DESIGN GUIDELINES FOR MODERN LIBRARY BUILDING

A DISSERTATION

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

MASTER OF ARCHITECTURE

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which has been presented in this dissertation entitled as **"DESIGN GUIDELINES FOR MODERN LIBRARY BUILDING"**, in partial fulfillment of the requirement for the award of the postgraduate degree of **MASTER OF ARCHITECTURE**, submitted in the Department of Architecture and planning, Indian Institute of Technology Roorkee, Roorkee, is an authentic record of my own work carried out by me during the period from July 2010 to June 2011, under the supervision and guidance of Dr. Mahua Mukherjee, Department of Architecture and Planning, Indian Institute of Technology Roorkee, Roorkee.

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

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CERTIFICATE

This is to certify that the above statement made by the candidate **Ms. Sreenita Mukherjee** is correct to the best of my knowledge and belief.

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EXECUTIVE SUMMARY

A library is a collection of information, thoughts and wisdom expressed in written or audio or video forms. It is a space to advance knowledge, foster creativity, encourage exchange of ideas and enhance quality of life. Library is one of the world's greatest social and intellectual spaces which influence the generations. Sustainably designed libraries would be built to last, to flexibly respond to changing functional demands, to provide an environment that is inspiring and safe, to perform efficiently by providing great financial value to the community that support its creation. It is interesting to observe transformation of the library through digital age. Though the primary function of the library as knowledge temple has remained same, the processes involved at delivery have revolutionized especially at the end of the last millennium.

The Thesis aims to understand the critical issues regarding library: **obsolescence crisis** of traditional libraries, the paradigm shift in designing library building at digital age, spatial requirements for planning, environment responsive approaches and advanced building services. The research will culminate towards development of guidelines for user friendly modern library building.

Obsolescence crisis of traditional libraries: Physical libraries are in crisis due to changes in culture of teaching and learning. Providing access to information is prime function of any library traditionally; only change is that the print media is not the most sought after source to get information for younger generation. The very traditional instruction-cantered models of pedagogy where good teaching is conceptualized as the passing on of sound academic, practical, or vocational knowledge are being replaced with learner-cantered approaches. This shift to a 'learning paradigm' has changed the role of different learning environments in a place to share information, exchange ideas, and participate in the experience of learning. Traditional appreciation of grand reading rooms with high windows, light-filled space, walls lined with number of books, book cataloguing system, are aspects of appreciation till date. But in future, interior of library will house fewer books and quiet reading rooms; and will see increase in space for people and teams, more desktop terminals, digitized cataloguing systems, plasma screens to facilitate collaborative activities among small groups. Principle component of learning has not changed much, but the expectations among students to receive the same have undergone a sea-change. So basically the traditional concept of library design is in crisis. At the same time, some principal design elements like the grand central reading hall, naturally-lit spaces, user friendliness, comfort, flexibility, will continue to be there for quite some time.

The internet is being predicted as the future library; some also opined that physical library is in a way of obsolescence. Traditionally library building houses valuable collection for learners. Library needs to find spaces for learners of every age using books and digital media as catalysts. With advent of digital technology, the young users are habituated to use computers; laptops have provided them wider freedom to get information anytime anywhere. Declining number of visitors to library establishes a desperate need to revisit library design. The Internet has tended to isolate people from real world. But library with the advantage of its physical entity is in better situation to fulfil the expectations of students, teachers and society. Connecting to both real and virtual world in right proportion would be the serious duty of today's libraries to dispense.

Changing patterns of student learning is the main reason of crisis in traditional library. The footfall of students will swell as availability of technology and resources provides new and friendly options of library services. In the past, expanding collections of books and other hard copies reduced user space for reading. On the contrary, modern library is placing reduced demand on physical space requirement due to digital technology. If the library has to overcome its static character, the space must flexibly accommodate evolving technologies. Beyond general changes to the spatial design of the library in the regime of paradigm shift, there is a need for change in the traditionally understood role of the same. The role of the library is to create an environment that inspires creativity in learners and to reinforce their sense of participation. Users need sources of inspiration. That inspiration comes from casual or formal conversations which help to make connections. Emerging need for collaborative study space is basically against the traditional library design concept.

Paradigm Shift: Paradigms are shifting due to changing perceptions and preferences of new generations. Evolving concepts like collaborative and interactive learning environment, use of digital technology as catalyst for change and environment-responsive open-book building command appreciation. To attract young people to the library in digital age, integration of digital technology with high-end equipment and services have important role for success.

Collaborative and Interactive Learning Environment is one emerging requirement for successful modern library. The library has moved ahead of the existing model that optimizes individual learning environment to one that allows group-study or work. This has brought major shift from independent study mode to more collaborative and interactive learning. Young generations' preference for learning space's mix with academic and social functions is influencing addition of spaces for group study reinforcing multi-disciplinary studies together. In this interactive learning environment, it is important to design space supporting collaboration, sharing and experiments.

Digital technology as catalyst brings access to wider variety of resources enhancing communication and interaction. This reduces barriers of place and time for users. Rapid changes in IT are reflected in the library's collection, services and spatial arrangements. In the digital age, speed of access and quantity of online information stored on a particular site is the benchmark. Young generations are dependent on and also importantly comfortable with digital tools provided by the library for convenience and to easily connect with others.

Environment responsive library building itself can act as an educator. The building should have the qualities of imparting lesser impact to natural and man-made environment. There is a strong need to create comfortable and healthy conditions for its occupants and society. Elimination of negative environmental impact through skilful, sensitive design is an important consideration. Mix of appropriate passive and active strategies, for optimum use of natural resource can create users' comfort.

This dissertation regarding ***"Design Guidelines for Modern Library Building"*** has been structured on six chapters like introduction, literature review, case studies, analysis & synthesis, design guidelines and conclusions and recommendations. The study focuses on the changing perception and need identification for modern library design as well as spatial requirements for environment responsive, user friendly modern library design. Enabling Digital Environment for 21st century library is a major consideration of this study. Integration of Passive planning strategies and advanced building services are also within the scope of work. Due to time constraint detailed spatial design and economic viability of proposed strategies for designing modern library building falls outside the scope of this study.

