermal movements such a construction throws a greater load on the outside edges

Thermal movement of a wall

The second aspect of study should be thermal movements in the wall of a large, heavy, stone structure. Each type of masonry will have different physical characteristics, for as the core has a greater proportion of soft mortar it is more compressible than the outer faces.

Thermal movement of a whole building

As it takes a great deal of heat to raise the temperature of a heavy building with thick walls by even 1 °C, so it takes time for the heat to flow through the stone and mortar. There is a tendency for the outer face to be heated up before the core can respond and long before the inner face is affected. This time lag would affect the theoretical temperature gradient. Generally, conditions at the inner face are for practical purposes nearly constant and almost dimensionally stable, whereas the outer face will expand and contract. In a continuously heated building where winter and summer internal temperatures are almost the same, movements in the inner face of a wall will be minimal. The degree of lateral restraint depends largely on the plan of the building's cross walls, along with the effect of the thermal mass of the ground, the strength of end walls and their superimposed weights, and the friction between the blocks of stone set in mortar. If walls are firmly restrained at their extremities to cross walls and to the remainder of the structure, they will tend to bow outwards in summer and curve inwards in winter as the outer face lengthens or shortens. As mentioned previously, the nearer one gets to the top of the building, the more it is affected by temperature changes, and these changes will be more acutely felt because there is less restraint at higher levels. In the vertical plane no movement would occur until the upward thrust due to the thermal expansion exceeded the downward thrust due to self weight. For example, in a wall loaded at 1600 kN/m^2 no vertical movement would occur until a 5.5 °C temperature had occurred across the whole sectional area. Even a large daily temperature change would be acceptable because, since only a small thickness of wall would be affected, the stresses could be absorbed within the stone and mortar. Whereas rapid daily temperature fluctuations tend not to penetrate more than a few centimetres, seasonal temperature movements create more noticeable effects because the centre of the wall core warms up and the whole building tends to expand. However, as with daily temperature changes, upward movement tends to be reduced by the compressive forces of dead weight, and horizontal movement is thus restrained. The expansion of the core of the wall has less effect because of the large proportion of soft mortar, and there is in any case a lower range of temperature movement in this region. Thermal cracks in a building are not likely to show in its horizontal joints, although there may be some crushing in the mortar joints. Movement in the horizontal plane will show by a tendency for vertical cracks to form if mortar is compressed beyond its limits or if the wall does not return to its original position. In such a case, the ends of the wall having expanded outwards, more so near the top of the structure when the seasonal contraction occurs, vertical cracks tend to open as there is no tensile force to close them. The mortar turns to powder as it is crushed, and when contraction occurs the fine particles tend to fall and fill the lower part of the crack. In addition, dust and grit from the atmosphere may also become lodged in the open crack, forming a new bearing surface for next season's expansion; cracks thus tend to widen gradually by the process called drift or sway, which has been noted by many observers.

Expansion of other materials

The above discussion of thermal movements in a building has dealt with stone masonry, as this illustrates the problems most clearly. Where the percentage of mortar is small the joints are most liable to show thermal distress. Often the external wall is plastered, and if this plaster has the same characteristics as the soft mortar then thermal movement will cause only fine hairline cracks. Wood moves markedly and fairly quickly with changes in the relative humidity of the air and these movements are far greater than thermal movements. Because of its nature, wood is generally used in a framed structure which is able to absorb both thermal and humidity movements.

The action of moisture

The presence of water in any of its various forms causes or accelerates the decay of most building materials. The access of water to porous masonry materials may be caused by rain. Water reaches a masonry surface when the rain hits the surface directly; it may also reach the surface indirectly, falling somewhere else on the building and gaining access through a more complicated path. The latter case often produces the worst damage, because the rain water picks up soluble materials along its path, and destructive crystallization processes occur when the water evaporates. Faulty disposal of rain water is the most frequent cause of deterioration in ancient masonry. Water also penetrates porous masonry materials through capillary action; suction is exerted by capillaries. The height of the capillary rise of water in porous masonry materials depends mainly on the pore size (the smaller the size, the higher the rise) and the rate of evaporation from the external surface (as evaporation increases, the rise is reduced). The capillary rise increases with time, as soluble salts are carried by water into the masonry and become concentrated there when the water that carries them evaporates from the side surfaces of the wall. The increased concentration of soluble salts causes in turn another force of attraction for water, since it must diffuse from low salinity to high salinity regions. The result is that an equilibrium is never reached, and the capillary rise of water increases with the structure's age. Old thick masonry sometimes shows capillary rises as high as 8m to10 m, 4m to 5 m being common. Sometimes the water drawn up by capillary action into the masonry is rain water that has been discharged near the base of a wall by a faulty gutter system. Finally, water can gain access to masonry materials directly through the air, either by condensation or by the deposition of aerosols, such as mist, fog or salt spray. Condensation occurs when the air is damp and the masonry surface is colder than the dewpoint of the air. Condensation occurs on the coldest surface available; therefore, 'cold' materials, i.e. materials with high density and high thermal conductivity, are most affected by it. Condensation water is far more dangerous than rain water because it sweeps a large volume of air in front of the cold surface, cleaning it completely of all suspended dirt or gaseous pollutants. Liquid solutions containing free sulphuric acid then form on masonry surfaces in polluted atmospheres, and particles of carbon black, iron oxides, calcium sulphate and other substances are deposited.

Aerosols are liquid or solid particles suspended in gases, in this case, air. Aerosols hit surfaces that are particularly exposed to air currents and discharge their particles on them. They are also attracted by cold surfaces, where they produce effects similar to those of condensation, even if the temperature on the surface does not drop below the dewpoint. It is often not easy to decide by which mechanisms water has gained access to a masonry material. Condensation, in particular, is often not sufficiently considered, the 'humidity' it produces being attributed to rising damp when it appears in the lower register of walls or to the penetration of rain when it appears in ceilings and vaults. The consequences of misjudgement are often ruinous. As a general rule, in the case of cold, compact, low porosity materials, it would be wise to suspect condensation first, while the reverse attitude might be taken for more porous materials. Accurate temperature/relative humidity surveys should be made as often as possible. A characteristic feature of water distribution inside hard porous masonry materials is the existence of a critical water content that depends on the type of porosity and the nature of the material. Above the critical content, water can move freely in the liquid state inside the porous body, whereas below the critical value, water is held inside pores and can be removed only by evaporation. It is often difficult to dry a masonry structure because the critical water content may be quite high. Walls appear wet up to a certain height in a structure where the water content is at the critical value. Above this point, walls appear dry, and the water content drops sharply to a low level.

Precipitation of moisture

Both the rate of rain falling in a short period and the direction in which it is driven are of crucial importance in the maintenance and preservation of a building. The ability of rainwater disposal systems to deal with the worst possible storms of short duration is vital. Rain can penetrate to the interior of a building and cause various kinds of decay. The absorption capacity of stone is much less, for most types are nearly waterproof. Rain penetration can cause internal decay in stone walls forming large internal voids, some of which may require 250 1 or more of filling material such as grout. A permeable or absorbent material must not be jointed or pointed with a more dense or impermeable mortar or else rain water will be trapped in the pores of the material and when there is a frost will cause severe damage. In warm weather, a thin porous wall wetted by rain may be so much cooled by rapid drying conditions as to induce internal condensation if the internal air is humid. Hard, impermeable materials throw greater strain on their joints and require harder mortars.

Frost and snow

In the case of foundations which may be affected by frost heave, the number of frost changes is rapidly reduced by increasing the depth of the foundations. Foundations should be deep enough to avoid frost heave or expansion which can cause the subsoil to move with consequent damage. Ground temperatures also vary between summer and winter. The resistance of these materials depends upon the size of the pores and their hydrophilic or hydrophobic structure. If ice forms in the pores having a good structure it can expand on freezing without damage. In prolonged frost, however, ice may actually build up inside the material because of condensation of water vapour.

Snow falls in flakes and lies in thick blankets on roofs and over the ground. Driven snow can attach itself to near vertical faces and be blown in through ventilators and other openings and, having penetrated, can cause stains on ceilings and floors when it melts. If there are parapets or valley gutters, melting snow can cause blockages, with melted water rising above the level of the waterproofing and so causing flooding. For hand operations, a wooden shovel is recommended in order to avoid damage to the roof covering.

Wind

Clearly the structure must be strong enough to resist wind pressures; it must also be able to resist the associated suction on the lee side. It might well be assumed that because an historic building has succeeded in resisting all probable strengths of winds during its lifetime, it will be strong enough to resist all future wind forces, but this does not always follow, as the structure may have deteriorated and there is always the possibility of an exceptional wind.

Wind exacerbates the general external erosion of most building materials. If a small piece of hard grit gets into a surface pocket, gusts can rotate it at high speeds and thus drill quite a large hole in soft stone. Rapid evaporation by wind causes salt crystallization to take place within the wall rather than on the surface. This breaks up the material of the wall and causes cavitation, which intensifies evaporation and further crystallization—a phenomenon called cavernous decay in stone. Indeed, the most serious effects of wind pressure are found in conjunction with rain. When combined with heavy rain, wind causes serious internal decay after the surface reaches saturation point and the rain, driven by wind pressure, penetrates cracks, fissures and porous materials. Wind will also blow rain sideways, a point often neglected in detailing, leading to unsightly streaks which occur where vertical upstands and joints check the sideways movement of the rain water and thus cause concentration of the flow downwards.

Particulates, smoke, dust and sand particles

Dust disfigures the exterior and interior of historic buildings.

Natural disasters

Besides earthquakes, the main list of violent, unforeseen and calamitous natural disasters which may affect historic buildings includes landslides and landslips and phenomena related to land movements and disruption, and even unexpected frost, for if this occurs only at infrequent intervals it can be all the more damaging for being unexpected.

Insurance against disasters

Insurance of historic buildings against fire and natural hazards poses difficult problems, particularly as much of the fabric and contents is irreplaceable. When insuring the fabric, allowance should be made of inflationary cost increases during the time it would take to renew the building, taking into account research, design and the shortage of skilled labour. But few owners of historic buildings can afford full insurance. If the loss were total the building could not be replaced; accordingly it should be insured for a reasonable figure by negotiation with the insurance company concerned, and the averaging clause usual in commercial insurance should if possible be deleted. Most important of all, after any incident or disaster the insurance company must be notified immediately (and the architect as well). Full insurance claims, however, should not be made until reports have been obtained from all concerned, including police and fire brigade if involved, and a meeting held under the chairmanship of a responsible person to establish all the facts of a case. Frivolous or badly framed claims only waste time and lead to increased premiums. Detailed estimates of damage should be obtained to substantiate the claim.

Earthquakes and historic buildings

Earthquakes cause immense damage to cultural property. Much damage can be prevented by prior inspection and simple strengthening of weak points in the typical construction of historic buildings in each country. The strengthening can be carried out economically as part of the maintenance strategy for each building. Historic buildings should be identified and fully documented before a possible earthquake, using photogrammetric techniques if available. After an earthquake, it is essential that an architectural conservator be consulted to advise the rescue organization and prevent unnecessary destruction of what cultural property remains. The resultant ground-shaking causes dynamic movements in all three dimensions of a building: height, length and breadth. In considering these movements and the associated loading one must think dynamically and not in terms of normal statics. Loadings and energy input are related to the mass and stiffnesses of the building. The ability of an historic building to absorb the energy input without damage is crucial. This is because damage caused by an earthquake of a given magnitude depends on many things: the condition of the buildings affected (i.e. whether they have been well maintained, the quality of their workmanship and of previous earthquake repairs); their form and design; local ground conditions; and the direction and type of the seismic waves and the distance from the epicentre. The collapse of buildings is the primary cause of loss of life, so preventive measures to strengthen historic buildings will also save life and limb. The secondary effects of earthquakes such as landslips, and ground movements, with changes of underground water levels and flow, can also be devastating. Their first effect is to disrupt communications and make rescue more difficult. In addition, an earthquake site is generally held in a pall of dust. Since the art of designing to resist earthquakes is in its infancy, all codes are still based upon gross simplifications, using subnominal horizontal loadings or base shears as the design criteria for new buildings. It is the considered opinion of experts that such codes should not be applied to historic buildings of very different structural types, and it must be stressed that no historic building should be condemned to destruction or taken out of beneficial use solely because it does not or cannot comply with the current official code. Many factors outside the code must be taken into consideration, starting preferably with a ground movement seismic spectrum, which can be predicted by a seismologist for a given site.

The seismic spectrum for any particular site will take local ground conditions into account, such as soil types, the slope of sedimentary soils, the existence of any bedding planes and their angle of slope, horizontal changes in soil types, the depth of soil over bedrock and the topography of bedrock including ridges and deposited soils. Water content and the level of the water table are also important, for with a water table less than about 8 m depth there is a danger of soil liquefaction in an earthquake. Examination of earthquake damage shows that the direction of the waves has a considerable effect on the resistance of the building. The structure disintegrates into large lumps if well built and rubble if badly built. With simple vernacular buildings the front walls fall out into the street and the roofs and floors crush the occupants. From examination it can be deduced that square, circular and octagonal buildings have the most resistant forms; rectangles, particularly if long, may have differential behaviour at opposite ends, while projecting wings and features produce weaknesses. The basic causes of damage are relative ground displacements and the inertia loads that result from ground accelerations. The factors affecting the seismic performance of an historic building are its mass, stiffnesses, periods of vibration (all of wh[illegible] damping capacity or ability to absorb energy, stability margins, structural geometry, structural continuities and distributions of mass and resistance. Historic buildings usually lack the ductility and structural continuity which can be designed into new buildings. The compatibility of the various structural elements and the availability of alternative structural actions, when some elements fail, are important considerations. Lastly, there is the general condition of the structure, has it been well maintained and carefully repaired in the past. Earthquakes seek out the hidden weaknesses in a building, so are often blamed for what was a faulty repair, bad workmanship or lack of preventive maintenance.

Structural performance of historic buildings in earthquakes

Having examined the risk to the historic building we can now consider its resistance in general terms and the available methods of improving this resistance. The resistance depends upon the form of the structure, the strength and workmanship of its construction and its material and its dynamic performance. Simple and symmetrical forms are best, not too elongated and with uniform and continuous distribution of strength. Each historic building is a case for individual study involving a meticulous inspection of the fabric. A study of its previous repair history and preventive maintenance are the first steps, followed by such strengthening against dynamic forces as is practicable and economic, in conjunction with its overall conservation plan, which gives a reasonable approach to prolonging its life and reducing the earthquake hazard to its occupants. In addition to the effect of the direction of the shock wave, the predominant frequency of these waves and the natural frequency of the building and ground are vital questions. The stiffness of the building in relation to the properties of the subsoil should be assessed by a seismic engineer. The whole building may vibrate in a certain frequency due to its form and stiffness, and if there is a dynamic resonance the structural damage will be much greater. Cracking and other disruption of the structure may accidentally increase or decrease this resonance. In a severe earthquake, badly bonded elements act like battering rams oscillating in different modes. It has been observed that a masonry building can survive a few shocks of great intensity, but that vibration of long duration is damaging. Historic buildings are generally stiff; if they are not also very massive they will have short periods of vibration and will be safer if they are on 'long period sites', resting on soft soils of some depth. Prevention of earthquake damage can only be practised within the context of the past history of the conservation of the building. In seismic zones the strengthening of valuable cultural property should be included in the general programme of preventive maintenance, as and when made economically possible, in conjunction with other major building repairs such as renewal of roofs or strengthening walls and foundations.

Methods of strengthening historic buildings

Timber structures are considered the most earthquake resistant among traditional forms, provided their joints are sound and the timber is not attacked by insects and fungi, but unfortunately they are vulnerable to fires which often follow earthquakes. Masonry structures are generally less resistant unless the masonry is reinforced. Unfortunately, apart from those with timber framing, most historic buildings come in the lower grades of resistance, being stiff structures made of brittle material. Re pointing grouting and replacement of defective mortar are the practicable remedies, but in extreme cases reconstruction may be the only course open. Examination of earthquake damage shows that bonding of walls together at the corners is vital, together with the tying of floors and roofs to walls. The insertion of tensile reinforcement with some degree of prestressing to bond elements together gives the masonry of historic buildings greater earthquake resistance. Similar strengthening should be done at roof level where the anchoring of wall plates and tying together of roof timbers should be given special attention, as earthquake damage often starts at this point. The mix of the reinforced concrete should have strength characteristics close to that of the masonry, so should consist of weak aggregates and mixes. Considerable strengthening of masonry buildings can be obtained by grouting procedures of all types using hydraulic limes. In special cases the use of expensive polyester and epoxy resin grouts will be more than justified. Such grouts can be used following the normal injections, thus exploiting their penetrating power to fill fissures and fine cracks and avoiding the necessity of filling large voids with costly materials. Cross walls and partitions must be securely attached to the main walls. Lintels over doors and windows should extend at least 400 mm beyond the opening to give extra protection. If doors and windows are so placed as to cause a weakness in a wall, long reinforced concrete ties may have to be inserted in a concealed way, so as to disperse the concentration of dynamic stress which occurs at their corners.

Earthquake shocks are transmitted to the building through its foundations. If the foundations fail the results will be totally disastrous, so foundations should always be investigated. If the water table is high the danger of soil liquefaction is much greater, so the possibility of natural drainage should be looked into when making the investigation. If a building rests on sloping strata or variegated soils, peat and clay, special measures will be necessary, such as piling of varying depth to support the whole building on the same stratum which must be sound itself and not liable to liquefaction when an earthquake occurs. The pilecaps must be linked with horizontal beams and secured to the existing structure carefully. In other cases it may be sufficient to unify the foundations with ground beams around the perimeter. Also, sculpture and landscape ornaments will need special fixings to prevent them being thrown about during an earthquake.

Preventive action before an earthquake

In high risk zones at least, there should be some preventive action before a possible earthquake. We have dealt with some structural possibilities of strengthening historic buildings. Fire fighting precautions also rate highly; public safety is the main concern of earthquake measures, followed by minimizing the cost of any incidents. In addition to listing and marking all cultural property, it should be fully recorded using photogrammetry where appropriate, priority being given to property of high value in a high risk zone. Emergency plans should be worked out in advance between the military and the civil authorities, with the advice of conservators of cultural property. A depot or store for emergency conservation supplies should be created. Regular inspections at five year intervals will provide the basis for preventive maintenance, thereby reducing risks to life and property. If the building collapses around the occupants there should be a chance of rescue. Public safety is increased if there is preparedness for a disaster. Each house should have a safe place specially strengthened which can be reached quickly. Here there should be a container of water, emergency food, a torch and a battery operated radio.

After an earthquake

Following an earthquake there is great human shock. Part of the unrecorded shock syndrome, however, is to assist in the destruction of what is left, arson is common and wanton destruction of historic buildings that could have been saved is surprisingly frequent, although prior documentation could have prevented this. The confusion of the event compounds these additional dangers to cultural property. Quick inspection of the damage is essential. Dangerous elements must be made safe. What can be saved should be shored and strutted to prevent collapse should there be further tremors, as often happens. An international colour code is necessary. Architects with sound engineering judgement and wide cultural knowledge are necessary for this work. Particular emphasis must be given to strutting and shoring techniques and structural first aid in earthquake situations. Often there is external difficulty and danger in making an inspection; in such situations a mobile photogrammetric unit could be of immense assistance as it could take measurements and produce drawings, without risk, to give general information. Although this is technically possible, suitable equipment has yet to be developed, and this should include plant to facilitate detailed inspections. The safety of working conditions will need constant monitoring. Helmets and dust masks should always be worn. An authoritative architect must have the authority and means to make historic buildings safe by temporary strengthening and shoring. Temporary roofing materials, in addition to polythene sheets, are urgently needed to protect valuable objects which cannot be moved. Later, after full documentation, when repair work can start, in addition to the traditional building materials, stone, timber and roof slates, the repair teams will need light drilling equipment with an electric generator, stranded stainless steel wire, grouting equipment, and special materials such as pulverized fly ash and fluid coke and epoxy resins. These supplies will enable local builders to make quite sophisticated repairs, leaving long shot drilling to specialist contractors.

The conservator must also have authority to organize transport of all movable works of art and other cultural property to safe storage outside the earthquake zone. Schools of architecture in seismic zones should be ready to send student volunteers to form a cultural property protection force, with tents and feeding arrangements.

Repairs after the emergency

After the first phase there comes a long climb back to normality, which may last several years. The amount of the damage must be assessed, which means detailed inspection of all cultural property and grading of damage. Bearing in mind that the detailed characteristics of earthquakes are unpredictable and the way an historic building will react to an earthquake is also unpredictable, the most profitable field of study is in analysis of the case histories of earthquake damage to the typical types of historic buildings in the locality. Taking whatever resources are available, the best use should be made of them by skilful application to the weakest parts of an historic building, as and when opportunities present themselves in a general programme of preventive maintenance, for well maintained historic buildings of good workmanship have proved themselves to have a high degree of earthquake resistance.

The principles of repair should be to restore and improve the building capacity to resist an earthquake, enabling it to absorb seismic energy without dangerous damage occurring. The fabric of the building should be considered as a whole, elements being tied together to better resist seismic stresses and to avoid disintegration into mutually destructive parts. One must imagine the most probable mode of destruction and design against seismic disintegration.

After an earthquake, examination of typical collapse sequences should be made in order to rectify defects in traditional local construction. There is never a single correct answer to the structural problems, so several alternatives must be considered and costed. The answer given by applying modern building regulations is rarely the right one, as each historic building is an individual case and must be treated as a special problem. One must consider the sequence in which the damage occurred; how it might extend and how it might be prevented in the next earthquake. Traditional practices of each region must be accepted where they have been proved to be good, but where they have failed they should be improved upon with modern techniques.

Weight at the top of buildings should be reduced if possible. Ties and struts should be inserted at strategic places, and the closer they are to the centre of gravity of the structure the more effective they are likely to be, hence the importance of bonding floor joists to the walls. Structural systems should not be mixed, as every joint between materials produces problems of unification of their reactions in an earthquake. The principles of conservation must be followed all the time, but with the added difficulty of considering, in addition to static forms, the dynamic force of an earthquake. The character of ensembles must be recognized and this includes the way they were lived in and utilized. The value of full documentation as a basis of scientific repair work cannot be overemphasized.

A disaster also presents opportunities to correct defects in town planning. At town planning level it may be the policy to upgrade dwellings or even change uses. The opportunity can also be taken to bury unsightly electrical wiring, especially if new trenches have to be dug for drainage.

A multidisciplinary team will have to be assembled and this should consist of conservation architects, specialist engineers, archaeologists, historians, urban planners, art historians and conservator/restorers.

Botanical causes of decay

Creepers and climber plants can cause damage if allowed to grow freely. Creepers drive a bullet headed roots into crumbling masonry and cause disintegration. Fresh creeper tendrils can, when forcibly removed, pull off a weak surface of brickwork or plaster, so the plant should be cut and killed and then left several weeks until it has lost its adhesive strength.

On the other hand, the rather familiar sight of a boundary wall covered with climbers should be studied carefully because the plant may in fact be holding up the wall, and if it is removed the wall itself may fall to pieces. On buildings proper, rather than garden walls, plants must be kept in check to prevent its growth getting out of control. When it is cut, the stem should be treated with a strong weedkiller so as to poison the roots and prevent its sprouting again.

Stonecrop and wallflowers are pleasant, but they usually indicate decay and poor maintenance. Indeed the presence of growth often indicates that the pointing has perished, in which case it should be renewed as soon as feasible, incorporating a toxic agent in the mortar if plant growth is a constant nuisance.

Some kinds of wall climbing plants do not damage masonry directly but must none the less be kept away from the eaves and gutters to avoid blockages. The architect may well come into conflict with a client who is a keen gardener and puts the life of his plants before the maintenance of his building, or the architect may himself think the building looks better covered up. In such cases it is good practice to insert galvanized vine eyes and use stainless steel straining wires. Alternatively, the plants can be grown on frames; an advantage of this is that when superficial maintenance of the wall is required the frame can be unfixed and the plants bent forward intact on the frames.

The roots of trees and bushes can cause blockages and local ground dampness by finding their way into rainwater drains. In extreme cases, when rainwater drains are broken by roots, the leaking water can cause sandy types of soil to wash away from below foundations. Conversely in clay soils there is the well known fact that trees can damage foundations by excessive withdrawal of ground moisture in summer, resulting in ground shrinkage and foundation movement with subsequent cracking of walls and partitions. Trees and plant growths can overwhelm historic buildings and sites in the tropics, where constant maintenance is required to hold them back.

Biological and microbiological causes of decay

Bacteria and lichens can cause the decay of building materials by producing acids which react chemically with the structural material. Algae, moss and lichens all grow on stone masonry and build up humus in which larger and more damaging plants can grow. There is an added risk from dampness and clogging of pores if the material is not adequately frost resistant.

Some micro organisms develop rapidly if the air has a relative humidity of over

65%, and they spread quickly if there is light. They may take the form of spotty staining of varied colour. A durable cure can only be effected if the source of dampness is located and eliminated. After removal there is some surface loss in the form of tiny holes which may at first be almost invisible.

There are a great many varieties of algae; those that occur on most stone surfaces are usually green, red or brown powders or filaments which may or may not be slimy according to moisture conditions. They derive their energy largely from sunlight, but need liquid water for survival.

Mosses need a rough, moist surface on which soil and dirt can collect; once established they tend to hold moisture in the supporting surface of masonry or wood.

Toxic washes are used to kill algae, lichens and mosses. Incipient lichen and algae can be softened and removed by wiping with diluted ammonia, while heavier growths can be killed by spraying with formalin. Large areas of masonry can be sprayed with a solution of 25 g/l of water of zinc silico fluoride or sodium pentachlorphenate or various branded solutions. Horticultural tar wash will also remove lichens and mosses, and as far as can t seen does not seem to discolour the background material more than temporarily. After th growth has died and shrivelled, it can be safely brushed away or carefully scraped off. Plant growing in joints or pockets of masonry can be killed by spraying with an appropriate gardene weedkiller. It is important to kill the roots and remove any humus which may encourag future growths, and any pockets should be filled with mortar.

Fungi

Fungi, mildew, moulds and yeasts do not require sunlight for growth; they depend upon organic material such as plant life for their energy. Moulds normally appear as spots or patches that may spread to form a grey green, black or brown furry layer on the surface. Any fungus has several basic requirements for propagation and growth: adequate wate and oxygen supply, suitable temperature, a congenial substratum on which to grow, the spac for growth, and finally of course the source of infection. If any of these requirements i inadequate, growth cannot take place. Water is a byproduct of fungal growth; thus, if fungu has established itself in a piece of wood and the rate of drying is less than the rate at which wate is produced by the breakdown of the wood substance, the attack will go on indefinitely with consequential decay. This fact emphasizes the importance of air movement and ventilation.

Certain minute fungi that attack wood can do immense and irreparable damage in a short time, and the softening effect of this decay or rot can encourage subsequent beetle attack. It is important to note, however, that fungal attack only occurs in well seasoned wood if damp conditions prevail, i.e. if the moisture content of the wood rises above 20%. Thus, continuous heating and good air circulation, together with elimination of the entry of rain and moisture, prevent timber decay.

Detection of fungal decay in wood

The inspector should arm himself with a handy torch with a strong beam, a penknife and magnifying glass, and wear overalls or old clothes. He requires a knowledge of the construction of historic buildings.

Advanced stages of fungal decay are easily recognized because the structure of the wood is damaged, either crumbling or broken up into shrunken distorted cubes of lignin in extreme cases or with a bowing inwards and outwards parallel to the grain or waviness and blistering effect. The colour may be changed with a brownish or whitish discoloration, depending on the type of fungus, and this may show through paintwork, the brown colours coming from fungi that destroy cellulose and whitish flecks on a darker background from those that destroy lignin. In extreme cases the fruiting body is found in the middle of a whitish mass of hyphae. It may be sterilized immediately to prevent the spread of spores, but its location as the centre of the attack is valuable evidence in planning eradication.

When inspecting historic buildings it is important to look into corners and poorly ventilated cellars to check for fungal attack. Beams and joinery should be tapped with a penknife and if they give a dull or hollow ring, the point of the blade should be driven into the wood in several places to see if it has become relatively soft. Any timber that is embedded in masonry may have too high a moisture content and is therefore vulnerable to both fungal and beetle attack. Where appropriate, a further test is possible in long grained soft woods by inserting the blade and prising up a splinter; a long splinter can never be prised up from decaying wood.

Wood-staining fungi

Wood-staining fungi grow on the surface of wood and so produce stains. They do not affect structural strength, but can cause painted surfaces to flake off.

Fungicides

Irrigation of the wall with fungicidal solutions from reservoirs into holes drilled at spacings, depending on the porosity of the wall and flow characteristics of the fungicide, is an effective method of sterilization. Care should be taken to ensure that the salts thus introduced into the wall are not hygroscopic and do not aggravate capillarity. Irrigation is particularly useful to impose a preventive cordon sanitaire between an outbreak and valuable woodwork as yet unaffected. Such irrigation also protects timbers embedded in a wall, which are most likely to be attacked because of lack of ventilation and high moisture content.

There are many powerful proprietary chemical products dealing with dry rot, most in a suitable white spirit vehicle. The following chemicals can be used:

(1) Sodium pentachloride in the strength of 50 g/l of water.

(2) Mercuric chloride or corrosive sublimate in the strength of 1 part to 1000 parts of water or methylated spirits (very effective, but highly poisonous, and needing great care in handling).

(3) Magnesium silicofluoride in the strength of 100 g/l of water or sodium fluoride in the saturated solution in water, i.e. about 37.5 g/l of water.

Brushing or spraying all timbers with preservative may also prevent a dry rot attack or stop it spreading rapidly. Wall plates and embedded timbers can be drilled and infiltrated along their grain to avoid rot and beetle attack.

Insects and other pests as causes of decay

Organic materials such as wood are all vulnerable to insect attack. Insects cause a great amount of damage by weakening structural timbers and in many parts of the world they are a more likely threat to woodwork than fungi. The situation is becoming more complicated due to the fact that eggs and larvae of tropical pests may be imported with tropical woods. It is important that the architect be able to distinguish among different types of beetle attack, so that he can make an accurate assessment of the probable extent of damage. He is referred to the technical literature relating to the insects common in his own country, for without a detailed knowledge of the biology of the different groups of insects, effective measures for prevention of attack and repair cannot be taken. Eradication is much simplified by the fact that the different species nearly all respond to the same chemical treatment.

Tropical insects

In many parts of the tropics, termites are commonly thought to be the main insect enemy but, apart from costal areas, if a building has been properly designed, constructed and reasonably maintained, the greater damage is reported to be inflicted by wood boring beetles mentioned above. Furthermore, when certain tropical hardwoods are used structurally, or where sapwood is included in the hardwoods used for joinery and flooring, the risk of attack by powder post beetles is more likely than by termites. Whereas softwoods (both indigenous and exotic) may be attacked by the longhorn beetle Oemidagahani spp., powder post beetles of the families Lyctidae and Bostrychidae attack seasoned hardwoods only, reducing the sap wood to a fine flour like powder. Although the damage is limited to the sapwood, the beetles may emerge through the adjacent hardwood. Most hardwoods containing starch are attacked and those with large pores such as antiaris and iroko are more liable to infestation. The attack is usually initiated in the timberyard and may be difficult to detect in the early stages.

In tropical conditions, the life cycle of these insects is completed very quickly. It is quite common for beetles to emerge and then reinfect the wood, causing serious structural damage to a building within a few years or less. Their presence is readily recognizable from the fine flour like frass, along with round tunnels and holes of 1mm to5 mm in diameter, depending on the beetle concerned. Through the agency of imported woods, many tropical pests have now to be combated in temperate zones, for example Lyctus africanus.

Termites are dangerous and voracious, and will attack wood, fibres or keratin materials and destroy almost anything, including synthetic material, that is not too hard, repellent or toxic. The species of termite that attack timber will be from one of two main groups, ground termites and drywood termites. Naturally resistant timbers tend to be gnawed by termites, but the soft nonresistant species may be completely hollowed out, except for an outside skin of wood, by drywood termites. Ground termites like to eat the soft spring and summer growth, leaving the late wood half eaten, so they tend to form galleries of concentric circles around the annual rings in the cross sections of wood, working along the grain and leaving thin paper like pieces of wood as divisions. Contrary to popular statements, no timber is immune to ground termite attack, although the range of resistance of different timbers is appreciable: exposed to conditions of equal intensity of attack one timber may last less than five years and another over 100 years, with other timbers having a service life falling between these extremes. Moreover, resistance to fungal decay is not necessarily an indication of resistance to ground termite attack.

Ground termites

Excluding 'damp wood' termites which are not found in buildings, two main types of ground dwelling wood eating termites are of concern and these are differentiated by the way they digest the cellulose in the wood. Effective control of ground termites is secured by proper design and construction of buildings with barriers provided not less than 200 mm above ground level in all walls. Such termite shields should be of 0.46 mm copper sheet acting also as a damp proof course under severe tropical conditions, and in less severe conditions 0.50 mm galvanized steel, or zinc sheet not less than 0.60 mm may be used with the conventional bitumen damp proof course below it. The shields, which must be continuous irrespective of changes in level, should extend outward 50 mm and then downwards at an angle of 135° for another 50 mm. Joints in the sheet material should be double locked and sealed by soldering or brazing. Any holes cut for anchorage bolts should be sealed with a hot poured pitch based sealing compound. With solid floors it is necessary to provide an impervious floor all over the site. At least 150 mm of concrete laid on a base unlikely to settle or crack and extending under all walls is recommended.

It is desirable to poison the whole area of the excavation and hardcore beneath the building and, using a stronger dosage, fill trenches around the footing with poisoned soil. Dieldrin, aldrin and chlordane have been found suitable, but it is advisable to seek the advice of forest entomologists before deciding upon a poisoning technique. Gaps must be sealed with poisoned mortar or a coal tar pitch base sealing compound. Woody or other debris containing cellulose will attract ground termites (and incidentally induce dry rot); care should therefore be taken to ensure that none drops into foundation trenches or is left under subfloors.

In existing buildings a precaution against ground termites is for foundations to be exposed and the earth poisoned as it is replaced. In the bottom of this trench and elsewhere, holes can be drilled at 300 mm centres and poisoned. Any soil at the foot of the cross walls should also be poisoned so as to prevent termites climbing up the walls. Soil poisoning is only the first line of defence against ground termite attack and may become ineffective after some years. Chemical control by introducing white arsenic powder into the runways is effective in keeping down the termite population, but it is a palliative and not a curative measure in spite of claims to the contrary.

If damage due to ground termites is found, their contact with the soil and moisture must be cut off, all soil runways from base or other parts of the structure must be cleaned off and the subsoil poisoned by drilling holes at 300 mm intervals and infiltrating appropriate chemicals. Any cracks and crevices in masonry and pipe runs where termites might gain access should be poisoned and sealed. Any untreated and unprotected timber which may temporarily join the building to the ground and through which termites could gain access must be removed.

Drywood termites

Drywood termites, live in small colonies feeding on seasoned wood. They require no access to the soil. They invariably feed just below the surface of the wood, and in most timbers attack is more or less confined to the sapwood; they produce granular dust, which showers out when the sound skin of the wood left on the surface of an attacked piece of timber is broken. The feeding termites also push out granular dust through their exit holes, the mounds of dust often being the only evidence of attack in progress, although their presence may also be indicated by heaps of excreta pellets, resembling small, light coloured seeds, appearing below infested timber.

They live on seasoned wood and are therefore an important pest. They live in completely self contained colonies and only leave the wood to swarm and form a new colony, so external evidence of their presence is only the small hard pellets which they excrete. Their activities may continue unsuspected until the timber is virtually destroyed. The colonies are much smaller than the ground termites, so the process of destruction is slower. The next colony is started when a reproductive pair, on entering a building, lodge in a crack or a crevice in something made of wood.