First chapter introduces the overview of the problem, the issues regarding library at the present scenario and the need for the study when prediction is that the traditional library would become obsolete at digital age. Formations of aim and to achieve aim, the some objectives have been identified in first chapter. Defining the scopes and limitations has been covered in the introductory part of the dissertation. Methodology adopted for the research and organization of the thesis discussed here.

Second chapter concentrates on literature review related to present scenario of library. For that data collection on library design issues from secondary sources like books, research paper, internet etc. have made. The literature review brought a clear understanding on importance of design in modern library building to accommodate paradigm shift, integration of environment responsive design issues and advanced building services.

Case studies have been referred in third chapter to strengthen the understanding of the change required and ways to accommodate the same. Case studies selected from secondary sources are environment responsive modern library buildings from abroad: Philological Library from Berlin, National Library Building of Singapore and Frederic Lanchester Library from UK. Libraries visited by the present researcher from Indian campuses are: Indian Institute of Management, Ahmadabad and Teri University. Environment responsive strategies of Aquamall, Dehradun- a factory building has helped a lot to develop a firsthand understanding of how-to-do-it issue. These cases have helped a lot to learn from practical issues and experience.

Structured model has been developed to analyze future-proof library design in the fourth chapter. This analysis model, **LIB-ED** is the basic structure covering multi-design criteria of modern library design to address new paradigm, like environment responsive built form planning issues, enabling digital environment and advanced building services. This is followed by 3 flowcharts, namely: “The planning process”, “Digital technology as catalyst” and “Environment responsive strategies”.

The guidelines for modern library building have been introduced in the fifth chapter. Need for considerations of different climatic regions are highlighted. Economic viability is not the part of these proposed guidelines for the time constraint.Literature study regarding 21st century libraries, obsolescence crisis, the shifting paradigm of library design and inferences from case studies help to understand the present scenario of successful library designing and to identify needs. It is identified that the library, which is still a combination of the past (print collections) and the present (new information technologies), must be viewed with a new perspective. Some requirements for library design are constant forever which can be called continued need and some requires modification that can be called modified need.

For an example grand civic space with emphasis on the sitting, orientation, design, and decoration of the library are continued needs. And integration of collaborative interactive learning space, integration of digital technology etc are modified needs for designing modern library. One another important consideration in 21st century is the building itself should stand as environment responsive building which can increase the awareness of people. The analysis model, LIB-ED and this is followed by 3 flowcharts, namely: "The planning process", "Digital technology as catalyst" and "Environment responsive strategies" helps to evolve design guidelines. These guidelines have been evolved following Indian standards and norms (ECBC 2007,NBC 2005,SP-41,other bureau of Indian standards, and green building rating system- LEED,GRIHA) and other primary and secondary sources. The design guidelines deals with main four issues like physical planning process of library designing, enabling digital technology, environment responsive passive planning strategies and active strategies & advanced building services. It has guiding principles regarding site level and building level built-form design issues and passive planning strategies. **Five types of user activity** for which space would need to be designed in a new library: information seeking, reader's space, connection & services, contemplation and recreation. Qualitative and quantitative data regarding library space designing has been covered here. Guidelines for Spatial qualities like thermal quality, day lighting, acoustical quality, indoor environmental quality has been discussed here. Guidelines related to passive planning strategies like land cover transformation, landscaping, orientation, different passive propositions, building envelope designing are discussed here. Guidelines regarding **Futuristic approaches** like hybrid digital library, the solution for modern library digitization process is proposed here. Some issues like Digital information Storage, digital technology preservation, accessibility problems and solutions, physical characteristics of server room are discussed here. Guidelines regarding advanced building services like access control system, elevator &, stairway control, plumbing system, HVAC system, lighting system, fire safety systems, power and video monitoring systems, are proposed here.

The final chapter deals with conclusions and recommendations of this research study. The design guidelines are recommended for every types of library like academic, public or private libraries. Recommendations for future libraries are like improving spaces for study, enabling collaboration and connections across different disciplines, making the discovery process more powerful. The future research implications also have been discussed in this chapter. Evolving some mechanism for inspiration among the library users group, can be developed in future.

Future-proof Library design: The most important purpose of any spatial planning is effective response of the facility provided to cater the needs of its service population like students for a library building. For a library building, traditional design issues are collection and storage of resources in book form, ergonomic space and furniture design, efficient connectivity, advanced building services, and universal accessibility. Library planning historically has involved organization of storage, display and reading spaces to allow easy access for users and maintain serviceability by staff. Library must be user friendly. In the pre-digital age, emphasis had been given on the sitting, orientation, design, and decoration of library. In this age of cyberspace, real space or the physical library building made of bricks and mortar, still matters. Planning for libraries today should be premised on 24-hour access, with critical services and technology provided and located when and where they are needed. Functions of libraries are very important consideration of physical planning stage. Access to information, Supporting the creation and dissemination of scholarly work, Supporting collaboration and sharing, Discovery and serendipity, Library transparency, Library should space for inspiration, findability, these are the main functions of all library. Though basic function of library building will remain primarily unaltered, some modifications will be required to make it future-proof.

Since the planning or designing stage itself, ***user-friendliness*** should get its due priority. ***Built environment*** of future library should be comfortable, aesthetically pleasing, as well as an example for environment responsiveness. They should be model for green buildings using green technologies in facility design. ***Spatial quality*** or the quality of space is typically considered from two perspectives: comfort and flexibility. ***Zoning*** of library in future have a significant role. Students may have different perception and preference about ideal workspace. The designer needs to serve to these disparate requirements by establishing different zones. Interactive floors at libraries may create a new attraction in the physical library by creating a place where people may playfully meet and interact with digital materials. Future ***Collections*** of resources in Libraries require inventing new ways to make it wide as well as varied, accessible, both through print and non-print media. One important design issue is spatial need to sore and display collection of resources in book and CD form. ***Discovery process*** is one of the important traditional activities of research libraries. Expert and thoughtful cataloguing of collections like books, journals, and archives for disciplinary and interdisciplinary research is essential. The library should create ways to facilitate increased personal control, fluidity, convenience and transparency to create more efficient and interesting discovery process. ***Flexibility*** is an important consideration of library design. The library functions being planned for today will need to be reconfigured in the future. The design can accommodate a wide range of individual preferences and abilities in future. Several principal design elements like articulation of the perimeter wall, the introduction of natural light, and placement of core areas for stairs, toilets, and heating, ventilation, and air conditioning will remain relatively constant. The majority of space should offer flexibility, re-constructability for future expansion. May be large, open spaces can offer easy re-constructability, so that they could be reconfigured to meet future needs. Its space requires accommodation of evolving information technologies or change of learning culture like collaborative interactive learning flexibly enough.

While the exact future of learning remains unknown, changing technology is inciting a distinct transformation. Libraries are already experimenting with ways to put these improvements in technology to use and should continue with these efforts of innovation. Tomorrows' library need to qualify as a space which is collaborative, digitech, user- friendly, contemplative, flexible, environment responsive, fitted with state-of-the art services, and finally aesthetically creating a landmark impression. The library of tomorrow would be an inspiring experience for learners barring age, creed and abilities.

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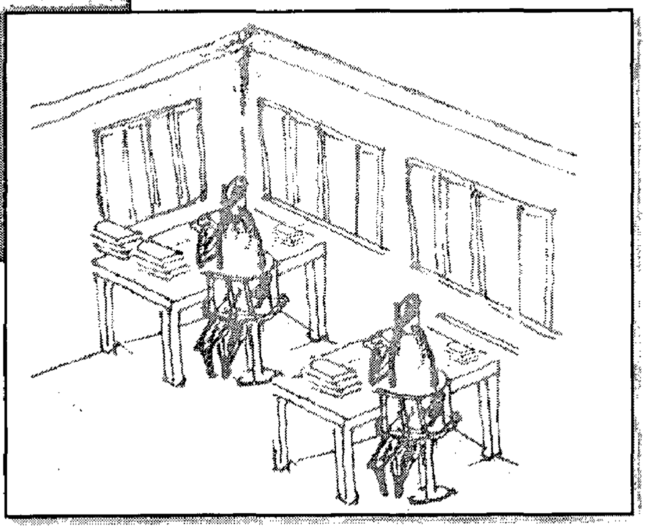

CHAPTER 1: INTRODUCTION

1.1 IDENTIFICATION OF THE PROBLEM:

Library is one of the world's greatest social and intellectual spaces which influence the generations. It is a space to advance knowledge, foster creativity, encourage exchange of ideas and enhance quality of life. Winston Churchill once said, "We shape our buildings and thereafter they shape us" (UIA/AIA World Congress of Architects "sustainable library design"). Library is a public place for lifelong learning and information provision for different categories of user groups. Sustainably designed libraries not only provide great socio-economic value to the community that support its creation, it also flexibly respond to changing functional demands and provide an efficient and intellectual environment that is inspiring and safe.

Library:

A library is a collection of information, thoughts and wisdom expressed in written or audio or video forms. It is interesting to observe transformation of the library through digital age. Though the primary function of the library as knowledge temple has remained same, the processes involved at delivery have revolutionized especially at the end of the last millennium. For a library building, collection & storage, furniture design, ergonomics, universal accessibility are considerable issue. Two factors in particular drive the need for a new paradigm. The more obvious of the two is the revolution in information technology that has been gathering speed since the 1960s and that took off in 1993 with the debut of the World Wide Web. The other perception, somewhat quieter but no less profound, is move in higher education away from a teaching culture and toward a culture of learning; that has brought major shift from independent study mode to more collaborative and interactive learning. Growing inter-connectivity is the social phenomena, and technological innovations have fuelled the change of perceptions for new generations.

There is importance of environment responsive design of library building. The modern library also has a role of educator of environment responsiveness. The notion of environmental responsiveness should relate to occupants and their activities, to the city, and to change, as well as to the outside climate. Interactions between buildings and the natural or manmade microclimates that surround them vary across space, as well as over time, generally affecting indoor conditions in counter-intuitive and unexpected ways. Predicting the outcome of such interactions and modulating their effects to provide thermal and visual comfort in and around buildings are aim of environment responsive design.

1.2 NEED OF THE STUDY:

With the emergence and integration of information technology, many predicted that the library would become obsolete. Many asserted that the virtual library would replace the physical library. The library as a place would no longer be a critical component of an academic institution. The library, which is still a combination of the past (print collections) and the present (new information technologies), must be viewed with a new perspective. Importance of environment responsive design in 21^{st} Century is the environmental stability of mother earth by preserving the natural resources and using them very cautiously. An environment friendly library building can act as open source information on good practices in design profession. It adopts passive and active strategies for optimum use of natural resource from the design stage itself. There is a need that the building itself will stand as environment responsive building which can increase the awareness of people.

With advent of digital technology, the young users are habituated to use computers; laptops have provided them the wider freedom to get information anytime anywhere. Declining number of visitors to library establishes a shrinking need to visit the library. The library design perspective emergently needs to be reviewed with a new understanding.There is a need of lifelong learning environment for library users. This study can provide guidelines to impart less impact to natural and manmade environment. There is need to create more comfort and health conditions for its occupants and society. So there is need to evolve design guidelines for modern library.

1.3 AIM AND OBJECTIVES:

1. 3.1. Aim:

The aim is to develop design guidelines for user friendly modern library.

1.3.2 Objectives:

To achieve aim, the following objectives have been identified:

1. To understand the paradigm shift in designing library building at digital age

2. To evolve spatial requirements and planning process of a modern library building

3. To analyze integration of advanced building services

4. To develop user friendly design guidelines for 21st century library

1.4 SCOPE

1.4.1 Scope:

The study will focus on the changing perception and need identification for 21st century library as well as spatial requirements for environment responsive, user friendly modern library design. Enabling Digital Environment for 21st century library is a major consideration of this study. Integration of Passive planning strategies, building services and building management system (BMS) are also the scope of work.

1.4.2 Limitation:

Due to time constraint detailed spatial design and economic viability of proposed strategies for designing modern library building falls outside the scope of this study.

1.5 METHODOLOGY:

The present study has been structured on four basic steps (refer Figure1.1) for developing design guidelines of modern library building.