Drywood termites can be more troublesome than ground termites because of the difficulties of control of these air borne pests. Precautions for rendering buildings safe from ground termites are ineffective against drywood termites; indeed, no economic methods exist to prevent drywood termite activity. The pest cannot be positively eliminated from building timbers and other indoor woodwork by screening buildings with fine metal gauze which, of course, is extremely expensive and usually impractical. Still, reasonable precautions can be adopted that will minimize the risk of drywood termite attack, with dependence on curative measures when attack occurs. Ordinary painting of wooden surfaces is recommended as an effective method of denying dry wood termites entry into such timber, and where this is practical the course should be adopted, as for joinery. Planing has been suggested, but this is not an economical measure for carcassing timber. It seems probable that the total exclusion of sapwood may appreciably delay drywood termite attack.

Finding evidence of drywood termite attack is difficult, even though they can be heard gnawing timbers at night. A thorough inspection by tapping the wooden members to find hollows is one laborious method of detection; another is to keep a close look out for frass or pellets of faeces when they fall from an opening.

The extent of the structural damage caused by dry wood termites is apt to be misjudged; at first sight it appears devastating, but closer inspection usually reveals the destruction to be less severe than was thought. In furniture, panelling and high class joinery, even a small amount of damage may be serious because the appearance is spoiled, but in carcassing timbers it is necessary for the damage to be sufficiently serious to weaken the structure before alarm need arise. In practice, drywood termite attack is localized. Some wooden members may be attacked while adjacent ones are quite free. Moreover, it is usually only parts of such members that are infested and then often only to a depth of about 13 mm. If the infested zone is removed and the remainder of the timber is liberally dressed with an oil solvent wood preservative or even a volatile toxic substance like orthodichlorobenzene, attack will often cease and the reduced member is usually strong enough to continue carrying the load required of it.

Inspections for insect decay

The non specialist who lives close to and cares for an historic building should be instructed in the differences between fungal and insect attack and be able to take samples of insects for specialist identification. Several samples should be put into a small bottle containing alcohol or methylated spirits and sent in a tin, to prevent breakage, to the architect or other person responsible for regular inspections of the building. Samples of bore dust and typical damage are valuable aids to identification and should be supplied.

The specialist, architect or surveyor should make a detailed inspection, using his knowledge of the relevant points in design and maintenance of buildings, including drainage and damp proof courses and the need for ventilation. He should have a general knowledge of timber so as to distinguish between commoner types of hardwoods and softwoods and be able to differentiate between sapwood and heartwood. He must also know the habits of wood boring insects, as this helps him to seek out the most likely areas of infestation. Identification of the different types of wood boring insects and some knowledge of other insects found in flight holes or in crevices in wood, such as clothes moths or carpet beetles, which cause little or no damage to wood is an important part of his skill, which includes an assessment of the present state of activity and the probable extent of damage and risk of further spread of attack. He must propose remedial measures, the most appropriate method of preventive treatment and structural repairs if these are necessary.

In historic buildings, wood boring activity may sometimes have ceased, thus rendering remedial treatment redundant but giving the architect the difficult task of assessing the strength of the remaining elements. It is unfortunate that both fungal and insect attack occur frequently at structurally important points such as the ends of beams, where the wood may obtain moisture from the wall and be insufficiently ventilated and softened by fungal attack, or in joints where crevices exist convenient for egg laying.

Special attention should be given to wall plates where these lie under gutters which may be defective or flood occasionally. All wooden articles in storage, especially in roofs where they may be forgotten for years and particularly if they are made of birch, plywood or wickerwood, should be carefully examined before storage and treated with preservative, as they may introduce infestation into structural timbers. During an inspection they should be carefully examined.

Tapping the timber with a penknife, or for heavier members a light hammer, will indicate the general condition. Badly affected timbers have a hollow sound or dull resonance, while sound timbers ring true. The penknife can also be used to prod into the timber and comparisons of penetration for the same force are indicative of condition. The penknife and a small artist paintbrush are of value in extracting samples of frass from bore holes, and a magnifying glass should be carried to examine this dust.

Termiticides and insecticides

Commercial termiticides are heptachlor, aldrin, dieldrin and chlordane, all of which are poisonous and dangerous to use. Creosote, sodium arsenite, DOT, gamma benzene hexachloride, pentachlorophenol, sodium pentachlorophenate, copper naphthenate and chromated copper arsenate are also used.

Chemical preservative treatment against insects

A preservative is a substance which is applied to protect cultural property from attack by pests, whereas a pesticide is used to eradicate an active attack by pests, some only having a very short life. The ideal pesticide does not exist, but a given product should meet as many of the following requirements as possible:

It should be cheap, safe to user, of low toxicity rating; be effective in killing insect adults, larvae and eggs; be fast working and easy to apply and be able to retain its killing power.

It should not leave or form dangerous residues; break down or lose its effectiveness in storage; be absorbed by and build up in animal or plant tissue; injure non target animals or plants; corrode or damage building materials or equipment.

For most people, protection by treatment means the economical preservative treatment of wood to prevent insect attack and fungal decay, but also under this heading should be considered soil poisoning and the surface treatments such as paint, varnish and textured finishes which have already been mentioned. In addition to their decorative purposes, these surface treatments play an important part in protecting wood from both weather and insect attack. The wood must have a sufficiently low moisture content to receive the treatment and have a suitable pore structure to accept the vehicle for the chemicals proposed.

Assessment of the possible treatment should be made from both the technical and aesthetic points of view. An analysis of the proposed treatment should be obtained and attached to the documentation of the historic building; failing this, a sample should be kept.

The supplier or manufacturer of the protective medium should be asked about how long will the protective effects last and will it be simple to renew or supplement the treatment during the life of the building; can the treatment be properly carried out if local resources of trained men and facilities are limited; is the treatment offered appropriate to the wood to be used and its probable moisture content at the time of treatment; is the protective medium or the method of application hazardous to man, animals or birds and if so is there an acceptable alternative; does the protective medium have a bad smell and if so how long will it persist; will the treatment have damaging effects on other materials, will other materials or the environment have a damaging effect on the treatment; after using the treatment is it possible to apply other coatings, paint, without serious difficulty; may or should the protective medium be coloured and if so will the colour be fast (note that the colour may be useful as a means of checking that treatment has been carried out and its depth of penetration).

Most chemicals that are effective against termites, such as Chlordane, must only be applied by licensed specialists. The local medical officer can advise on municipal or provincial and state legislation regarding use of pesticides, as can the Forestry Department or Ministry of Agriculture.

Application of insecticides

In historic buildings it is generally impossible or very difficult to apply insecticides using vacuum or pressurized techniques. Oil based preservatives and insecticides mostly need dry wood for their application to be effective, and it must be remembered that the solvents used give off fumes which are toxic and may be dangerous in high concentrations. These factors limit the effective application of insecticides and preservatives. Among the practicable techniques, brushing may be assumed to have 2 mm to 4 mm penetration. Emulsions are less liable to produce toxic hazards and fire risks. Infiltration, by drilling staggered holes and filling them until saturation is achieved along the grain, is effective in softwoods but tests should be made for hardwoods. Impregnation at high pressure by guns fitted on to plastic nozzles is a pressurized type of infiltration but needs smaller holes and has advantages.

Liquid insecticides are mostly organic solvent type preparations containing contact insecticides and stomach poisons. In addition to eradicant action, these preparations give some protection against reinfection. Emulsion type paste insecticides show promise for treating large dimensioned timbers by virtue of the amount that can be applied and their good penetrating powers.

Thoroughness of application is most important. First, all disintegrated wood must be cut away and all dust and dirt should be cleaned up with an industrial vacuum cleaner. Cracks, splits and holes for plumbing and electrical wiring should receive special attention. Low pressure spray application, working up and down the timber and flooding the surface with about 11 to each 3 m^2 to 4 m^2 of surface area, is the most convenient method of treatment and is necessary where access to timber is difficult, such as undersides of floors, ends of rafters and wall plates. Flight holes in large timbers may be injected, or specially drilled holes may be repeatedly flooded with preservative. Application by brush is an alternative to spraying for small areas; the liquid should be flowed on freely, not rubbed in.

Brush applications of wood preservatives are not fully effective unless repeated at frequent intervals, in tropical conditions as often as 6 to 12 months. Vacuum impregnation processes are in a different category; with adequate absorption of suitable preservatives, wood can even be made to outlast its mechanical life. Where new timber is being prepared for building purposes it must be soaked in preservative or given repeated brush coatings, each coat being applied before the previous one is dry. No cutting or boring should take place after treatment unless the exposed surface is retreated. Structural timbers already built into the structure should receive two or more flowing brush coats, care being taken to soak the preservative into the end grain of beams or posts, since it is here that the attack generally begins.

It is important for both vacuum pressure and hot and cold tank processes of timber impregnation that the wood be at a moisture content of less than 25%. Brushing or dipping with preservative is of doubtful value in the tropics, any protection afforded being literally only skin deep.

Aqueous solutions of preservative, which may cause damage by making the timber swell, are less desirable. It is always wise to test samples of new preservative solutions for their staining effect before use. Some preservatives damage plastics used in electrical insulation or elsewhere.

Damage by animals and birds

The danger of pest borne infection inside an historic building depends on three factors: its location, its use and its construction. Unfortunately, the construction of historic buildings often enabled pests to establish themselves. Preventive measures must rely on controlling the internal environment. Mice can squeeze through holes about 6 mm in diameter when young and young rats through a hole of 9 mm. Mice are excellent climbers and rats can burrow to depths of 750 mm and will dig long distances horizontally, especially if the soil is loose, along the course of buried pipes or cables. Pigeons can be kept out by reducing gaps to 40 mm and for sparrows to 20 mm. Animals, including man, can damage buildings by urinating and defecating. Rats cause damage by building nests, which provide a likely spot for the start of a fire, and by gnawing at electric wires, for which they have a strange predilection. Old fashioned 'combined' rainwater and soil systems give rats many opportunities for climbing up untrapped rainwater pipes and entering a roof space via a gutter. Birds, in particular pigeons and to a lesser extent starlings and jackdaws, can damage and disfigure buildings. Their droppings can block roof rainwater outlets and can cause grass and other vegetation to grow in gutters and in reentrants on sloping roofs, and the bodies of dead pigeons frequently block drain outlets and downpipes. If birds win entry they build up so much mess and rubbish that it is a major task to get rid of it and so unpleasant that workmen have refused to tackle the job owing to the lice and filth that have to be faced. Roosting and nesting birds can be prevented by netting or spikes; sticky bird repellents can be applied to masonry, but there is a danger of staining the stone. A simpler method which often works is the fixing of black nylon thread about 25mm above sills and landing edges. Prevention of damage by animals and birds needs vigilance and routines of regular inspection if it is to be effective.

Manmade causes of decay

Manmade causes of decay are complicated and have widespread implications in the conservation of historic buildings. What can be said is that unless the causes of decay of cultural property are properly analysed and the effects of each harmful agent to some extent quantified, there is a danger that the wrong priorities will be applied to protective measures. Much more measurement and evaluation of the effect of manmade causes of decay is needed. Industrial production, together with electricity generation, is the main cause of atmospheric pollution as well as the heavy traffic that causes vibration damage. However, several major industries already have conservation officers and are able to consider the effects of their proposals at the planning stage instead of bearing the cost of correcting mistakes at a later date.

Damage by vibration

In dealing with the effects of vibration on historic buildings, it is apparent that little research has been done and practically none of it has been financed by those interested in historic buildings. Further, it is very difficult to measure vibration, which, although small, may be sufficient to cause longterm damage in an historic building in poor condition. Such a programme would require intensive instrumentation to cover all the permutations of a massive indeterminate structure, and no such programme has yet been financed or initiated. Positive proof of damage resulting from a given incident is almost impossible to obtain, as it is very difficult to distinguish between damage from vibration and the inevitable aging of a building. In the event, vibration pollution probably accelerates the aging process in proportion to its intensity. It is wise to remember that damage caused by vibration is generally irreversible and in practical terms irreparable.

It is extremely difficult to get any certain proof of what damage may or may not have occurred due to vibration. Damage from pile driving vibration is certainly common. The practical difficulties of measurement to the required high degrees of accuracy over a sufficiently long period are very considerable, taking into account variable weather and temperature changes due to the annual cycle of seasons.

In the short term, lath and plaster ceilings are particularly vulnerable to vibration. The key to the plaster and the condition of the lath should be carefully examined before any exposure to exceptional vibration such as piling. Wall panelling is also vulnerable as loose material may wedge behind the panelling and force it outwards. Vibrations may well initiate cracks in materials already subjected to temperature and humidity changes and settlements, and it is suspected they contribute to the fatigue of building materials. It is known that vibration can cause loss of foundation strength by affecting the subsoil. In some noncohesive soils, such as sands, the longterm effect of vibrations is to increase the soil density by causing compaction. In some cohesive soils, such as silts, the effect can be destructive in terms of bearing capacity, and may even reduce load bearing silt to a fluid. Therefore the problem is twofold: first, possible loss of foundation strength; secondly, loss of structural strength in the superstructure. The architect must consult an expert if there is sufficient circumstantial evidence to make investigation in depth worth while, but must warn the owner of the building that such investigation involves sophisticated instrumentation and will probably be a long and expensive operation.

Measuring vibrations

The academic scientific approach to the problem of vibration pollution is that if you are going to ban causes of vibration that may damage historic buildings, such as piling, you must state the level or amplitude of vibration that should not be exceeded. This might be done by extrapolating data from long term fatigue tests, the fatigue concept being based upon possible resonances in the individual structural members of the building when the waveform of the disturbing vibration contains these resonant frequencies. If such an analysis were possible, it would probably cost unreasonably large sums of money.

Vibration from pile driving

Vibration damage from pile driving may be the most common cause and source of danger to an historic building, particularly if it has poor foundations, cracked walls and spreading roofs. Bored piles generally give rise to very little trouble, driven piles may cause some damage, dependent on subsoil conditions, whereas piles with expanded in situ bulb bases are particularly liable to cause damage.

To protect historic buildings against damage from piling, recognized good practice should be for a 'stop clause' to be written into all piling subcontracts for all adjacent historic buildings. If this is done, the piling may be stopped immediately without incurrence of extra costs due to disturbance of the building contract; so that when a genuine complaint is made by the owner of the historic building, it can be met. As the cost of the delay will fall on the piling contractors the very existence of this 'stop clause' will make him more careful when advising on the choice of a pile, which, taking subsoil conditions into account, would not cause vibration damage to adjacent buildings.

The emphasis should be on prevention rather than cure of damage, for the cure is costly, doubtful and frequently impossible. Local authorities with their role of protecting the public interest could insert an appropriate clause in any planning approval to give nearby historic buildings adequate protection. The criteria for the decision can only be determined by qualified professional judgement, unhampered by commercial pressures.

Methods of protecting historic buildings from vibration

Before proposing such methods of insulation it would, of course, be necessary to carry out a thorough site investigation using soil mechanics techniques. In the case of traffic, town planning measures should be initiated to remove traffic from areas where there are important or large numbers of historic buildings. At the very least, road surfaces near historic buildings should be carefully maintained, heavy vehicles banned and vehicle speeds restricted.

Because historic buildings were built long before the increase in the vibration environment, whether airborne or earthtransmitted, the onus of proof should be on the people whose project might cause vibration damage to show that this is not the case, taking full account of the fact that an historic building is old, probably decrepit and full of latent defects. This is not just a debating point, as the facts are that vibration damage is irreversible and generally incapable of repair, except by rebuilding. It is impossible for the owner of an historic building to maintain a constant vibration watch and inspect his charge each time a suspected incident occurs, the cost would be phenomenal, the results at most impossible to prove and the culprits unidentifiable. When a severe vibration incident damages an historic building, it may be likened to someone scratching the surface of an 'old master'. There is no real repair, it will never be the same. Because positive proof is unobtainable, it is therefore essential that local and central government should be persuaded to act in a civilized way and take steps to protect historic buildings from traffic vibration.

Atmospheric pollution

Atmospheric pollution is primarily the byproduct of industrial and commercial activities. The reduction of such effluent is an expensive matter, and its control should be international so that consistent standards are applied world wide. The greatest part of the pollution of the atmosphere arises from the burning of fuel in boilers, furnaces, domestic fires and in internal combustion engines. There are three principal categories of pollutant: first, particulates, grit and dust, emitted mostly from industrial chimneys; secondly, smoke or finely divided solids, which coagulate to form soot; thirdly, gases, the two most important of these being carbon dioxide (CO_2) and sulphur dioxide (SO_2).

Pollution is worse in anticyclonic weather when there are clear skies and low winds. A temperature inversion can aggravate the situation seriously, when the usual condition of air getting cooler with height is upset by a warm layer acting as a lid and preventing the pollutant gases from rising and dispersing, so their concentration rises.

Examination of decay shows that the greatest effect occurs on cold, damp misty days when full office heating supplements the normal industrial emissions. Levels of pollution well above the average occur on such days, while in contrast, when there is a fresh wind with rain the SO_2 is either blown away or diluted.

However, while our buildings may stay cleaner, the danger from air pollution is not necessarily decreasing, for pollution is the byproduct of a higher standard of living, which is supported by the high consumption of fuel necessary to produce the energy needed to maintain this standard. Unending efforts should be made to reduce the amount of fuel burnt and the sulphur content of fuels.

Air quality

The air pollutants that are considered most significant are photochemical oxidant (or ozone, O_3), carbon monoxide (CO), sulphur dioxide (SO_2) and the total suspended particulates (TSP).

Design precautions to counter air pollution

It may not be possible, because of aesthetic considerations, to build the chimney in an historic building high enough to counter any possible damaging products of combustion sufficiently to avoid affecting the building. For this reason, choice of fuel to be used can have a direct effect on the life of the building, and natural gas is therefore to be recommended.

Some building materials are more pollution resistant than others.

Some preventive measures against air pollution

Atmospheric pollution is so universal that effective preventive measures are bound to be difficult to achieve for whole historic buildings. The precaution is to ensure that all weatherings, cornices and string courses shed acid laden rain water clear of the building and do not drip on to valuable features.

Regular maintenance and washing of stone in appropriate cases is another precaution. Indeed, in general terms the prevention of ingress of moisture through joints in masonry also reduces the damage from pollution.

Internal environment of historic buildings

The internal environment of a building is a complicated interacting system, comprising the movement of air and water vapour, and the transfer of heat. Thus we have to deal with two main factors, relative humidity and temperature, and the ways in which a building modifies the external conditions to create an internal environment.

Low relative humidity may cause serious damage to the furnishings, fittings and other contents of a building, as well as minor discomfort to the occupants. Hygroscopic materials such as wood will shrink. High relative humidity results in expansion of wood, growth of moulds and fungi, and prevalence of wood boring insects. Low relative humidity damages the contents of a building; high relative humidity is destructive alike of the contents and the structure. It is therefore desirable to keep relative humidity within reasonable limits.

Clearly, the complicated functions of the external membrane of a building are highly important—good insulation, thermal mass and permeability to moisture are beneficial.

The concept of a wall 'breathing' should be considered as a condition that facilitates the transfer of moisture in liquid or gaseous phases more than the passage of air. Since the internal environment of a building is such a delicate balance of influences, before undertaking an intervention involving any historic building it is advisable to arrange for readings of internal and external temperatures and humidities throughout an entire year, so as to study the climatic variations and the building's response and performance. Thermo hygrographs make such readings on weekly charts, but they should be calibrated regularly against measurements taken with an accurate psychrometer.

It is vital that all the effects of an intervention should be beneficial to a building, its contents and its occupants. Some new requirements imposed upon a building (such as new forms of heating) may cause damage, and under the altered environmental balance, materials which had been effective for centuries may fail. The building, and the way it has been and will be used or abused, must all be considered together. From the environmental point of view, it can be concluded that good insulation, high thermal mass and permeability to moisture are beneficial characteristics in the external membrane of a building, and that buffer material is helpful in equalizing changes in the internal environment.

Moisture content of air: relative humidity and vapour pressure

Differences of temperature between the inside and outside of a building tend to be equalized by the transfer of heat. This is important for two reasons: first, because it means that a concentration of moist air, such as in a kitchen or bathroom, readily disperses throughout a dwelling, and secondly, because water vapour at higher pressures inside buildings tries to escape by all available routes to what are usually the low vapour pressure conditions outside. Escape may be through ordinary ventilation routes, but vapour can also pass through many building materials. In winter, as warm internal air holds more water vapour than cold external air, the vapour pressure being higher inside a building than outside will cause water to move outwards through permeable walls in vapour form. In summer, the internal and external environments are much more in equilibrium.

Water vapour moves by two methods: first, by bulk transfers of air containing vapour, that is by winds, draughts and convection, and secondly, by the more subtle process wherein the difference of vapour pressure is the driving force through the structure itself. For a vapour barrier to be effective it must be impervious to water in both its liquid and gaseous state.

Insulation and condensation

When insulation is added it should ideally be on the warm side. It is a major factor in saving energy. Fortunately, with thick walls most historic buildings are reasonably well insulated. However, roofs are generally areas of major heat loss, although they can be insulated relatively easily. In a cold climate the improved insulation often requires that there be an efficient vapour barrier, which should also be on the warm side.

Structural insulation can play a part, but only a part, in reducing the likelihood of condensation. It will be appreciated that no amount of insulation makes a cold room warm, but that a small amount of heat will raise the temperature of a well insulated room in proportion to the insulation value and thermal capacity of the structure. Placing the insulating materials on the inner side of the structure will allow the inner surfaces to respond quickly to heating, an obvious advantage in achieving comfort. The overall insulation value affects internal surface temperatures and thus the probability of surface condensation, while the arrangement of the insulation determines the way temperature varies through the structure and therefore whether interstitial condensation is likely to take place within wall material permeable to vapour. As surface condensation depends upon surface temperature, the total amount of insulation is important, unless the surface can be heated by radiant sources.

The occurrence of interstitial condensation within the thickness of the fabric depends upon how easily water vapour can enter and whether it will reach a position where the temperature drops to the dew point. With an impermeable vapour barrier at the inside surface to prevent the passage of any vapour, interstitial condensation is prevented, but with an impermeable barrier at the cold exterior surface and the remainder of the construction permeable, condensation within the structure is almost inevitable. Prevention by an internal vapour barrier or arrangements to drain condensed water by a cavity are two methods that may be used. Although completely impermeable vapour barriers at the inside surface are difficult to achieve, a partial vapour check is still useful, if it can be installed easily.

Condensation and ventilation

A sizable proportion of outbreaks of wet and dry rot are caused by condensation. If a building is left unoccupied, particularly in winter, local condensation of stagnant air when the temperature drops can produce suitable conditions for such fungal growth as moulds on walls and ceilings and dry rot in the structural timbers. Occupants cause air movements by opening doors and windows and, when walking about, by causing floors to deflect, thus moving air through the joints in the floorboards, reducing the danger of stagnant air. Impervious coverings, particularly on the ground floor if there is no damp proof membrane, increase the risks of dry rot. If an old floor without a damp proof membrane underneath must be covered, a perimeter band of 200 mm to 250 mm should be left to allow vapour to escape, so avoiding driving moisture into the wall. With suspended wood ground floors it may even be necessary to promote circulation by drilling holes in corners where air may become stagnant.

Excessive internal moisture

Dampness is a common but vague word. It generally means unwanted moisture either in materials or in air which has sufficient vapour content to cause condensation if the surface temperature falls low enough. Nearly all historic buildings suffer from dampness. This dampness may be an asset to the contents, as it keeps the relative humidity high, but as it is uncontrollable it may also be a liability. It is always a liability to the fabric because it induces condensation and high moisture contents. If the moisture content of wood is above 20% there is a serious risk of attack by 'dry rot' because it can carry its own moisture long distances from its source and attack dry wood, or 'champignons' because it smells rather like mushrooms. There are many other forms of decay induced by excessive moisture content in organic materials.

To cure dampness, the source must be found, but it is always wise first to eliminate the possibility of condensation by taking readings on a thermohygrograph which should be properly calibrated and regularly checked. The source may be ground water or wet soil feeding capillarity and assisted by salts dissolved in the ground. In this case, the cure is to cut in a horizontal dampproof course if possible. The source may also be faulty rainwater disposal, leaking gutter and downpipes or broken drains. It is sometimes caused by rain penetration through a wall. However, a wet wall if dried quickly by wind can become so cool that it causes condensation in the interior The interior of each building has a varied microclimate. If there is lack of ventilation, moisture vapour builds up in recesses and external corners which are liable to be those most exposed to heat loss. Gentle air movement is one of the simplest ways of avoiding condensation and ensuring safe storage for the contents of historic buildings. Occasionally, when after a long cold spell there is an influx of warm humid air, usually in the spring, the moisture in this air will condense on the walls of an unheated building. Unless heat can be applied, all one can do is close the windows and so reduce the amount of incoming air and cut off the source of moisture.

Windows

Nowadays, an historic building gets more intense use, but we seem to have forgotten the damage that light causes, especially to sensitive colours and valuables. Blinds and ultraviolet filters can be fitted to windows to reduce this damage. Most historic buildings will continue to rely upon natural ventilation because of the cost and difficulty in installing ducts and plant for air conditioning.

Excessive ventilation, above 0.3 m/s through windows and doors can be reduced by draught stripping. Such weather stripping may cause an increase of internal moisture content in winter and dehumidification in summer, and if well fitted it is valuable. If not well fitted, it may actually increase rates of ventilation.

Ventilation

Air flow rates are normally greatest in rooms on the windward side of a building, from which air will tend to move through the rest of the building. For this reason, when planning alterations, rooms producing odours or moisture should not be on the prevailing windward side—for example lavatories and kitchens. Control of draughts is partly a matter of detailed design and adequate weather stripping. Attention must be drawn to the danger of cold draughts causing freezing of water in plumbing systems which incidentally is more likely if there is little movement of the water inside the pipes. One of the most vulnerable points is the rising main to the cold water feed tank if this main is run up an external wall and passes close to draughty eaves.

Fortunately most historic buildings contain a large amount of buffer material in wood panelling, floors and ceilings and to a lesser extent porous permeable masonry, which give up moisture when relative humidity is too low and absorbs it when too high. The mass of an historic building helps to protect its contents against violent environmental changes by 'damping down' the rate of change.

Lighting

Natural lighting of historic buildings is a subject in its own right. Nowadays, historic buildings get far more intensive use than in the past, so reduction of incoming light is a part of the general environmental strategy.

Historically, light levels were very low until incandescent sources, either gas or electric, were developed. Previous to this the candles and lamps that were available emitted a lot of soot. Artificial lighting of historic buildings introduces new aesthetic and technical problems. Apart from visual effects, it affects the internal environment by radiation and heat input which, if high, can have undesirable side effects such as timber shrinkage and may even in an extreme case be a cause of the outbreak of fire. The effect of each could easily be reduced, in the case of the lighting by fitting up to date low heat output fluorescent tubes.

This tremendous heat input from lighting fittings is dangerous to the internal environment, but luckily is usually only occasional. When the use of television is regular, the heat must be extracted by mechanical ventilation and this can cause the sudden lowering of relative humidity. The heat from electric bulbs, however, must always be dissipated, as otherwise it can become a serious fire risk. Dimmers, which run bulbs at a lower output until their full capacity is required, are useful both in protecting the environment of the building and also in lengthening the life of the electric light source.

Precautions must be taken to control the light falling on most art objects, as damage caused by light cannot be reversed. Paints, pigments and some dye stuffs are the most seriously affected. The amount of damage is proportional to the quantity of UV light that the object has received. For equal quantities of light, the following are arranged in order of increasing likelihood of causing damage: tungsten filament, warm fluorescent, daylight and north light, fluorescent, sunlight and blue sky. For valuable objects, the amount of illumination should be measured with a lightmeter, and for objects susceptible to damage, 50 to150 lux is generally accepted for display purposes. Glass and plastic filters for fluorescent lights should never be perceptibly yellow. Chemical filters are also available in special fittings, all of which reduce the damage from the UV element in light.

Heating

Heating is the major environmental factor which can be adjusted or controlled by the occupants. Three states should be considered—no heating, intermittent heating and continuous heating.

The choice of heating systems depends on many factors; for instance, if floors have to be renewed then floor panel systems are possible, otherwise the cost may be excessive. The choice of heating systems must be a three cornered compromise between the needs of the occupants and avoiding damaging conditions for both the contents and the building itself. For example, in a cold climate to insist on 55% to 60% RH throughout a long winter may cause frost damage due to freezing of the moisture passing outwards through a wall with no vapour barrier. Convected intermittent heating is not to be recommended, because it does not give real comfort to occupants and induces great stresses in materials due to sudden temperature and humidity variations, and the theoretical savings in cost are usually illusory. Ideally, low but continuous heating should be provided to protect the fabric against frost, but not so much as to lower the RH much below 50% as then wooden furniture may be damaged, and to provide local radiant heating for occupants' comfort.

There is a need to establish ranges of heating that will not cause cycles of crystallization of ground-water salts. A flexible approach relating the inside temperature to the average daily outside temperature is recommended, as the differential can be set at a figure that is unlikely to cause damage to the fabric or contents.

Regular maintenance and checks on the operating controls of the heating system are essential. The best way of monitoring performance is to have recording thermohygrographs, but these must be calibrated every month.

Various types of heating systems have been used:

(a) local radiant heating (open gas or electric heaters with directional effect);

(b) local heating elements (warm water or electric converters, storage heaters, heating panels attached to walls or fixed seating);

(c) ducted hot air heating, either convected or radiant low temperature floor panel heating.

Defects arising from heating

Defects observed as a result of improper heating of the interior of historic buildings vary according to the nature of the surface finishes. The main ones are listed as follows:

(1) Deposition of dust and dirt together with pattern stains on plaster areas of low insulation and greasy dirt on the inside of windows. Din is either brought in by the air or by detritus from the users (hair and fluff) or by din brought in by their feet.

(3) Shrinking, warping and cracking of wood and other organic materials.

(4) Blistering, flaking and powdering of paint layers. Changes in chemical composition of some paints and damage by crystallization of salts.

It is generally the convection component in heat transfer that causes the above defects, although radiant heat from powerful electric light bulbs can also be damaging.

The walls of most historic buildings built of masonry are thick but permeable and generally have good total thermal resistance, although the materials themselves may be poor insulators. Their thermal mass is great, so therefore they do not respond quickly to intermittent heating, but are able to maintain remarkably uniform internal temperatures when heated continuously. In an unheated state there are but few internal air currents; however, when heating is introduced draughts inevitably appear, but this practical problem can be mitigated by skilled design, after investigation using smoke to indicate the paths of air movement.

In an old damp building or even a recently constructed one, rapid drying out by newly installed central heating can be dangerous to the fabric, especially for the first few weeks. Also, if the building is not kept well ventilated during this period, moisture extracted from the porous fabric will saturate the air within, and in the cool parts of the building, such as unheated roof spaces or attics, heavy condensation may occur. Windows should be opened top and bottom so that the hot moist air may be expelled and temperatures raised only gradually, thus allowing moisture to dissipate slowly and reducing damage by shrinkage of materials and expansion of the structure. Months, even years, may elapse before equilibrium is achieved in a heavy structure.

Temperature and relative humidity are interdependent in forming the internal climate of a building. This climate affects both occupants and contents; people are rather sensitive to temperature, only achieving comfort when the effective temperature is between 18 °C and 25 °C, whereas historical artefacts are more demanding because many require strict humidity control to reduce the rate of deterioration. Air movement is desirable for comfort but too much, a draught can cause discomfort, and relative humidity if too low can cause discomfort to people and desiccation of leather, wood and other sensitive organic materials.

Acoustic environment

An historic building may nowadays find itself in an environment of intense noise and vibration for which it was not designed. On a hot day, it may be necessary to close all the windows and forgo natural ventilation because of the external noise, the most common cause of environmental complaints. However, in any proposals to improve audibility in an historic building, its acoustic personality should be respected as much as its visual qualities.

The balance of the internal environment

An attempt has been made to outline factors which affect the internal environment of historic buildings and to show that a delicate balance exists among them. It has been demonstrated that the internal environment is modified by atmospheric, thermal and aqueous influences. Wind causes air movement with consequential pressures and suctions which vary the rate of internal air change, so affecting heat losses and the comfort of the occupants. If changes in methods of usage, heating and artificial lighting are proposed, their effects on the fabric and contents of the building must be carefully assessed. An imprudent alteration of the internal environment may upset a very delicate, long established equilibrium. It has been shown that this environment is peculiar to each building, depending upon its design, construction, materials, thermal mass buffer effect and insulation and upon its maintenance, condition and usage, as well as its acoustics, lighting, heating and ventilation. In this context the atmospheric, thermal and aqueous components all interact to produce a spatial environmental system which if thrown out of balance may create a new danger for the building and its contents. Typical examples of interventions which may have an adverse effect are:

(a) Portland cement rendering, external or internal;

(b) Portland cement pointing;

(c) insertion of damp proof membranes without 'safety valves';

(d) introduction of heating at too high temperatures;

(e) introduction of air conditioning;

(0 application of plastic paints;

(g) sealing up natural ventilation systems, fireplaces.

(h) preventing air movement by changing slates to metal or plastic roofing.

Lastly, mention must be made of the effects of building operations which generally introduce large amounts of water into the structure, and internal archaeological excavations which encourage a considerable amount of evaporation of ground water from exposed surfaces. These, however, are exceptional and temporary changes of the internal environment.

7.4. Building repairs

This part deals with some of the practical problems met in repairing ordinary domestic buildings which comprise the great majority of historic buildings the world over.

Roof drainage and rainwater disposal systems

Rain is collected by the roof coverings into valleys and gutters and thence discharged to outlets and downpipes which discharge over gulleys into rainwater drains. Valleys between large areas of roofing and parapet gutters are particularly vulnerable to blockage by snow. Sagging eaves gutters with water dropping over the edge are another source of trouble. In the course of time, rainwater drains that are not self cleaning, due to insufficient gradient, can cause blockage due to silt being deposited; or if the gradient is too steep, it causes solids to separate from the water vehicle. Roots can also cause blockage by penetrating the rainwater system.

Because of the danger of flooding, it is always wise to have duplicate outlets from sunk areas and from cesspools to hopperheads, one placed about 30mm to 50 mm above the other. This ensures that the same piece of rubbish cannot block both outlets. Gutters and hopperheads should have notches or spouts on their outer edges to divert overflowing water, in the case of blockage, away from the building.

Failures are all too frequent because maintenance considerations were not taken adequately into account at the design stage; unblocking a hopperhead set tightly under the eaves; painting the back of a cast iron pipe, particularly if rectangular, when it is fixed hard against the wall. Pipes that need painting should be fixed on bobbins or precast concrete blocks so as to be at least 25 mm away from the wall and should discharge over trapped gulleys or have cleaning eyes so that rods can be pushed up from below to free the inevitable blockage. Unnecessary bends, twists and offsets should be eliminated, as these are all sources of potential trouble. Trapped gulleys with gratings may be necessary to stop vermin, but as the gratings are liable to clog they should be designed with surrounds and overflows, or back inlets if a cleaning eye has been provided.

It should be understood that higher standards are necessary for historic buildings; also as the building already exists, the design procedures are different from those for a new building and these have been set out in a new chart. Study may bring to light weaknesses in the original design and raise difficult aesthetic problems, because the rainwater downpipes are an integral part of the appearance of the historic building, so great ingenuity may be required to solve the rainwater disposal problem.

It should be noted that a fall of not less than 1/600 can add 40% to the capacity, whereas sharp bends within 2 m of the outlet on level gutters reduce capacity by 20% but easy bends only cause a 10% reduction. On sloping gutters the reduction is greater, being 25%. Flow is reduced by the length of the gutter. Outlets from gutters need careful attention and should be round cornered, and because the outlets are often the limiting factor, twin outlets can be used with advantage, but this will generally require a hopperhead. Downpipes of less than 75 mm are not recommended on historic buildings. Together with rounded outlets, this size is sufficient to take the maximum flow from a 125 mm gutter if situated in the middle, or a 150 mm gutter at one end. A valley or parapet gutter should be at least 300 mm wide for maintenance purposes, and in addition to the calculated height required for adequate capacity should have at least 75 mm of vertical 'freeboard' to allow for the wave action of wind. The rise at drip steps in a lead parapet valley gutter must be greater than the permissible depth of flow in the gutter. Traditionally, a slope of 1/60 is regarded as good practice. The valley or parapet gutter should discharge into a box receiver or cesspool, as this will increase the transfer rate into the downpipe inlet. In order to avoid flooding, the discharge capacity of both receiver and downpipe must be greater than that of the gutter.