First step is the identification of the problem and formulation of the aim. In this stage some objectives are developed to achieve the aim.

Second step is collection of relevant information or data from primary and secondary sources for understanding issues related to library building at modern era. Literature review and case studies from primary and secondary sources to understand the present scenario, falls under this stage.

Third step is analysis. In this stage detailed analytical study is done after literature review and case study. In this stage need identification of new paradigm, spatial requirement and environment responsive issues are analyzed. The structured model LIB-ED for future-proof library design is analyzed here. In the next step design guidelines will be formulated based on this analysis.

Fourth step is conclusions and recommendations of this study. Design guidelines in which library design issues regarding both physical and digital environment, environment responsive design issues are discussed.

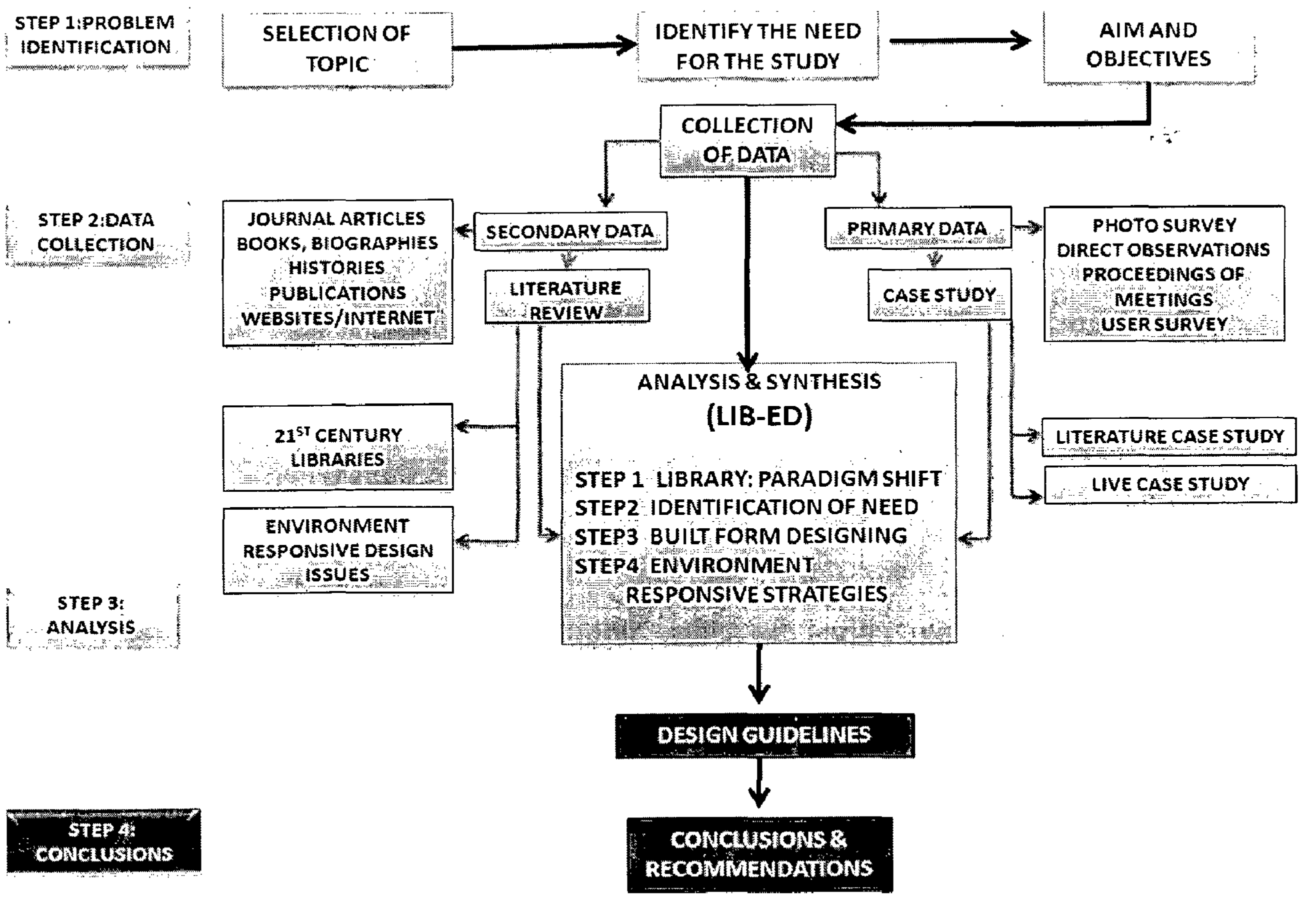

Figure 1.1 Methodology

1.6 ORGANIZATION OF THE THESIS:

Chapter 1 introduces the overview of the problem, the issues regarding library at the present scenario and the need for the study when prediction is that the traditional library would become obsolete at digital age. Formation of aim and objectives of the dissertation and defining the scopes and limitations have been covered in the introductory part of the dissertation. Methodology adopted for the research discussed here.

Chapter 2 concentrates on literature review related to present scenario of library. For that data collection on library design issues from secondary sources like books, research paper, internet etc. have made. The literature review brought a clear understanding on importance of design in modern library building to accommodate paradigm shift, integration of environment responsive design issues and advanced building services. Literature review is done to have a clear understanding of obsolescence crisis of traditional libraries and to identify the relevant data for the analytical part.

Case studies have been covered in chapter 3. literature case study covers environment responsive modern library buildings of abroad like Philological Library from Berlin, National Library Building of Singapore and Frederic Lanchester Library from UK and Libraries visited by the present researcher from Indian campuses are: India like Indian institute of management Ahmadabad library building, Teri University Library and environment responsive strategies of Aquamall, Dehradun, a factory building has helped a lot to develop a firsthand understanding of how-to-do-it issue. The critical analysis and lesson learnt from case study has major role in the formulation of data base for analytical part. These cases have helped a lot to learn from practical issues and experience.

Structured model has been developed to analyze future-proof library design in the fourth chapter. This analysis model, **LIB-ED** is the basic structure covering multi-design criteria of modern library design to address new paradigm, like environment responsive built form planning issues, enabling digital environment and advanced building services. This is followed by 3 flowcharts, namely: “The planning process”, “Digital technology as catalyst” and “Environment responsive strategies”.