The outlet should not be central as this may induce swirl, so reducing the capacity of the downpipe by about onethird; it also should not be closer than its own diameter from one side of the box. If the pipe inlet is tapered over a length greater than its own diameter, the efficiency of the rainwater downpipe is approximately doubled, so that the pipe can be reduced to two thirds of the inlet diameter. Gratings reduce the effective area of the inlet. These design criteria are useful if the capacity of an irreplaceable downpipe needs to be increased, as attention to such small and inconspicuous details may well achieve the desired result of retaining the downpipe and improving its performance.

Gratings should be placed where the gutter falls into the inlet; such gratings should have a sloping surface so that litter or dead birds do not totally block the gutter flow. On the other hand, care must be taken to ensure that, if there is a partial blockage, back flooding does not occur, and as generous 'freeboard' as possible should be arranged for the adjacent length of gutter. With combined rainwater and soil drains, the pipe inlet may also need a balloon grating to prevent rats from gaining access to the roof space of a building by climbing up the rainwater pipes. All such gratings are liable to blockage and should be inspected monthly if possible, or at least quarterly.

If rain water is not collected, there is no need for a disposal system. Provided an adequate arrangement, such as the use of splash plates, is made at ground level and the wall is waterproof, dripping eaves have been proved satisfactory by centuries of use, and they could well be reintroduced to contemporary domestic architecture with its cavity wall construction and dampproof courses, provided the ground is porous or else there is a drain trench filled with gravel at the base of the wall.

The simplest rainwater disposal system is the spout, often discharging through a carved gargoyle. The outlet must be large enough and, in case of blockage, a relief outlet is required; the spout is also more effective if served by a cesspool. Because spouts from a high roof can be a nuisance when wind spreads large quantities of water at random, they should only be used for relatively small areas of roof.

Apart from ensuring that the underground drainage system can be cleaned out, is functioning properly and is not subject to decay, settlement, subsidence, cracks or breakages, there are no special problems that affect the drainage system of an historic building, because the size is generally found to be adequate.

Faults in existing roof coverings

Roofs, together with gutters, valleys and rainwater disposal arrangements, are vulnerable and exposed parts of a building, and can be damaged by high winds as well as penetrated by driving rain from certain angles and by driven snow. Major defects in roofs are indicated by leaks or by damp patches appearing on the ceiling after rain, but it should be remembered that water may run down a rafter or seep sideways under a flat roof, so that the defect is not necessarily above the damp patch.

Slates are dependent on nailing and cannot be renailed singly because of the covering afforded by the adjacent upper slates, they must be refixed with copper tabs.

Lead tabs should be avoided as they straighten in time. If there is a major failure due to nail sickness, it is possible to apply fibreglass mats bedded in resin adhesive from below to the underside of the slate. Loose slates can also be held in position against sliding by gluing them on polystyrene blocks from below.

The fundamental design of a roof should be checked before renewal of its covering material. The pitch should be sufficient for the material and exposure. As mentioned earlier the rainwater disposal system should be calculated.

Any change in the dead weight must have an effect on the supporting roof structure which must be carefully assessed. In stripping a roof, care should be taken to avoid producing grossly unbalanced loading on the existing framing, which might easily become irreparably distorted, with joints strained or broken.

Protection for repairs

Before repairs are carried out, proper protection against the weather must be arranged. Tarpaulins have to be withdrawn and fixed daily, and are liable to be blown about and to fail in a sudden heavy storm, but they are cheap and quick in the first instance. However, they should be used only for small areas on sloping roofs. A temporary covering of tarpaulins fixed to scaffolding clear of the working space is better, but the tarpaulins are liable to be damaged and to wear at points of contact if the work goes on a long time.

It should be remembered that tarpaulins are a fire hazard. The site supervisor should ensure that fire extinguishers are immediately available and that stored tarpaulins are folded neatly and do not cause a risk.

For longer periods, corrugated iron or transparent reinforced plastic sheets on a scaffold or light steel frame are preferable. Care must be taken to secure this temporary structure against wind. The temporary structure may be used as a gantry for lifting out heavy members, provided it is designed to carry the loads envisaged. Great care should be taken over disposal of rain water from such temporary coverings.

Need for ventilation of roof spaces

Stone slates, all have sufficient air space below to allow ventilation. Nowadays the practice is to lay untearable felt or its plastic equivalent below the tiles or slates; nevertheless, the roof space is not completely sealed, because the sheets lie loosely so that some ventilation of the roof space can still occur. This degree of ventilation may not be adequate when there is central heating, causing hot moist air to move into the cold roof space, with consequential consensation. Extra allowance for controllable ventilation at eaves and ridge may be needed under these circumstances. It can be obtained at the eaves by leaving gaps between soffit boards or drilling holes in them, or by leaving out packing pieces and pointing between rafters where there is no soffit. All gaps wider than 10 mm or so should be wired to exclude birds and insects. When there are parapets, roof ventilation is more difficult to obtain, but it can usually be contrived by forming a high upstand to the gutter and air inlet at the end of the rafters.

Slate roofs

A quarried block of slate is split with hammer and chisel along the cleavage planes into individual laminae or slates. The thinner the laminae, the better the quality of the slate and the lighter the overall roof structure will be. Apart from its traditional use as a roofing material, slate is used for sills and copings, where it is liable to extreme thermal expansion. It is also used for damp proof courses. Concrete roofing tiles, which are a popular replacement for slates, can be used down to pitches as low as 171/2°. However, care must be taken to ensure that the roof structure will carry the extra weight of concrete tiles, which may be three or four times as heavy as a good thin slate.

Slate roofs are generally laid butted close, making a very tight roof. A variation can be seen on some residential buildings, where the perpends are left with about 25 mm gap between adjoining slates which allows air movement and prevents condensation. As a roof covering, slate is light, waterproof, snowproof and stormproof down to low pitches (depending upon the size of the slate, the larger the slate, the lower the pitch that can be used). Its principal weakness lies in the nail fixings which either corrode or come loose and break with fatigue.

Standard roofing slate sizes were usually based on historical precedent, and these sizes are still available. In laying practices for smaller slates and for best practice when laying larger ones, the roof framing has to be tightly sheathed with boards, battened and counter battened. Tilting fillets of wood, 65 mm wide, 19 mm thick on one edge and triangular in section, were nailed to the edge of the roof. Laying of the largest pieces of slate was begun at the eaves; after these were nailed in place a course of smaller pieces was pushed up under them, breaking joints, and held in place only by the weight of those on top. A line was then stretched to mark the place for the lower edge of the next course; these slates were laid and nailed, and so on upwards. It was common, for the sake of economy, to lay the larger sizes of slates on battens 65mm to 75 mm wide and 19 mm to 25 mm thick instead of solid boarding. In that case the battens were installed by the slater instead of the carpenter, so he could locate them to fit the length of the slates as the laying progressed upward course by course.

Later oakshingle laths and oak pins, or battens 65 mm X 12 mm or larger, and cast iron or copper nails, hung over the upper edge of battens were used to replace decayed oak pegs. Sometimes slates were laid with lateral gaps between each slate, so providing a ventilating roof.

A new slate roof should be laid over untearable felt as a standard precaution. Nails should be of tin alloy or hard aluminium alloy. Slate roofs should have standard 192 N/m^2 lead soakers at abutments, and a rather heavy ridge is best so that it will hold the slates securely in high winds.

A slate roof is generally as durable as its fixings. Damage occurs through people walking on it and through exposure to gales. The initial workmanship and materials are the key to its durability. Some slates are vulnerable to atmospheric pollution. When over 30% of the slates have been refixed it is sound policy to strip and re-lay the whole roof, re-using as many original slates as possible. The above points indicate that the decision whether to repair, relay or replace a slate roof depends on many factors. The following questions should be considered, how sound are the slates; what percentage can be re-used; is the subroof sound; will nail holes have to be remade; what is the estimated life of the old slates; can replacements be obtained; what is the cost of the operation and how long will the repair last.

If the slates of a roof are to be reused it is important to relay the roof before the nail holes in the slates are enlarged, for if new holes have to be made there is a high risk of shattering and thus losing many of the old slates. This risk can be reduced by drilling the holes rather than using the usual pointed hammer. Any slates that slip or become loose should be refixed promptly. If a slate roof is not close boarded and there is sufficient access to the underside, it is claimed that it can be stabilized by the application of resin and fibre glass matting on the underside, but as this would prevent the latter reuse of the slates, lifting and renailing may be better.

Repair of timber roofs

This means either intensive ladderwork or extensive scaffolding if wheeled platforms cannot be used. At this stage, all reachable sapwood and superficial decay should be removed provided this does not remove historical evidence. If the roof is likely to be saved, it is useful to treat the timbers with preservative as this will be beneficial to the timber and will aid in identification of new insect flight holes by creating a greater colour contrast with the old ones, but the preservative should not be applied where glue repairs are anticipated or where painted decoration has to be conserved.

In conservative repairs, as much of the old material as is economically possible must be reused and all historical evidence recorded, before work is begun. Any new material added to the old should be a copy of the original; new pieces of wood might well have the year carved on them inconspicuously. Defective lengths of old rafters can be replaced by new or salvaged material that matches. The joint can be a simple bolted or glued scarf made over a purlin. The apex of rafters can be strengthened by a short tie. As wall plates tend to suffer more than other timbers from rot and beetle, because of their vulnerable position, a dampproof course below and ventilation on the other three sides is desirable. Wall plates are designed to spread the load from trusses and rafters and to link trusses and prevent them spreading laterally, but, if the design permits, this function can be taken over by a concrete ring beam which is less vulnerable to decay. Purlin joints may be repaired by a false tenon of steel throughbolted on top of the purlin, with the heads of the bolts pelleted for concealment.

Timbers which have to bear against a wall for structural reasons, such as wall posts, cornices or knee braces, should have either a dampproof course or an air gap separating them from the wall, and the same techniques used as for floor beams. The ends of ties and beams are generally vulnerable to rot and beetle. These can be repaired by scarfing in new timbers using concealed iron or steel flitch plates, or water and shockproof resinbonded plywood of 25 mm thickness.

The repair of old roofs should be done bay by bay, for if an historic structure is taken down completely it may not be possible to replace it. The procedure is to arrange the temporary covering, strip the roof covering material and store it carefully, then remove the close boarding carefully if it is capable of reuse. It is then possible to see exactly what work is necessary and to decide upon the repairs for each individual member. If possible, the principal rafters or trusses should be repaired in situ; if not, the roof will have to be taken down, the parts first being numbered in accordance with the survey drawing. It should be stressed that old timber roofs are rarely incapable of repair.

Timber roof structures can often be strengthened by the addition of diagonal boarding and turned in effect into 'stressed skin' or deep inclined beam structures, all without altering their outline but at the expense of 25 mm or 50 mm thickening and some additional weight. A new design must ensure that only vertical loads are transmitted to the masonry walls, so in open roof spaces tie rods may have to be used. Difficulty may be experienced if the roof planes are distorted, but if the boarding is made thin enough by using more layers, it will bend over the irregularities.

Sometimes it will be found that a timber roof is so decayed and weakened that it is beyond repair. There are two elements to consider: the design, which can be reproduced, and the material, which it may not be possible to preserve. Because the archaeological and antiquarian value of the old material must be respected, ample time should be allowed for the competent authority to measure, record and investigate the construction, the joints of which are often of particular interest and are useful for dating. Samples can be taken for dendrological dating or dating by the use of Carbon 14.

Repair of timber beams

Load bearing capacity of decayed beams can be reinstated and increased and parts destroyed by rot can be reformed in situ without expensive reconstruction. Timber preservatives, which may prevent satisfactory gluing, should only be used after repairs have been completed.

The design of the steel extension of a rotted timber beam depends upon the loads applied, the length of timber decayed or missing and the condition of the existing timber in respect to its strength and length of bond. Bending movements, buckling, shear and bearing must all be checked by calculation. The aim is to repair in situ, but often in complicated timber structures the framing has to be dismantled and then reerected. Questions of stress distribution and movement of structural timber due to humidity cannot be ignored. Also, as these techniques depend upon epoxy resin, which softens and loses strength under fire conditons, the fire resistance aspect must be carefully considered and tested.

The glue consists of epoxy resin plus 2% to 3% methanol with hardeners (10% cobalt naphthenate) and fillers (diatomaceous earth). It can be used alone or with fibreglass or steel rods or steel plates. For mixing, separate measuring dishes are essential, and batches should not be larger than can be used in the time permitted by the pot life of its mix. The rate of hardening depends upon the air temperature.

The best material for structural repairs is plain weave glass fibre cloth, which when tightly rolled up to fill the container needs the addition of 25% of the volume of the container as the required amount of epoxy. For steel reinforcement, the volume should be calculated in order to avoid waste. There are practical difficulties in assessing the volume of irregular voids, so some surplus must be mixed. Vent holes, which are later plugged, make the filling of voids easier. In certain cases, voids can be filled efficiently by using vacuum impregnation methods.

Two methods, surface or deep impregnation with inclusion of steel reinforcement, are possible. The wood must be cleaned by brushing and frass and dust should be removed as far as practicable in order to avoid subsequent osmophilic fungus attack. Surface impregnation is by brushing, pouring or immersion. Deep impregnation is by drilling 10 mm holes at 500 mm centres and filling until saturation is obtained. Cracks and fissures must be filled with potters clay or plasticine.

The two components must be mixed for at least 1 min in the proportions specified by the manufacturers. Pot life is 60 min at 25 °C however, this is reduced at higher temperatures and if large batches are mixed.

The treatment leaves the wood with a waxed appearance that is rather unpleasant; nevertheless a dull surface can be obtained by applying a paint remover and washing afterwards with water. The wood can be sawn, drilled and painted in the normal way after treatment. The effectiveness of the treatment depends on the type of wood, its porosity and the type of attack. Tools are cleaned with methylethylketone. The components will last at least two years if kept cool and drv in closed containers.

Repair of suspended timber floor beams or joists

Floorboards are one of the most used parts of a building and so wear out comparatively quickly; thus, replacement with the original material or a substitute is a common event in building maintenance. Electricians all too often damage valuable boarding and leave loose and squeaking replacements.

Access to floor structure is gained by lifting the floor surface covering. This may be difficult if the boards are cross tongued or tongued and grooved or even have a parquet covering laid at right angles to the boarding proper.

The most usual cause of decay in timber upper floors is rot at the ends of beams and cracking in the middle, the former being most likely if these are embedded in masonry or rest on an embedded wall plate. A whole floor which has dropped slightly, leaving a wide gap between the boarding and the surrounding skirtings, should be suspected as a possible case of dry rot, involving shrinkage and collapse of hidden wall plates. In every case, the bearing of the ends of beams must be carefully investigated. Indeed, wall plates which have been corbelled out on masonry brackets are a far sounder form of construction.

If the bearing walls are thick enough, new corbels of stone or reinforced concrete can be inserted under the decayed ends of the beam, and if the beam is concealed it can be strengthened by plating galvanized angles or channels under the floor joists. All joints between metal and wood should be filled with mastic or caulking to prevent local condensation. All new timbers should be impregnated with insecticide and fungicide. Old timbers should be treated by brushing or spraying. Embedded ends should be drilled and injected with preservative and ventilated and, if possible, set up on a damp proof course; in difficult cases, a slate wedge or slip might be driven in under the timber bearing. In the concealed spaces of double floors, various methods of strengthening can be used. Weak beams can be made stronger by inserting flitch plates or T shaped angles, by plating on the underside or by trussing with steel ties which can be tightened by turnbuckles. Ends of decayed beams can be spliced or strengthened by bolting steel brackets on to the sides, and defective tenons can be repaired using wrought iron straps. Where structural timbers are visible, they should be spliced or repaired with laminated inserts, using a modern gap filling resin glue. Floors that have too much deflection, are springy and have 'twig', can be stiffened by the insertion of more joists or strengthened by the use of steel channels or angles bolted to the sides of existing joists.

When repairing boarding, it is important to preserve the joint lines between the boards. When the original material of boarded floors can be saved, great care must be taken in lifting the boards to avoid splitting. Usually the floor material is replaced completely. Often, the method used for repair is determined by the need to keep a fine painted or plastered ceiling in position.

Repair of joinery: Doors & Windows

The defects that such doors generally develop are shrinkage and cracking of the panels and main frame members, warping and sagging. Door frames themselves may be distorted by settlement and inclination of the structural wall in which they are set; indeed in the course of its life a door may have been frequently adjusted to allow for sagging and settlement of the primary structure. Hinges may also wear out and throw the door out of adjustment. Also doors may have been altered and adjusted to receive many different types of lock in the course of their life, and this may have produced an area of weakness in the middle rail.

Patching fine old joinery in situ is not to be encouraged: all joinery, even door and window frames which are made off the job, are best repaired in a proper joinery workshop.

Staircases

Old stairs fall apart from pest attack and rot and through wear in the tread, which becomes thin. The remedy is to screw a sturdy stiffening batten on the underside close to the riser, and to replace the worn nosing with a new piece screwed and glued to the old. If the framing of the stairs is coming apart through failure or decay of the joints or through shrinkage from excessive heating, then the whole feature must be taken down and removed to the workshop and treated as a joinery repair job, fitting in new wood as necessary with scarfs, dowels, pins and glue.

Windows

Windows suffer if the walling becomes distorted, but the most common defect is penetration of moisture at the bottom joints, particularly in the frame between the jamb and sill, leading to rot in the sill. If the joinery sections are very lightweight, and have rotted, renewal in hardwood, copying the existing design, is probably the best solution.

Repeated painting can stop casement windows closing and may also block up the throats of window sill drips. This can only be cured by burning off, scraping and starting the paint build up again. Throats should always be large, not less than 12 mm. There should be a damp proof course under every window, as rain run off is concentrated here.

Plasterwork

Plastering should follow the sun's progress around a building in order to avoid too rapid drying out.

Old plaster is often remarkably thin and hard, indicating excellent technique. The outer layer of this thin old plaster often falls off and is difficult to replace satisfactorily. As the character of an old wall may depend upon the texture of its materials showing through under thin plaster, particularly if the quoins project only slightly, a renewal should not ignore this problem, as the appearance of the building would be drastically altered by the use of modern thick plaster techniques. Thin coats have been applied successfully, relying upon a 'fat' lime and 'soft' sand mix. The sand must be washed several times and all impurities removed. The mix should be one part of lime to two of sand, applied in one coat about 6 mm thick; and one wall elevation should be completed in the day to avoid unsightly joints.

The choice of sand depends upon the purpose of the plaster and the texture of finish required. Coarse sharp sands are generally preferred for external work and soft sands for internal work. Identification of the causes of deterioration is imperative before any conservation process can be adopted. These may be: capillarity, condensation, penetrating rain, air pollution, frost, dehydration, evaporation, abrasion, thermal stresses, as well as micro organisms, vegetal causes, insects, animals and human causes, such as air pollution and vibration, have to be identified and we must also include faulty previous interventions.

Plaster may become cracked, either due to shrinkage or to movement in the substrate. It may lose its adhesion to the substrate or between separate coats or its key to laths; it may also blow and bulge. Being soft, it may suffer from abrasion or impact damage and it may be attacked by insects and spiders. If exposed, plants may grow in it and in a rainy, humid tropical climate, moulds attach themselves to the exposed parts of a building, the parapets and cornices.

In walls, cracks often occur where plaster has to cover the wide face of a beam or stanchion; the lathing may have been omitted or the plaster may have failed to get a key due to lack of counter lathing which would have given space for the squeeze to hook over the laths; in such cases, expanded metal lath can be used for repair purposes.

Repair of plaster

All cracks should be filled before redecoration. Stopping cracks in a plaster ceiling or wall is one of the most laborious of jobs, as much patience and conscientious attention are required to provide a key for a fragile strip of plaster. Modern fillers with their adhesive qualities are a great help, but will not work if the crack is dirty. Therefore cleanliness is essential and every trace of dust should be removed with a hand vacuum cleaner. Larger cracks should have a dovetailed key formed in their sides using a fine chisel or file.

Renewing areas of plaster is most difficult. When one area is cut out this action leads to disturbance in the next area and so on. If a repair has to be made to an area, it nearly always shows round the edge, because it is impossible to follow the plane of the existing work exactly. When areas of plaster have to be renewed, one often ends up replastering a whole wall or ceiling.

If the structure is not damp, a patent plaster containing vermiculite is found to be more workable and can be made irregular by being pressed with a cloth bag to match the texture of old work. This type of plaster can also be used in greater thickness than lime plaster. The vermiculite absorbs excess moisture and gives it up when the relative humidity is lowered, so provides useful buffer material.

Maintenance of external plasterwork on walls

Cracks allow the entrance of water, so must be filled. Decoration needs renewal at regular intervals to keep out water; lime based paints are the best for the maintenance of lime plaster. Moulds and lichens should be destroyed with fungicides.

Maintenance of internal plasterwork on walls

The main causes of decay are penetrating moisture and rising damp, which softens and makes the plaster decompose and blister. The evidence is usually obvious, but condensation may also be the cause. Repair and renewal of plaster have already been discussed.

Internal plasterwork is simply the smooth face on rough masonry. If it loses its adhesion for any reason and shows the defects listed earlier, consolidation or repair will be necessary. Cracks are less serious than with external walls. Much damage occurs from abrasion, particularly in narrow corridors, and from impact due to carelessness; exposed angles are specially vulnerable. In the management of an historic building these factors must be taken into account.

Paintwork

Most paints used in the interiors of historic buildings were oil based distempers with coarsely ground pigments. The fine grinding of modern paints and the use of thixotropic media make matching even more difficult. Ideally, one should copy the old techniques and in special cases this may be necessary; however, economical considerations may force the architect to use modern paints which are very finely ground. It is essential that such paints be brushed both up and down and sideways.

Varnishes become yellow with exposure.

Yet, where restoration is deemed to be expedient, it is necessary to find the original colour, which is often a very difficult task. Even if one has ancient accounts for the colours as purchased, this gives no accurate idea of the colour scheme. Similarly, chemical analysis of pigments can also often be inconclusive. Problems in identifying pigments arise from two main causes: first, they were often unstable and secondly they varied greatly, since they originated from a number of sources. Handgrinding and other dispersion techniques used in the past gave uneven results, which are difficult if not impossible to analyse accurately, although experienced chemists can make an estimated guess based upon electron or light micrographic analysis. Intelligent guesses as to the colour and type of paint used can also be made by studying buildings of similar period. Also, there is no known way of determining the nature of the original vehicle, as a wide range of different vehicles were used with old paints, and this may also affect the colour.

Colours change with time, although ochres and earthbased pigments are generally permanent and have a preservative action. Vermilion also turns grey in time and oils can cause lime to oxidize. Ultraviolet light will alter any newly exposed pigment, so it is advisable to wait at least six months after making a colour test by scraping to enable the exposed pigment to adjust itself before making a match. Gilding is generally durable and old work should always be preserved for its patina.

A 1 kW electric stripping gun which is designed to produce temperatures of 204 °C is a relatively safe method of paint stripping as it works at below the temperature at which wood burns. Infrared guns are similar in performance, but dark glasses must be worn to avoid risks to eyesight. The last layers of paint should be removed using a methylene chloride type of paint remover.

Drip trays should be arranged to catch stripped off paint because it can adhere elsewhere. A water filled bucket with a wire stretched across the top against which paint can be scraped off tools is a good receptacle. A series of tools with rounded corners to avoid digging in will be required to deal with all the details of an historic building.

Aesthetic decisions cannot be avoided, as colour is a subjective study in which no two people necessarily see exactly the same thing. Most satisfaction is obtained if decisions on colour are related to the building as a whole. Normal maintenance practice establishes the correct context for restoration of paintwork. Then natural weathering should be allowed to take its course; nothing is worse than artificial weathering by so called restoration experts, for in a year or two it looks patently false, a mistaken attempt to create a patina.

In a well maintained historic building with good internal environment, interior decoration can last decades and should be preserved because its patina cannot be reproduced. Both external and internal paintwork are best maintained by regular washing to remove chemical deposits concentrated by condensation.

Normally, external painting of all joinery and exposed woodwork at five year intervals is essential to good maintenance. New exterior paint should be of a type that weathers away gradually in time so that the building does not accumulate thick, inflexible scales of brittle paint that crack, peel and chip off all too easily.

New vehicles, such as coal tar, alkyd resins, phenolic resins and vinyl, have been developed to replace tung and linseed oil. Various claims are made for these new vehicles, such as resistance to severe weather, mild chemical exposure, high humidity and condensation, as well as mildew and flame resistance. The new paints are not usually so satisfactory as the old as a base for repainting.

Good preparation of the surface is always vital. If maintenance has been neglected for some time or there is a buildup of old paint, preparation may take considerably longer than actual painting. Oil and grease should always be removed with solvents. For plaster, the surface should be free from dust and loose pieces. For wood, all knots should be stopped and all rot and defects repaired; it should be treated with primers and undercoating and rubbed down after each coat.

External painting with limewash is widely practised and ancient in origin. Quicklime is burnt and slaked and stirred up to form a thin paint. Durability can be improved by adding tallow or linseed oil with the quicklime, and colours obtained by adding earth and mineral pigments. Such lime-based paints have been used wherever the vernacular architecture of a country used plaster finishes, and although the pigments may fade they always look attractive and acquire a patina of age sympathetic to an historic building quite quickly.

Similar techniques can be used today for historic buildings. With paint renewed every second year, the effect is striking, the buildings always looking fresh and continuing the historic practice for these former royal buildings.

The cure of excess moisture

Moisture is one of the main causes of decay, for it weakens materials and causes them to be damaged by frost and wind erosion.

If the moisture content goes above 20%, wood becomes vulnerable to fungal attack and is softened, so that insects and pests are attracted. Walls with a moisture content of 3% to 5% are generally considered dry, but when this figure is exceeded, mould and stains appear, paint becomes smeary and blisters, plaster bulges or crumbles away and joinery rots. Moisture should never be bottled up. Walls and floors in historic buildings should be allowed to 'breathe', transmit molecular water vapour. It is fatal to trap moisture by applying impervious finishes, as this only drives it upwards. Without the presence of moisture, other agents of decay are mainly inoperative or at least their activity is greatly reduced.

There is always ground water beneath a building, but the depth varies greatly and the level may change with the seasons or the tides near the sea. The soil always has a high moisture content. The characteristics of building materials, their porosity, permeability, moisture content and capillarity all have to be considered when treating excess moisture. Before diagnosing any decay, the cause must be found, so if water is involved in any form its source must be discovered. It may be condensation, rising moisture or rain penetration. Condensation is by far the most difficult to diagnose, but until this possibility has been eliminated positively, one cannot be certain that other possible causes of apparent damage caused by moisture are the true ones. Expensive mistakes can result from wrong diagnosis of excess moisture. The investigation of excess moisture, loosely called humidity or dampness, is a complicated problem, much depending upon the environmental history of the site and the whole building itself.

Rain penetration

Rain penetration depends upon the exposure of the building, the amounts and duration of rain and wind pressure and the materials of which the building is made, and the wall thickness together with condition of the jointing material. If the building is of cavity wall construction, penetration also depends on the detailing of cavity gutters and damp proof courses by the architect and the workmanship of the builders in keeping cavities clean. Neglect of routine maintenance leading to leaking roofs, blocked gutters and outlets, broken downpipes or leaking valley and parapet gutters will also allow rain penetration. Penetrating water tends to percolate downwards by gravity and also sideways and upwards by capillarity.

Rising moisture

To investigate rising moisture, it is essential to find the depth of the foundations and the depth of the water table. In simple cases one hole may suffice, dug alongside the external walls to the depth of the footings, with a further small hole away from the footings to find the water table, or a hole may be dug internally if circumstances permit. Such holes should be dug by archaeologists or at least under archaeological supervision, in order to record evidence rather than risk destroying it. If the foundations are immersed in the ground water, they act like a lampwick with the full effect of capillarity, otherwise they draw their moisture from the soil which may receive its supplies from rain or by its own capillarity. So, in addition to the depth of the foundations, it is necessary to know the nature of the soil and the seasonal variations in its moisture content, as well as the level of the water table. Shading by surrounding buildings and vegetation can alter the evaporation rate of the soil and increase its moisture content and, consequentially, the effect of rising moisture.

The level of ground water varies with rainfall, and even (when a site is near a tidal river) with the tides. The level can be ascertained from adjacent wells and from records of soil mechanical investigations, which should always be lodged with the competent authority responsible for buildings. The local water supply authority may provide information. The object is to discover whether the ground water level has risen or fallen, and what has caused the change.

In saturated walls, the moisture content is dependent on the porosity of the material. Water rises by capillarity from moist ground and permeates a wall, climbing to a height determined by the effects of evaporation and marked by the crystallization of soluble salts on a line roughly parallel with the ground. There is possible disintegration of the wall materials in this zone. With the seasonal raising of the temperature of the external air, the rate of evaporation increases and the crystallization zone retracts. When the wall is saturated with a moisture content of 20% or over, the evaporation is only on the surface, but where the moisture content is less and evaporation balances the capillarity, crystallization takes place inside the pores and may damage the wall material. The long term result of these seasonal movements of water with entrained salts is to form a wide zone of decay. If there is no evaporation, water will rise by capillarity to a maximum level that is determined by the pore structure of the wall material and by the influence of dissolved salts derived from the soil, so increasing the possibility of evaporation can assist in reducing the height of excess moisture in a wet wall.

Condensation

Inside a building, condensation will occur on the surfaces containing the volume of air. If there is a general relative humidity of, say, 80% and the surfaces are colder by some 4°C, then condensation is likely to occur where the insulation values are lowest in the first instance, showing most readily on smooth surfaces and least readily on rough porous surfaces; however, as water vapour can penetrate walls, in these cases one would get interstitial condensation and in cold climates even the danger of the build up of ice, with consequential damage to the material against which vapour barriers are provided in modern construction. With absorbent materials such as wood, concealed condensation may occur, with the material taking the excess moisture into its structure. The temperature at which condensation occurs is called the dewpoint.

With high relative humidities, however, the micro climate of the building comes into effect with regard to condensation. Without active air circulation, pockets of air with high relative humidity may exist, and with changing temperatures the thermal mass as well as thermal conductivity of materials affects the micro climate.

Condensation is a thin film of water deposited from the water vapour in the air. It forms on cold surfaces and releases latent heat and collects all types of aerial pollution, so it is an active agent of decay. Although one can get an idea of the thermal conductivity by touch, and this is one of the specific characteristics of a material which induces condensation, it is not possible by such rough and ready means to determine the thermal resistance or the moisture content of the surface. It may even happen in the case of condensed moisture that the measuring instruments fail to record the phenomenon, for it is intermittent. At interior temperatures between 5 °C and 20°C it may only require a lowering of temperature by half a degree for condensation to take place where the relative humidity of the atmosphere is around 95%.

Different conductivity and thermal mass of mortar and partition blocks can likewise show up in a pattern, outlining the blocks with faint condensation on the colder mortar joints. This same effect can even be seen when two rooms are warmed equally and simultaneously, but if one is cold, then the effect is more pronounced. The pattern shown is similar to that staining of ceilings caused by the different insulating values of rafters and lath and plaster, the poor insulating value of the lath and plaster attracting convected heat from the air, which deposits dirt.

Cold weather condensation

Condensation usually needs an agent to trigger off the process and to act as a condenser: in buildings, this agent is usually the cool internal surface of an external wall. In cold weather there are, therefore, two condensation risks. First, when the inner surface of the structure is cooler than the dewpoint of room air, surface condensation occurs; secondly, interstitial condensation occurs when vapour pressure drives water vapour through all except completely impermeable materials, when colder conditions bring the vapour to the dewpoint, interstitial condensation will occur, even when surface condensation is absent. In cold climates, this condensation may freeze and with the further continuing action of vapour pressure, ice may build up inside the material.

The factors controlling whether cold weather condensation occurs or not are as follows:

(1) The absolute moisture content of the incoming air.

(2) The temperature and relative humidity of internal air resulting from how the dwelling is used.

(3) The rate of ventilation.

(4) The temperatures of room surfaces.

(5) The permeability of the structure.

(6) The temperature gradients within the structure.

(7) The insulating values and thermal capacities of the surface materials.

It is clear that while cold weather condensation can be influenced by design, the way in which the building is used is also important.

Warm weather condensation

In this event, incoming air has a high moisture content and may condense on a structure which is still chilled by the cold spell.

The surfaces of an unheated building may be seen streaming with water, sometimes to the point where pools of water form on a stone floor. Painted or varnished surfaces of wood become wet, whereas unsealed wood can absorb the moisture and therefore may appear to be dry. Warm weather condensation is liable to be particularly acute in unheated historic buildings because of their high thermal capacity. Increasing ventilation merely introduces more moisture. It is difficult to avoid warm weather condensation, but shutting windows for a time helps as it slows down the supply of moisture while allowing the building time to warm up. Continuous background heating to keep the structure warm is the best answer, but if this is not available some temporary heating will help.

Hygroscopic salts

Allied to condensation is moisture showing in patches where chemical salts have become impregnated into the wall plaster. This moisture appears when the relative humidity is high, as the salts are hygroscopic. When the relative humidity is low they disappear, often leaving a stain which indicates the area of defective plaster. It is possible however, that a previous partial repair may also leave decoration in a patchy and stained state, so it is necessary to study the evidence carefully before pronouncing a diagnosis.

Relationship between condensation and heating

Intermittent heating systems with quick reaction may be attractive to occupiers because of the speed with which they meet the occupants' requirements of temperature if not thermal comfort, but they are generally inadequate in keeping the structure warm enough to prevent condensation. The heating system should be matched to the construction, usage pattern and contents of a building. To minimize the risk of condensation, long periods of low heating are better than short sharp bursts of high temperature, as the whole building is then heated. If the temperature and relative humidity records are taken as recommended earlier, the designer can find the mean temperature and then plan the heating to give temperatures slightly above this figure. Intermittent heating can cause severe condensation, since by raising the temperature of the air for a short time it enables the moisture content to increase, only for this moisture to be released when the temperature falls and the dew point is reached.

Moulds caused by condensation

Condensation is the prime cause of moulds occurring inside buildings. Treatments with chemicals such as zinc silicofluoride, 25 g/1, or suitable proprietary products kill the mould, which can be brushed off when dry, but such superficial treatment does not remove the cause. Unequal or partial heating leads to condensation troubles if warm air of relatively high humidity is allowed to find its way from a warm into a cold part of a building where moulds will start to grow.

Testing for moisture

Methods of testing moisture range from placing a glass sheet over the affected area to the use of electric moisture meters and special built-in condensation recorders.

Recording temperature and relative humidity

Instruments should be 'zeroed' for accuracy, using a whirling psychrometer and accurate thermometer, and rechecked at monthly intervals. The starting time should be noted on each occasion on the graph paper when it is renewed. After being studied, the graphs should be put into the building's log and ultimately its archives.

Surface tests for moisture can be made using a 'protimeter' or similar electrical resistance measuring device, but the accuracy is only relative, and can be completely upset by condensation as the meters only measure superficial water content; also, it should be remembered that condensation can be caused even by the evaporation of driving rain on one side of a building.

Accurate tests are made by taking borings to at least 100 mm depth but preferably 200 mm and then placing them in sealed glass containers. Each sample is dried in a laboratory so as to find the moisture content of the material at that place (calcium carbide site-testing methods have recently been introduced). A sectional drawing of the wall with the moisture contours will help identify the cause of dampness. One difficulty is in getting the samples, as a blunt drill, generating heat, may upset the accuracy of the investigation. This can be overcome by changing to a sharp, new drill for taking the actual samples. Samples are taken at various heights at about 1 m spacing at the centre and about 100 mm from both faces of the wall, enabling moisture content contours to be plotted, and from this it is possible to determine the source of the moisture.