The proposal of guidelines for modern library building has been introduced in the chapter 5. The design guidelines deals with main four issues like physical planning process of library designing ,enabling digital technology, environment responsive passive planning strategies and active strategies & advanced building services.

The final chapter deals with conclusions and recommendations of this dissertation. The future research and implications also have been discussed in this chapter.

1.7 SUMMARY:

This is basically introductory chapter where overview of the problem, introduction of library, need of the study, Formation of aim and objectives of the dissertation are discussed. The aim is to develop design guidelines for environment responsive, user friendly modern library.To achieve aim, four objectives have been identified.Scopes and limitations, methodology and organization of the thesis, are covered in this chapter. The present study has been structured on four basic steps of methodology. The next chapter deals with literature review, keeping in mind the aim and objectives of the thesis. Collection of data, from secondary survey based on the data acquired from books, research paper, internet etc, are required for literature review.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

2.2 Libraries of 21st century

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2.5 Summary

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION:

The history of library in the in world is very rich and interesting. The Royal Library of Alexandria, or Ancient Library of Alexandria, in Alexandria, Egypt, seems to have been the largest and most significant great library of the ancient world. The primary function of the library is knowledge temple for students (CLIR, 2005).

The primary goal of any spatial planning is effective response of the facility provided to cater the needs of its service population like students for a library building. New paradigms have emerged out of changing perceptions and preferences of new generations. With the objective of moving beyond conventional sources and ideas of what was relevant to the development of libraries in an academic setting as well as public environment, a broad literature review has been done. The purpose for literature survey is to know present scenario of library building and new need for designing and to identify the relevant data for the analysis.

2.2 LIBRARIES OF 21ST CENTURY:

Library is a place for gathering knowledge and for contemplation. Universal trend is that doing "real" work outside of the library (Bennett Scott, 2003). But still library is one of the most important research places for students. As physical libraries and collections are becoming less integral parts of a scholar's daily life, many libraries around the world are rethinking their use of public space .With availability of new tools, pervasive computing environments, and the ubiquitous use of personal laptops equipped with wireless Internet access (Waters & Donald, 2001)., many librarians seek to redefine what knowledge gathering, production, and scholarly contemplation look like in the 21st century. So new need identification is required for modern library.

2.2.1 Present scenario:

From survey data we know that 36 percent of students use the college library daily and that an additional 50 percent use it at least once a week. Students use library with an average visit lasting two-and-a-half to three hours. The library is busiest Sunday through Thursday evenings. Research shows that many functions traditionally considered "nonlibrary" were included in 182 surveyed academic libraries built or renovated between 1995 and 2002. For example, 25 percent of survey respondents included art galleries, 32 percent cafés, 20 percent auditoriums, 53 percent seminar rooms, 83 percent conference rooms, and 17 percent writing labs (National Survey of Student Engagement, 2002). With the emergence and integration of information technology, many predicted that the library would become obsolete. Many asserted that the virtual library would replace the physical library. The library as a place would no longer be a critical component of an academic institution. There is a great importance of the behavioral aspects of a user's experience with the library .Growing desire for the library to serve as a "connector of people" is to be understood (National Learning Infrastructure Initiative, 2004). There is differing visions across disciplines on the role of serendipity in research and in the library and different expectations for the role of the library. Stacks browsing, a traditional staple of the discovery process in research, is one of the most beloved and discussed activities. The introduction of electronic resources and tools into libraries has made the question of serendipitous finding even more crucial (Bransford, 1999).

2.2.2 New Importance of Architecture and Design:

In attracting people to the new library of the digital age important role of architectural design in creating spaces that are functional and, even more important, inspirational. In a sense, this, too, represents a return to origins: The first important issue on library design placed great emphasis on the sitting, orientation, design, and decoration of the library. Likewise, in the age of cyberspace, real space, made of bricks and mortar, still matters library a social gathering centre on campus (Dourish, 2005). It not only has meeting rooms, classrooms, and faculty offices but also provides enough book storage for an anticipated 50 years of service while at the same time accommodating other media, including digital media. Perceptions have been changed in this generation. The library's rapid adoption of technology and its substantial role in developing innovative research strategies and technologies is also a factor in scholars' ideas of the role of the library in scholarship. With libraries serving as more than book repositories, the use of space expands to support collaboration and social interaction as well as digital technology-enabled study spaces. Users' expectations for the space and services of a library are heavily influenced by commercial ventures, both physical locations and digitization and services. The library needs to anticipate these expectations with ways of addressing them (Berry, 2004).

2.2.3 Paradigm shift in Library design:

The Libraries of modern era should expand services beyond traditional conceptions of 'the library' and thus serve as a centre of intellectual life. There should be modern tools and services offered by the libraries, as well as of its role in the intellectual production of the University and the city (Barr and Tagg, 1995). By continuing to build relationships between librarians, faculty, graduate students, and other stakeholders in the University community, the libraries can enhance its role in intellectual and cultural life of society. New paradigms have emerged out of changing perceptions and preferences of new generations. Most important changing perceptions are emerging collaborative and interactive learning environment and integration of digital technology.

a) *Collaborative and interactive learning environment*: The library has moved ahead of the existing model that optimizes individual learning environment to one that makes sense for group-study (refer Figure 2.1) or work. Young generations' preference in the learning space's mix with academic and social functions is influencing addition of spaces for group study to reinforce the multi-disciplinary studies together. In this interactive learning environment, it is important to accommodate space for supporting collaboration and sharing, sometimes including experimental spaces. The use of digital technology, digitized formats and interactive media has also fostered a major shift from the dominance of independent study to more collaborative learning (Bruffee & Kenneth, 1999).

b) *Digital technology as catalyst:* Academic libraries are undergoing a makeover driven by changes in teaching and learning, new information technologies (IT) and changing needs of users. The digital technology (refer Figure 2.2) improves access to wider variety of resources enhancing communication and interaction and reduces the barriers of place and time. Rapid changes in IT are affecting the library's collection, services and spaces. With the emergence and integration of IT, many predicted that the library would become obsolete. The library, which is now combinations of past technology i.e. print collections and digital form, must be viewed with a new importance. Integration of IT has actually become the catalyst that transformed the library into a more vital and critical intellectual center of life at institutions today (Chodorow & Stanley, 2001).