The contours of moisture percentages should be plotted on sections of the wall and should enable correct deductions to be made about the source if the nature of the wall material and its characteristics of porosity and capillarity are understood.

The infrared thermovision method of investigating condensation requires sophisticated, expensive specialist equipment which will, however, identify 'cold' spots which are susceptible to condensation, and 'hot' spots which may suffer from thermal distress.

Before making a diagnosis, it is essential to look at all the surroundings of the building and consider the thermal behaviour of the relative masses of structural materials together with air movement patterns, ventilation and heating.

Cure of penetrating moisture in walls

When local penetrating moisture is the result of broken gutters, blocked outlets and defective down pipes, it is cured by attending to the defects. General penetrating moisture may be due to poor walling materials or to poor pointing and jointing, the latter defect being the most common. If the pointing is known to be in good condition and penetrating moisture is still a problem, then consideration will have to be given to lining the wall or to the dubious expedient of external application of water repellent silicone treatments. The latter can only be regarded as temporary, for the silicones may only have an active life of about five years, and they should not be applied to stone because they give it a shiny appearance and possibly accelerate decay.

Wall linings

Walls may be lined to cure both penetration of moisture and condensation. Traditional methods were to build in fixing battens or blocks and to line the wall with softwood panelling, canvas or tapestry hangings. In most cases the old battens or blocks will have suffered from rot and pest, against which any new wood fixings must be impregnated.

Cure of rising moisture

When moisture proofing a floor, the insertion of a new damp proof membrane may upset the moisture equilibrium of a building by driving the moisture up the walls, so allowance for this should be made when improving old floors. If a stone floor is to be sealed, a sealer that will transmit molecular vapour will help mitigate the build up of moisture. If the ground floor is extremely damp, the water table may be exceptionally high or there may be underground springs under the building, and in this case either a complete horizontal damp proof membrane under the floor and through the walls may be necessary or efforts should be made to lower the water table by installing a ring system of well point drains using automatic electric pumps in extreme cases.

Insertion of moisture barriers in walls

After the symptoms have been recognized and the cause identified and investigated, it is safe to prescribe the repair of a moist wall. Rising moisture may be cured by cutting in a horizontal damp proof course either by underpinning and using impervious brickwork set in an impervious mortar, or by sawing horizontally and inserting two courses of slates set in cement mortar, or a metallic damp proof course of soft copper or lead, or lead in a bituminous sandwich. Unfortunately, it is rarely possible to carry out the above proposals on historic buildings because the walls are too thick, or because the cost is too great, or because the effect of the work may be aesthetically or archaeologically undesirable. So it is often necessary to consider some expedient such as chemical infiltration, by drilling holes at about 150 mm centres and infusing a patent solution based on silanes or silicones.

In less acute cases it may be reasonable to alleviate the situation by assisting the escape of the moisture in various ways. The classic method is to form a dry area by excavating a trench round the base of the damp building and filling this with gravel to reduce capillarity. This only works for surface water and does not affect rising damp from the water table. A refinement is to put a land drain at the bottom of this trench and excavate to falls and drain to a sump. With dripping eaves a further refinement is to protect the base of the wall with splash plates to deflect the drip outwards away from the wall. Another method, used in the past, is to cut in porous tubes so as to extract the damp air; it was claimed that the moisture first absorbed the damp air into the porous material and then the heavy saturated water vapour ran out of the tube, which must slope downwards and outwards. However, after many years of promotion it has been found that these tubes rarely work. A further disadvantage is that the drilling equipment necessary for the tubes make this method expensive, particularly for small jobs.

After a horizontal water and vapour proof membrane has been inserted it may take years or even decades for a saturated wall to dry out. The amount of water that has to evaporate can be calculated if the percentage moisture content has been measured. The wall will dry out from the top downwards, evaporating moisture only from the surface when saturated and from the whole thickness when it reaches a low moisture content. When walls dry out, crystalline salts may appear. These should be removed by poulticing, as described for stone cleaning.

One way of reducing rising moisture in a building is to lower the water table. Nowadays, there is a danger of artificially raising thelevel of the water table through the introduction of water borne sewage leading to septic tanks with no drainage to remove the excessive amount of water from the subsoil.

The water table is lowered by inserting wells at strategic points and pumping to reduce the table to the desired level. In an operation such as this, extreme care must be taken not to remove silt and to pump frequently and by small instalments rather than at longer intervals and more violently, as this may remove material from beneath the foundations. If a vertical waterproof curtain can be formed in the soil around an historic building, then the amount of pumping can be greatly reduced and the danger of removal of silt also reduced proportionately.

The pumps should preferably be submerged in the water, using a type which is not damaged by this method, and they should be duplicated, as a failure could be disastrous. The inlets should be through some form of filter bed to avoid removing silt. Frequent inspection of the plant is necessary and some form of warning should be devised in case of a malfunction.

Correction of condensation

As condensation is controlled by factors relating to the weather, by ventilation and particularly by the occupant's usage of the building, it should be mentioned that if the building has been made impervious to the passage of moisture molecules, condensation is more likely to occur, especially if there is inadequate ventilation. If the insulation value of the wall can be increased, such as by lining it with polystyrene, then the risk of condensation is reduced because the dew point is less likely to be reached at the inner surface. In the same way, heating tends to prevent condensation in warmed spaces but, on the other hand, may aggravate condensation in unheated spaces if warm, wet air is allowed to migrate into cold areas which have inadequate ventilation. This is the reason for providing vapour barriers. Condensation on floors can be prevented by the installation of underfloor heating, which even if it only keeps the floor 1 °C above the dewpoint will prevent moisture appearing. Since external air in cold weather nearly always has a fairly low moisture content, it would in theory be possible to prevent all condensation by means of ventilation. Ventilation rates are now likely to be in the region of two air changes per hour rather than the previously accepted four or more changes. In bedrooms, especially small rooms, the rate may well be even lower. With such low change rates, unventilated pockets are more likely to occur, thus increasing the danger of condensation which may induce dry rot.

To correct condensation several methods may be used singly or collectively:

(1) Removal of an evaporation source by the insertion of damp proofing will help by reducing the amount of water vapour.

(2) Insulation will reduce the risk by keeping the surface warmer.

(3) Heating, either radiant or by embedded conductors, can control condensation by raising the surface temperature.

(4) Air movement will help by preventing local concentration of humidity.

(5) Extraction of the air moisture by dehumidifiers or silica gel is a successful method of removal of moisture from air only.

Cleaning, preserving and consolidating masonry

In most cases, the reason for cleaning whole buildings is aesthetic. One of the most significant arguments in favour of regular cleaning of stone is that it reduces the danger of salts building up behind the stone face and causing blistering which can result in replacement becoming necessary. Heavy encrustations of dirt are an obstacle to the natural weathering pattern.

A surveyor or architect cannot detect cracks, active movements or deterioration in a building covered by soot pollution—a point ignored by the 'anti-wash' school of thought. Some buildings have permanent provision for cleaning and access for maintenance. If the expense of regular scaffolding is to be avoided, permanent provision is to be recommended.

Before cleaning

The approach to a cleaning project should be flexible, the best method being chosen for each part, bearing in mind the risks involved. The contractor's attention must be drawn to all possible hazards. Test areas should be prepared in order to agree on the amount of cleaning that is required and to find the most suitable method. A spray or mist of pure water is generally considered the safest, but in case the local supply of drinking water contains trace salts which might damage the stone, analysis and assurances should be sought from the supply company. The effectiveness of the rainwater drainage system should be investigated, as this will be required to carry continuous and heavy flows of waste water, possibly the equivalent of a thunderstorm, for several weeks.

The fabric of the building to be cleaned must be inspected in detail. Projecting cornices and string courses should be given special attention to ensure their waterproofness. These may need special treatment before the general cleaning and will certainly need protection during the works.

Salt impregnated carvings and sculpture should be examined by an expert for cracks and fissures which might indicate case hardening of the stone with hidden sulphate attack. They must be given prior treatment so as to avoid further damage by recrystalization of salts, assuming that water spray methods are most likely to be used.

Preventive consolidation is desirable to fix unusable areas in an advanced stage of decay. This treatment may even decide the subsequent methods to be used. Absorbent clay packs based on clays such as 'Sepiolite and 'Attapulgite', using a solvent or water, can extract unwanted soluble salts. Solvent jellies enclosed in aluminium foil or polythene with pH below 7 to 8, followed by washing, can be used to clean tender surfaces unless they are very porous. Washing water should have the same pH value, but to ensure that the basic components of the jelly are removed, final washing should be with distilled or deionized water of pH 6. The specially valuable work can then be consolidated before the general cleaning, as described later.

As every stone is different, no consolidant can be said to be preferable to another. Tests must be made to see which material and which technique will improve the stone's resistance to decay under the atmospheric conditions to which it will be exposed. These tests take time, so arrangements must be made well in advance.

Methods and relative costs of large scale cleaning of masonry

Methods that have been used in the past for cleaning historic buildings may be divided into three classes: (a) those that use water in the form of spray, steam, high pressure water or vacuum and soft brushing or poulticing after initial softening with water; (b) those that use abrasives by either blasting or mechanical means, with or without water; (c) chemical pr using hydrofluoric or other acids and solvents. It must be stressed that dry abrasives and mechanical means should only be used on the outer layers of heavy incrustation, otherwise they will cause damage to the surface patina of the masonry.

Cost factors are liable to change with time, but as a rough guide, using water spray as an index of 1.0, a water lance with abrasive may be slightly less expensive (0.75), whereas chemical processes are nearly twice as expensive (1.75). Mechanical processes including hand rubbing have a factor of 1.25 to 3.01 abrasive processes work out at wet 2.0 or dry 2.0 to 4.0 depending upon the detailing of the surface to be cleaned and risks to adjacent properties.

If the water used in spray cleaning is excessive it may cause flooding of basements and damage to foundations; in any case, it must be collected at the base of the wall and run to rainwater drains. If possible, recirculation from a settlement tank should be arranged in order to save water. With all wet methods there is a risk of drain blockage, so cleaning out and inspection at the beginning and end of the job must be done. Normal washing is worked from top to bottom so as to get maximum use of water, whereas chemical treatments should be applied from bottom to top in order to avoid double treatment and resulting pattern stains.

Water spray or mist cleaning

Water spray should not be used in winter when freezing can be expected. As the mist gets blown about by wind, the working area should if possible be enclosed. To obtain a fine mist or spray, sufficient water pressure is necessary, so if the mains pressure is inadequate an elevated storage tank supplied by a small electric booster pump will provide the required pressure.

The time taken to soften the dirt may vary from minutes to days and must be found by trial and error. When the dirt has been softened, it can be removed using bristle brushes. On historic buildings, wire brushes of any sort must not be used, as they may damage the patina and broken bristles may corrode and cause stains. A few hard areas of dirt may remain; these can be carefully picked and scraped so as not to damage the stone face. Water lances and high pressure water sprays containing a small amount of abrasive are also useful but can be too violent.

Internal washing is considerably more expensive than external cleaning owing to the need to protect or remove furniture and fittings, together with the difficulty of collecting and disposing of surplus water. When a fine water spray can be used for a long period, the majority of the dirt is removed or at least softened without any additional labour. In internal cleaning, the use of less water means that more labour is needed for the same results. Fortunately, however, internal dirt has generally not become so securely fixed, and can first be dealt with by vacuum cleaning, then scrubbing with brushes and water, sponging off the dirt as work proceeds, followed by a clean wash. The water used for cleaning will fall to the floor or run down the wall and should be collected from the base of the wall in a waterproof trough. Ideally, scaffolding which is primarily arranged to give access to the ceiling and wall should have provision over the central area for a tent, the slope of which will guide the water to the perimeter trough from which, after allowing settlement of entrained dirt, the water can be recirculated.

It is also valuable in internal cleaning operations, as it reduces the amount of water used and the danger of flooding together with damage to the fabric and disruption. Specially designed jets with controlled water and pressure flows produce the fog, which has the effect of loosening and removing dirt by keeping areas damp for a period of time.

It is claimed that 70 ml of water will cover $9m^2$. The equipment can be purchased, but it is best used by a specialist firm.

Choosing the appropriate cleaning method

A specialist contractor able to use several methods should be employed, as no one method will solve all the problems likely to be met in cleaning an historic building. The choice must depend on a careful survey in which the following checklist may be helpful; is cleaning necessary for the maintenance of the building; is cleaning aesthetically desirable; are there any specially sensitive details or art works that need prior treatment and consolidation by a conservator; what objects need special protection, windows, memorials, fixed furniture; is there a hazard from using water, dry rot in embedded timbers, areas where recrystallization of salts may occur, and danger to the foundations or flooding a cellar; are there any places where water treatment is unlikely to succeed; will chemical methods leave residual salts and cause discoloration.

Works after cleaning

Both internal and external cleaning are valuable in revealing existing defects, including localized stains and previous repairs which have been misguidedly 'toned' with oil or soot to match the general background of dirt. Allowance should be made in the programme and contract for all sorts of unexpected repairs, along with some redecoration which will probably be necessary after the internal cleaning; these works should, of course, be carried out from the same scaffolding erected for cleaning. Efflorescence may appear after internal washing and cleaning, but the salts should be allowed to crystallize and when dry should be brushed off and the area then poulticed.

This stain does not show immediately after washing but begins to come to the surface after one or two years. The stain can be easily removed by re-washing the stone, and if a building is washed at regular intervals as a proper part of a planned maintenance programme, it will probably stop recurring. This stain is reported to be less likely, or at least slower, to appear if washing is done in the summer.

Paint removal

Removal of paint from masonry is a difficult matter, depending upon the suction of the pores. A trial should be carried out on a sample area before attempting removal from the whole building. The paint remover may only soften the surface layer; the stripper may drive the remainder of the paint deeper into the pores. To combat this effect, poulticing by applying a paste of paint remover mixed in whiting and talc should be tried. This slows the action of the solvent, allowing time for it to penetrate deeper, and also prevents surface evaporation of the solvent. The paint remover must not contain alkalis. In difficult cases, one type of remover may be insufficient and a series of removers should be tried. When using proprietary products, fire risks danger to persons from contacts, splashes and fumes should be guarded against.

Localized stain removal

For localized staining, most cleaning agents can be applied in the form of a poultice by thickening with a inert filler such as bentonite (fuller's earth), powdered chalk or 'Sepiolite'. Stains should be loosened with wooden scrapers or stiff fibre brushes to; damage to the surface patina of the masonry.

Stone preservation

Commercial waterproofing agents and stone preservatives have been marketed for many years. Their intended function is to fill the pores of stone with a water insoluble deposit. Linseed oil, waxes and metallic stearates have been used. The former tend to change the stone's appearance and attract dirt. In general, it can be said that none of these treatments can be recommended. Often, having been applied, they cause complications when scientific conservation is proposed.

Silicone water repellants, supplied by a few major manufacturers to a large number of distributors who add organic solvents or aqueous bases, have been widely advertised. If the preservative is caustic, it may cause staining if iron salts are contained in the stone.

Silicones are at best only temporary in their effect; at worst, they may aggravate moisture trouble. There are two main reasons why shallow surface treatments may accelerate decay. First, moisture invariably gets trapped behind the treated layers and is prevented from evaporating at the surface. Instead it evaporates slowly, forming larger crystals from the dissolved salts, and it may cause spalling or powdering of the surface. Secondly, the treated layer has different thermal movement properties from the underlying stone and this may eventually cause a shear failure.

After over 100 years of effort we have had, in effect, 100% failure in finding a general purpose stone preservative suitable for application to buildings in normal weather conditions.

Special techniques of repair and structural consolidation

In addition to the traditional techniques already described, the repair, consolidation and restoration of historic buildings requires a number of special techniques and some unusual skills such as drilling and grouting. Architects are not generally concerned with scaffolding, shoring and such matters as planking and strutting, yet unless these techniques are skilfully carried out, the conservation of an historic building may not be possible, or at least may be made much more expensive. Just as the building must be seen as an individual 'whole', so the work of conservation must be planned as a totality if it is to be efficient.

Grouting, by means of a liquid cementacious mix inserted under pressure after drilling into a building, is a means of consolidating its structure. The special techniques of prestressing with jacks in compression and for post tensioning reinforcement, subsequently grouted, depend also upon drilling. These are the universal methods of putting strength back into historic buildings in such a way as to maintain their structural integrity and conserve the original materials. The object of grouting is to strengthen and consolidate decayed masonry which is weakened by large fractures and voids. It can also be used to introduce preservatives into stone by vacuum methods of impregnation. Although grouting is a useful preliminary treatment it cannot usually be regarded as a complete structural repair in itself, nor can it be trusted to fill fine cracks. It does, however, consolidate and increase the stiffness of an old structure.

Searching out voids for grouting presents difficulties; often a hit or miss method has to be adopted, with holes drilled in a predetermined grid and water testing used to give advance warning of the existence of and probable size of the void. Other methods involve simple tapping with a hammer and listening to the note, which varies with the solidity of the masonry, or the more complicated use of gamma or X rays, which can only penetrate about 1 m overall, or ultrasonic testing. Each method should be tried, as particular circumstances like multiple fissures or even fine cracks may render the searching out of voids impracticable.

Grouting is the insertion of a fluid cementacious mix, called grout, with good flow characteristics into the cracks and fissures of masonry or concrete. Before inserting the grout it is first necessary to clean out the voids and wet all the surfaces. The grout is inserted under pressure of gravity or by a hand or air operated pump. Vacuum grouting is also a hopeful development, but relies on suitable resins for its effectiveness.

Grouting mixes are formulated for each specific project, in order to obtain the desired strength and penetration characteristics. Sand and pulverized fly ash may be added to the cementing material which may be lime, hydraulic lime, Portland cement or various epoxy resins or silane formulations. Proprietary additives are used to promote flow and penetration.

The addition of pozzuolanic material to lime in grouts and mortars is important. Lime itself sets by carbonization, the action of carbon dioxide, and the setting consists of hardening from the surface inwards, so that in thick walls the process may never occur, leaving powdered calcium hydroxide instead of hard mortar. However, carbon dioxide is not needed if pozzuolanic material such as volcanic earth, including alumina and silica or crushed brick and tiles, is added in equal proportions to the lime.

Pulverized fly ash which is extracted from power stations, is a pozzuolanic material and can be used with lime to form a hydraulic mortar of attractive colour; but the use of some types of fly ash with a high soluble salt content should be avoided. Two parts pulverized fly ash with two parts lime and, in order to keep the binding material in suspension, one of bentonite clay additive, to promote flow characteristics, is a useful grouting mixture which avoids the excessive hardness and strength of Portland cement grouts. If Portland cement is used, there is a danger that the grout will be too hard and impervious and not marry well with masonry. If hard and impervious material comes too close to the surface of masonry it may promote frost attack and should therefore be cut back at least 50 mm before it hardens, and in any case it does not have the necessary resilience to be structurally sympathetic to old masonry.

A form of gravity grouting can be carried out by forming clay cups against open joints in masonry and filling these repeatedly with grout which flows through the open spaces and consolidates the masonry. The mixture may need some help in its flow, by working a hacksaw blade or similar probe through the joint. Fine sand and the addition of pulverized fly ash assist the flow and, together with lime as the cementatious agent, they make a good grout mix in the proportions 2:1:2; more fly ash can be added along with a little Portland cement if quicker setting is desired. For more sophisticated forms of grouting, probe holes are drilled into the masonry at appropriate centres, the spacing of which depends upon the condition of the masonry and the incidence of cracks. In very fissured masonry, probes at close centres are desirable, whereas where large lumps of stone or flint concrete have cracked, it is only necessary to have grout probe holes at 1 m centres, following the line of the crack upwards.

The holes having been drilled, water is inserted to wash out the loose materials and wet the masonry so that the grout will adhere. For this, one works downwards, whereas for insertion of grout one must work upwards in order to avoid trapping air in pockets. The probe itself fits into the hole and may be caulked there, or merely held in position with a foamed rubber washer around it to stop undue leakage.

As all grouting work is liable to be messy, protection of furniture and fitments is essential; if they cannot be removed they should be covered with polythene sheets. The masonry walls themselves must also be protected or at least cleaned down with hoses immediately after a spillage of grout. It is also best to put a protective coating of potter's clay to avoid staining or otherwise damaging precious historic masonry which may be difficult to clean thoroughly. Recent developments of plastics also suggest application of a thin coat that can be peeled off later.

The grout is inserted working first sideways then upwards. When the grout flows out of an adjacent hole sideways, this hole is stopped and the grout allowed to move as far as it can, even up to some 6 to 7 m. Then one proceeds to the next hole, and in this manner completes a horizontal row, recording the amount of grout inserted into each hole and the distance of flow. After the horizontal row is complete one moves upwards to the next row and repeats the process.

The advantage over mechanical pumping is that pressures cannot build up if there is a stoppage. The grout is mixed in a raised reservoir, from which it is fed by flexible pipe of about 25 mm to 30 mm diameter and controlled by a plunger stopper.

A slightly more complicated method is to use a hand pump with 50 litre reservoir with the mix continuously agitated by an electric or compressed air motor. A hand pump can be used to produce pressures of two or even reaching six or seven atmospheres to achieve a deeper penetration of grout. Pressures must be controlled carefully, as there is a danger of blowing stones out of the face of a wall and other damage. The pump operator is supported by at least one man on each side of the wall who stop up leaks as and when they show, and if this is not possible stop the pumping. Sometimes this has to be done very quickly, and if communication by word of mouth is difficult then the use of throat microphones and radiotelephone is the best substitute, telephones are too slow. With hand pumping it is possible to feel the rate of flow and judge the situation and react quickly.

This is not possible with mechanically operated pumps, which should not be used on historic building grouting work. However, reservoirs which inject using compressed air, at a predetermined pressure that cannot be exceeded, are probably the most efficient, especially in large operations.

Epoxy resin formulations have been used in much the same way as cementacious mixes to consolidate fissured masonry or cracked stones. The dangers from staining and surface damage are greater, so protective measures have to be more stringent. The pot life of some formulations is short and may cause difficulties in practice. The plant may have to be stripped down and cleaned completely after each injection. As the epoxy resin material is expensive it is not practicable or desirable to use it on large voids, so in some cases it may be desirable to fill the large voids with ordinary grout and then re-grout with a weak penetrating mix of epoxy resin so as to consolidate friable and broken up areas. In suitable circumstances, vacuum impregnation may be used in order to obtain maximum penetration.

Full records of all grouting operations should be kept and deposited with the archives of a building. The amounts injected are a rough guide to the structural condition of the fabric: up to 21/2% of the total volume is by no means uncommon, but far larger amounts have often been injected into areas which have suffered high stresses over a long period of time, which is not surprising as one would expect these parts to wear out more quickly.

After repair of an historic building involving grouting, particularly with Portland cement, serious condensation problems can arise—first, because the water used in the injections may cause damage as it dries out; secondly, because the grout, if different from the wall mortar, may form zones of unequal density and promote cold bridges causing condensation which could result in disintegration of the wall plaster or staining of wall paintings; and lastly, there is always the danger of soluble salts in the cement causing damage by crystallization.

7.5. Adaptive Reuse Options

The best options for any Adaptive Reuse Design proposals is minimum intervention. Therefore these hiatoric buildings, once refurbished, are essential put into similar types of functions, as they held before, with slight alterations to internal spaces only, tearing down the internal partitions, keeping the exterior facades intact. The best interventions formulated were those of open plan shops, exhibition stores, cafes and art workshops. Basic plans forcthese are shown in Fig. 7.1.

7.6. Conclusion

Once we figure out the remediation for Adaptive reuse projects, its also essential to incorporate specific guidelines and recommendations for the same for future maintenance prospects. These are discussed in the concluding chapter that follows.

8.1. Introduction

Adaptive Reuse means the process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values. This concluding chapter discusses the various guidelines that should be observed following recommendations into Adaptive Reuse of dwellings

8.2. Guidelines for Adaptive Reuse

1. Every reasonable effort shall be made to provide a compatible use for a property which requires minimal alteration of the building, structure, or site and its environment, or to use a property for its originally intended purpose.

2. The distinguishing original qualities or character of a building, structure, or site and its environment shall not be destroyed. The removal or alteration of any historic material or distinctive architectural features should be avoided when possible.

3. All buildings, structures, and sites shall be recognized as products of their own time. Alterations that have no historical basis and which seek to create an earlier appearance shall be discouraged.

4. Changes which may have taken place in the course of time are evidence of the history and development of a building, structure, or site and its environment. These changes may have acquired

5. Distinctive stylistic features or examples of skilled craftsmanship which characterize a building, structure, or site shall be treated with sensitivity.

6. Deteriorated architectural features shall be repaired rather than replaced, wherever possible. In the event replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual qualities. Repair or replacement of missing architectural features should be based on accurate duplications of features, substantiated by historic, physical, or pictorial evidence rather than on conjectural

designs or the availability of different architectural elements from other buildings or structures.

7. The surface cleaning of structures shall be undertaken with the gentlest means possible. Sandblasting and other cleaning methods that will damage the historic building materials shall not be undertaken.

8. Every reasonable effort shall be made to protect and preserve archeological resources affected by, or adjacent to any project.

9. Contemporary design for alterations and additions to existing properties shall not be discouraged when such alterations and additions do not destroy significant historical, architectural or cultural material, and such design is compatible with the size, scale, color, material, and character of the property', neighborhood or environment.

10. Wherever possible, new additions or alterations to structures shall be done in such a manner that if such additions or alterations were to be removed in the future, the essential form and integrity of the structure would be unimpaired.

8.3. Recommendations for Applying Standards Of Adaptive Reuse

The following guidelines are designed to help individual property owners formulate plans for the rehabilitation, preservation, and continued use of historic. The guidelines pertain to buildings of all occupancy and construction types, sizes, and materials. They apply to permanent and temporary construction on the exterior and interior of historic buildings as well as new attached or adjacent construction.

Adaptive Reuse approaches, materials, and methods which may adversely affect a building's architectural and historic qualities are listed in the 'not recommended' column on the right. Every effort will be made to update and expand the guidelines as additional techniques and treatments become known.

The environment should follow the following recommendations for retaining distinctive features such as the size, scale, mass, color, and materials of buildings, including roofs, and stairways that give a neighborhood its distinguishing character; retaining landscape features such as gardens, street lights, signs, walkways, streets and building setbacks that have traditionally linked buildings to their environment; using new plant materials, fencing, walkways, street lights and signs that are compatible with the character of the neighborhood in size, scale, material and color.

Avoid introducing new construction into neighborhoods that is incompatible with the character of the district because of size, scale, color, and materials; destroying the relationship of buildings and their environment by widening existing streets, changing paving material, or by introducing inappropriately located new streets and parking lots that are incompatible with the character of the neighborhood; introducing signs, street lighting, new plant materials, fencing, walkways and paving materials that are out of scale or are inappropriate to the neighborhood.

Building site follows the following recommendations of identifying plants, trees, fencing, walkways, outbuildings, and other elements that might be an important part of the property's history and development; retaining plants, trees, fencing, walkways, street lights and signs, that reflect the property's history and development; basing decisions for new site work on actual knowledge of the past appearance of the property found in photographs, drawings, newspapers, and tax records. If changes are made they should be carefully evaluated in light of the past appearance of the site; providing proper site and roof drainage to assure that water does not splash against building or foundation walls, nor drain toward the building.

Avoid making changes to the appearance of the site by removing old plants, trees, fencing, walkways, outbuildings, and other elements before evaluating their importance in the property's history and development; leaving plant materials and trees in close proximity to the building that may be causing deterioration of the historic fabric.

Building: Structural systems involve recognizing the special problems inherent 'in the structural systems of historic buildings, especially where there are visible signs of cracking, deflection, or failure; undertaking stabilization and repair of weakened structural members and systems; replacing historically important structural members only when necessary. Supplementing existing structural systems when damaged or inadequate.

Avoid disturbing existing foundations with new excavations that undermine the structural stability of the building; leaving known structural problems untreated that will cause continuing deterioration and will shorten the life of the structure.

Building exterior features like masonry: adobe, brick, stone, terra cotta, concrete, stucco and mortar need retaining original masonry and mortar, whenever possible, without the application of any surface treatment; repointing only those mortar joints where there is evidence of moisture problems or when sufficient mortar is missing to allow water to stand in the mortar joint; duplicating old mortar in composition, color, and texture; duplicating old mortar in joint size, method of application, and joint profile; repairing stucco with a stucco mixture that duplicates the original as closely as possible in appearance and texture; cleaning masonry only when necessary to halt deterioration or to remove graffiti and stains and always with the gentlest method possible, such as low pressure water and soft natural bristle brushes; repairing or replacing, where necessary, deteriorated material with new material that duplicates the old as closely as possible; replacing missing significant architectural features, such as cornices, brackets, railings, and shutters; retaining the original or early color and texture of masonry surfaces, including early signage wherever possible. Brick or stone surfaces may have been painted or whitewashed for practical and aesthetic reasons.

Avoid applying waterproof or water repellent coatings or surface consolidation treatments unless required to solve a specific technical problem that has been studied and identified; coatings are frequently unnecessary, expensive, and can accelerate deterioration of the masonry; repointing mortar joints that do not need repointing; using electric saws and hammers to remove mortar can seriously damage the adjacent brick; repointing with mortar of high Portland cement content can often create a bond that is stronger than the building material. This can cause deterioration as a result of the differing coefficient of expansion and the differing porosity of the material and the mortar; repointing with mortar joints of a differing size or joint profile, texture or color; sandblasting, including dry and wet grit and other abrasives, brick or stone surfaces; this method of cleaning erodes the surface of the material and accelerates deterioration. Using chemical cleaning products that would have an adverse chemical reaction with the masonry[7] materials, i.e., acid on limestone or marble; applying new material which is inappropriate or was unavailable when the building was constructed, such as artificial brick siding, artificial cast stone or brick veneer; removing architectural features such as cornices, brackets, railings, shutters, window architraves, and doorway pediments; removing paint from masonry surfaces indiscriminately. This may subject the building to damage and change its appearance.

Installing on significant facades shutters, screened blinds, security grills, and awnings which are historically inappropriate and which detract from character of the building; installing new exterior storm windows and doors! which are inappropriate in size or color, which arel inoperable, or which require removal of original)] windows and doors; installing interior storm windows that allow moisture to accumulate and damage the window; replacing sash which contribute to the character of a building with those that are incompatible in size, configuration, and reflective qualities or which alter the setback relationship between window and wall; installing heating/air conditioning units in the| window frames when the sash and frames may be damaged. Window installations should be considered only when all other viable heating/cooling systems would result in significant damage to historic materials are all avoided.

Wood clapboard, weatherboard, shingles and other wooden siding

Retaining and preserving significant architectural features, wherever possible; repairing or replacing, where necessary, deteriorated material that duplicates in size, shape, and texture the old as closely as possible.

Avoid removing architectural features such as siding, cornices, brackets, window architraves, and doorway pediments; These are, in most cases, an essential part of a building's character and appearance that illustrate the continuity of growth and change; resurfacing frame buildings with new material that is inappropriate or was unavailable when the building was constructed such as artificial stone, brick veneer, asbestos or asphalt shingles, and plastic or aluminum siding; such material can also contribute to the deterioration of the structure from moisture and insects.

Roofs and roofing should preserving the original roof shape; retaining the original roofing material, whenever possible; providing adequate roof drainage and insuring that the roofing materials provide a weathertight covering for the structure; replacing deteriorated roof coverings with new material that matches the old in composition, size, shape, color, and texture; preserving or replacing where necessary, all architectural features that give the roof its essential character, such as dormer windows, cupolas, cornices, brackets, chimneys, cresting, and weather vanes.

Changing the essential character of the roof by adding inappropriate features such as dormer windows, vents, or skylights; applying new roofing material that is inappropriate to the style and period of the building and neighborhood; replacing deteriorated roof coverings with new materials that differ to such an extent from the old in composition, size, shape, color, and texture that the appearance of the building is altered; stripping the roof of architectural features important to its character.

Windows and doors retaining and repairing window and door openings, frames, sash, glass, doors, lintels, sills, pediments, architraves, hardware, awnings and shutters where they contribute to the architectural and historic character of the building; improving the thermal performance of existing windows and doors through adding or replacing weatherstripping and adding storm windows and doors which are compatible with the character of the building and which do not damage window or door frames, replacing missing or irreparable windows on significant .facades with new windows that match the original in material, size, general muntin and mullion proportion and configuration, and reflective qualities of the glass.

Introducing or changing the location or size of windows, doors, and other openings that alter the architectural and historic character of the building; replacing window and door features on significant facades with historically and architecturally incompatible materials such as anodized aluminum, mirrored or tinted glass; removing window and door features that can be repaired where such features contribute to the historic and architectural character of the building; changing the size or arrangement of window panes, muntins, and rails where they contribute to the architectural and historic character of the building.

Exterior finishes should discover the historic paint colors and finishes of the structure and repainting with those colors to illustrate the distinctive character of the property.

Avoid *r*emoving paint and finishes down to the bare surface; strong paint strippers whether chemical or mechanical can permanently damage the surface. Also, stripping obliterates evidence of the historical paint finishes. Repainting with colors that cannot be documented through research and investigation to be appropriate to the building and neighborhood.

Building Interior features *recommend r*etaining original material, architectural features, and hardware, whenever possible, such as stairs, elevators, hand rails, balusters, ornamental columns, cornices, baseboards, doors, doorways, windows, mantel pieces, paneling, lighting fixtures, parquet or mosaic flooring; repairing or replacing, where necessary, deteriorated material with new material that duplicates the old as closely as possible; retaining original plaster, whenever possible; discovering and retaining original paint colors, decorative motifs or, where necessary, replacing them with colors, or decorative motifs based on the original; where required by code, enclosing an important interior stairway in such a way as to retain its character.

Avoid *r*emoving original material, architectural features, and hardware, except where essential for safety or efficiency; replacing interior doors and transoms without investigating alternative fire protection measures or possible code variances; installing new decorative material and paneling which destroys significant architectural features or was unavailable when the building was constructed, such as vinyl plastic or imitation wood wall and floor coverings, except in utility areas such as bathrooms and kitchens; removing plaster to expose brick to give the wall an appearance it never had.

Changing the texture and patina of exposed wooden architectural features (including structural members) and masonry- surfaces through sandblasting or use of other abrasive techniques to remove paint, discoloration and plaster, except in certain industrial or warehouse buildings where the interior masonry or plaster surfaces do not have significant design, detailing, tooling or finish; and where wooden architectural features are not finished, molded, beaded, or worked by hand is avoided.

Enclosing important stairways with ordinary fire rated construction which destroys the architectural character of the stair and the space and altering the basic plan of a building by demolishing principal walls, partitions, and stairways is also avoided.

For **new construction** keeping new additions and adjacent new construction to a minimum, making them compatible in scale, building materials, and texture; designing new work to be compatible in materials, size, color, and texture with the earlier building and the neighborhood; using contemporary designs compatible with the character and mood of the building or the neighborhood; protecting architectural details and features that contribute to the character of the building; placing television antennae and mechanical equipment, such as air conditioners, in an inconspicuous location.

Avoid designing new work which is incompatible with the earlier building and the neighborhood in materials, size, scale, and texture; imitating an earlier style or period of architecture in new additions, except in rare cases where a contemporary design would detract from the architectural unity of an ensemble or group. Especially avoid imitating an earlier style of architecture in new additions that have a completely contemporary function such as a drive-in bank'or garage; adding new height to the building that changes the scale and character of the building. Additions in height should not be visible when viewing the principal facades; adding new floors or removing existing floors that destroy important architectural details, features and spaces of the building. Placing television antennae and mechanical equipment, such as air conditioners, where they can be seen from the street is not allowed.

These guidelines and recommendations further the Adaptive reuse prospects and ease implemention techniques, with minimum intervention.

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