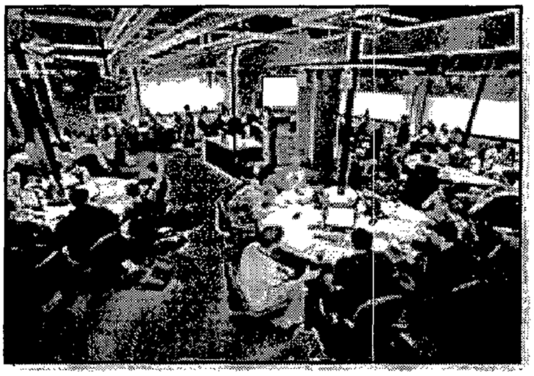


Figure 2.1 Group Learning

Figure 2.2 Digital Technology as Catalyst

c) *Environment Responsive Building:* An environment friendly library building can act as open source information to society on good practices in design profession.

2.2.4 Library planning:

Planning for libraries today should be premised on 24-hour access, with critical services and technology provided and located when and where they are needed. In the pre-digital age, people used to measure the importance of a library primarily by number of books on its shelves and quantity of journals to which it subscribed. In the digital age, quantity of online information stored on a particular site is the measurement tool. Young generations are dependent on and comfortable with digital tools provided by the library for convenience and to easily connect with others (Edwards, Phillip, 2004).

Library planning historically has involved organization of storage, display and reading spaces to allow easy access for users and maintain serviceability by staff. There should also be proper circulation and traffic space. All areas should be easily accessible. Library must be user friendly (WBDG, 2010). Academic library collections grow at the rate of 4 to 5 percent a year and double in around 16-17 years (Scott-Weber, 2004).. Library should expect space of at least twice their present size. Large percentage of the floor space as possible should be usable for any of the primary functions.

Function of libraries:

Functions of libraries are very important consideration of physical planning stage. Access to information: Supporting the creation and dissemination of scholarly work: Supporting collaboration and sharing: Discovery and serendipity, Library transparency, Library should space for inspiration, findability, these are the main functions of all library (Marcus et al., 2007).

a. Access to information: Users expect to be able to find any book, article, or multi-media resource easily. Scholars, depend on access to works-in-progress and informal interactions with others. Users expect instant gratification, so much so that when financial resources are available, users, especially faculty, prefer to buy the books they need. digitization of "all the world's knowledge" is expected, thereby making it more and more possible for users to expect, if not obtain, full electronic access to anything they want to read, view, or download. So access to information in any academic library is one of the primary functions.

- Expert and thoughtful cataloguing of collections for disciplinary and interdisciplinary research
- Assistance with navigating research resources
- Diverse collections of the old and new; long-term preservation
- Supporting serendipity in the discovery process
- Promoting information literacy

b. Supporting the creation and dissemination of scholarly work: Student should enjoy free and immediate access to the journals needed for producing their work. The trend within libraries to build a repository of institutional knowledge that is accessible and cross-referenceable is part of how libraries are cultivating their roles as stewards of knowledge management (Hartman, 2000).

c. Supporting collaboration and sharing: Collaboration is admittedly valuable to the scholarly work of interviewees, but the library does not yet play a vital role in the processes of collaboration. Users know the library provides "meeting space," but desire more effective virtual collaborations (e.g., sites that allow real-time communication and writing, version sharing and control, and even collections of relevant sources and tools). Physical meeting places, though, are still needed, and some interviewees would be more inclined to take advantage of library spaces designed for collaboration if they supported social interaction alongside scholarly work.

d. Discovery and serendipity: The rise of search engines and digitized content redefine the way users engage with material. At the same time, decreasing the distinction between the virtual and physical realms (e.g., more virtual workspace technologies reducing dependence on physical collaboration space) makes it possible for the library to serve as a gateway to resources wherever they may reside.

e. Independence and idiosyncrasy: library users are independent and accustomed to helping themselves from booking travel, to buying stocks, to looking up medical information and this affects how they want to interact with the library and its resources. There is also a spreading trend to request service from a distance.

f. Library transparency: There is need for clear and transparent book locating system or "book locator".

g. Growing interconnectivity of social phenomena, academic scholarship, and technological innovation: The emerging need for new patterns and roles associated with information chains, as well as rapid advances in technology, requires a flexible approach to planning for an explosion of information. Internal "centres of information" are increasingly necessary as libraries offer new functions to users.

h. Library should space for inspiration: library is basically Physical and virtual space for contemplation and research .library can attempt to make visible the invisible: the processes of finding, understanding, and representing the rich resources of research. Electronic displays of flow charts that map the array of subjects held within the library's collections can produce a sense of liveliness and depth. The items displayed may be books, DVDs, CDs, videotapes etc. By visualizing the statistical information of titles and categories, the library presents a living picture of what the community is thinking and doing (Inayatullah, S 2008).

i. Spaces for work, user friendliness: The library should create personal workspaces, comfort, commonalities, variations on atmosphere, and ubiquitous networks. Throughout the library, there are varying styles of behaviour and expectations among scholars that necessitate different working environments. By providing a variety of public working spaces, the library can attract a range of scholars who reflect the diversity of interests and working styles. Adaptable spaces with adjustable furniture, lighting, and size could also be ideal spaces for inspiration.

Just as flexible reading rooms provide public spaces that accommodate a range of working styles and preferences, individual study carrels and work areas – spaces that are traditionally isolated , can be adapted for scholars who prefer working in solitude (Shill, 2003). Ample natural light, attractive and comfortable furniture and other aesthetic additions can also make the library a desirable and effective place to read, think, and work.

j. Findability : Discovery, perhaps the traditional and sustaining lifeblood of research libraries, is a core activity of scholars. The library should create ways to facilitate increased personal control, personalization, convenience, fluidity, efficiency, and transparency to create a more powerful discovery process. Technology produces new ways of finding, organizing, and sharing information and ideas. To address needs of multi-media resources for research and teaching, the library can create new and innovative ways to integrate the variety of services and materials available into the interdisciplinary crossroads of researchers.

2.3 ENVIRONMENT RESPONSIVE DESIGN ISSUES:

2.3.1 Present need of environment responsive design:

An environment friendly library building can act as open source information to society on good practices in design profession. It may mix appropriate passive and active strategies for optimum use of natural resource to create users' comfort from the design stage itself (B M Givoni.1976). Building orientation maximizing north and south façade exposure for daylighting and reduced heat gain, creation of buffer spaces on east and western portions of the building to control heat gain and glare, appropriate building configuration in terms of aspect ratio and solid-void ratio, eco-friendly materials selection, suitable fenestration design to allow daylight and natural ventilation and apt maintenance of indoor air quality to avoid sick building syndrome etc. are some of the aspects to be resolved through design. Landscaping i.e. proper selection and placement of vegetation and surface covers for lawn, garden, roof, pavement, driveway and parking, efficient outdoor lighting would help to mitigate environmental encroachment adversities brought by the buildings' construction. Water conservation and solid waste management are important services to manage sustainably to make the library design an exemplary one (A Krishan, 1992). Implementation of environment responsive strategies is important consideration in 21st century library building.

2.3.2 Resource conserving strategies for environment responsive building:

To take care of the general quality of building stock all over the country, the Bureau of Indian Standards (BIS) has introduced the National Building Code for India (NBC or SP7) which get updated regularly to accommodate increasing knowledge base in the subject areas. The NBC-2005 and Handbook on Functional Requirements of Building (other than Industrial Building) (SP41-1987) are two important documents which helped the Indian designers to grow sustainably through decades. To provide a boost to energy conservation activities, the Indian Parliament passed the Energy Conservation Act 2001in 2001 (The Energy Conservation Act, 2001). The Bureau of Energy Efficiency (BEE), an autonomous body under Ministry of Power (MoP) was set up in 2002 under the act to provide a policy framework and direction to national energy conservation and efficiency. Under its statutory authority, BEE developed the Energy Conservation Building Code (2007) for India in association with the International Institute for Energy Conservation (IIEC) under contract with the United States Agency for International Development (USAID) as a part of the Energy Conservation and commercialization (ECO) Project. The purpose of this code is to provide minimum requirements for the energy-efficient design and construction of buildings.

In addition to these measures there came in the rating systems for appraising building performances throughout its lifecycle. Internationally, voluntary rating systems have been instrumental in raising awareness and popularizing green building design. However, most of the internationally devised rating systems have been tailored to suit the building systems of the country where they are developed from. The first rating system used in India is the Leadership in Energy and Environmental Design (LEED) introduced by United States Green Building Council. Later on LEED-India has been introduced by Indian Green Building Council to address local need. Keeping in view of varied climatic conditions and in particular the abundance of non-AC buildings, Green Rating for Integrated Habitat Assessment (GRIHA) has been developed in India by TERI. The concept was initially conceived and developed by TERI (The Energy & Resource Institute) as TERI-GRIHA. Later it was endorsed as national rating system GRIHA by the Ministry of New and Renewable Energy (MNRE) after incorporating various modifications suggested by a group of architects and experts from the field. It has derived useful inputs from the building codes and guidelines like SP 41-1987 and NBC-2005 introduced by the BIS, the ECBC- 2007 of BEE, and legislation on EIA initiated by MoEF etc. In the following sections, significant aspects of ECBC, GRIHA and EIA will be considered for discussion.

ECBC: The ECBC encourages energy efficient design or retrofit of buildings without constraining the building function, comfort, health, or the productivity of the occupants. With an appropriate focus on economic considerations through life cycle cost (LCC) analysis, the code is planned to be mandatory (once enforced) for commercial buildings or building complexes to set minimum energy efficiency standards for design and construction. Scope of the ECBC includes mandatorily commercial buildings and applies specifically to new construction.

The draft code of 2006 has been widely circulated and modified final code is published in 2007. The process of development involves extensive data collection and analysis regarding building types, building materials, equipment for air conditioning, lighting etc. The code takes into account of 5 distinct climatic zones of India for building envelop design. The "base case" models are developed for buildings in these climatic zones with options for energy conservation in different building systems. The building systems that are covered include building envelope (walls, roofs and windows), lighting (indoor and outdoor), heating ventilation and air conditioning system, solar water heating and pumping and electrical systems (power factor, transformers). It is proposed to make the Code mandatory for all new building with a connected load of 500 kW or greater; and/or a contract demand of 600 kVA or greater. The code would also be applicable to all buildings with a conditioned floor area of 1,000 m2 (10,000 ft2) or greater (ECBC, 2007).

GRIHA: The GRIHA evaluates environmental performance of a building holistically over its entire life cycle for Indian climates. The rating system, based on accepted energy and environmental principles, strikes a balance between the established practices and emerging national and international concepts. It is developed in response to the need to have a framework that address national concerns in built environment, integrates national codes and standards, complements relevant policies/programs and charters a way to build green in a cost effective way. The primary objective of the rating is to help design green buildings which can provide comfort to users and in turn, help evaluating 'greenness' of the buildings. GRIHA Assessment is based on predicted building performance over its entire life cycle. The issues addressed at various stages are as follows:

- Pre-construction stage (intra- and inter-site issues)
- Building planning and construction stage (issues of resource conservation and reduction in resource demand, resource utilization efficiency, resource recovery and reuse, and provisions for worker and occupant health and well being). The prime resources that are considered in this section are land, water, energy, air, and green cover.
- Building operation and maintenance stage (issues of operation and maintenance of building systems and processes, monitoring and recording of consumption, and occupant health and well being, and also issues that affect the local and global environment).

In GRIHA system points are earned according to meeting the design and performance intent of the criteria. It has a 100 point system consisting of some core points which are mandatory to be met while the rest are optional points. There are 34 criteria in total covering passive and active energy, health, site, water, waste and operation and maintenance issues out of which criterion on energy audit and simulation is mandatory but would not lead to scoring. Each other criterion has a number of points assigned to it. Innovative design strategies would fetch additional 4 credit points over and above the 100 points. Different levels of star certification are awarded based on the number of points earned. The minimum points required for certification is 50. Buildings scoring 50-60 points, 61-70 points, 71-80 points and 81-90 points shall get one, two, three and four stars respectively. A building scoring 91 to 100 points will get the maximum rating viz. five stars (MNRE & TERI, 2008).

2.3.3 Passive planning approaches:

2.3.3.1 Site level:

a. Surface generation & Land cover transformation: When there is a vacant land, then the environmental impact is natural or there is no negative environmental impact, but if the land is transformed into any artificial footprint like building, paving, any other structure etc, then some environmental impacts will be there.

There are different types of surface like natural vegetative surface, water body, landscaping and artificial surface like hard paving, soft paving and building footprint area. The intrusion of any structure is basically natural surface intervention. The intension is to minimize negative environmental impact through an environment friendly and user friendly design (Goldsmith, 1998).

For example, the green roof can replace the building footprint, but the building envelop has to be taken care off. Building envelop should have environment responsive property that the total built environment become comfortable and user-friendly. Or for the paving area, the surface should be permeable, proper ground water recharge should be there to avoid storm water runoff. Or at a construction stage of a building, the native existing plantation should be preserved. So at every stage of building construction, there should be environmental concern.

b. Landscaping: The south yard needs the most careful planning. There are some Environment responsive landscaping solutions like Reduction of storm-water run-off through the use of bio-swales, rain gardens and green roofs and walls, Reduction of water use in landscapes through design of water-wise garden techniques , Landscape irrigation using water from showers and sinks, known as gray water, Creating and enhancing wildlife habitat in urban environments , Energy-efficient landscape design in the form of proper placement and selection of shade trees and creation of wind breaks. Energy efficient landscaping materials for careful passive solar choices include “hardscape” building material and "softscape" plants. All can be used to create summer shading. For winter solar gain it is desirable to use deciduous plants that drop their leaves in the autumn gives year round passive solar benefits (B M Givoni, 1976).

2.3.3.2 Building level passive planning strategies:

2.3.3.2.1 Orientation:

The relationship of the building to the land, the sun, and the wind will greatly affect the overall efficiency of the library building (C P Kukreja, 1978).

Site Orientation: Ideally, the long side of the building faces directly south and shorter sides face east and west. This arrangement captures heat and natural light in winter, but minimizes unwanted summer heat gain. However, pointing the house up to 30 degrees to the east or west typically sacrifices only about 5 percent of the solar gain. A library that is sited to maximize the use of natural light and to allow for natural ventilation will require less energy to operate. Understanding a site's orientation with respect to wind patterns is also an important criterion for site design, natural ventilation might be useful for cooling isolated or semi-enclosed areas of the library (UIA/AIA Sustainable Library Design, 1993).

Building orientation: Careful consideration should be given to the east and west orientations, as these exposures will have more significant solar heat gain in hot climates. Fewer windows should be placed in east- and west-facing walls to reduce solar heat gain. Building should be oriented along North and South side. For most regions, optimum façade orientation is typically south. South-facing glass is relatively easy to shade with an overhang during the summer to minimize solar heat gain. North-facing glass receives good daylight. Buffer spaces should be there along E & W side. Buffer spaces (such as- toilets, corridors, staircases, lifts and service areas etc.) along western and eastern facades can help to reduce solar heat gain (B M Givoni, 1976).

Environment responsive strategies relating to building orientation:

- Maximizing north and south façade exposure for daylight harvesting to reduce lighting electrical loads
- Using southern exposure for solar heat gain to reduce heating loads in the summer
- Using shading strategies to reduce cooling loads caused by solar gain on south
- Turning long façades toward the direction of prevailing breezes to enhance the cooling effect of natural ventilation
- Turning long façades in the direction parallel to slopes to take advantage of cool updrafts to enhance natural ventilation

2.3.3.2.2 Building envelope design:

Window Wall Ratio: The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area. The window to wall ratio is limited to a maximum of 60% of gross wall area and the skylight to roof ratio is limited to a maximum of 5% of gross roof area .Window to Wall Ratio (WWR) –40% equally distributed on all elevations is optimum (ECBC, 2007). Circular shape with W/L ratio 1:1 is the optimum geometric shape (receiving the lowest amounts of annual total solar insolation). Level of daily average solar insolation is received on the east wall, followed by the south, west and north walls. So solid void ratio and placement of window is important.

Surface area to volume (SAV) ratio: The influence of solar radiation on vertical surfaces of high-rise building shapes and the effect of geometric shapes with variations of W/L ratios and building orientation towards minimizing the total solar insulation.

Compact homes, are more energy efficient than irregularly-shaped homes. They gain less heat in the summer and lose less heat in the winter since a smaller surface area has less exposure to the outside elements of sun, rain, and wind. Compact homes use fewer building materials. The most compact orthogonal building would be a cube. Contrary to the cube, a building massing that optimizes daylighting and ventilation would be elongated along its east–west axis so that more of the building area is closer to the perimeter. More than one story homes are generally more efficient than one story homes. Because of the reduced footprint and roof area and the summer sun is higher in the sky and a smaller area of the wall is exposed to the direct sun (Koenigsberger, et al., 1975).

If a building has a large surface area, the internal condition is more influenced by the external climate than in one with less surface areas. Smaller buildings have larger skin/volume ratio than large buildings. A building with less surface area is dominated by its internal load, which is the heat of the people, machinery, lighting and so on. Curtain walls are mostly glass which permits daylight to enter the building. On the other hand, curtain walls act as wrap to seal the whole building and thus they seal the whole building making it dependent on a mechanical cooling system.

Olgay's conclusions for basc building forms are (Kim, 1998):

1. The square building is not the optimum form in any location.

2. All shapes elongated on the north-south work both in winter and summer with less efficiency than the square one.

3. The optimum in very case is a form elongated somewhere along the east-west direction.

Building shapes are one of the important considerations (refer Figure 2.3). There is a steady progression on the building form, as we move from cold climates to hot-arid areas. Studies of square and various oblong shapes and orientations of buildings in major climate regions show that there are certain standard shaped for minimum heat gain and heat loss. These shapes are a balance between the under heated season when solar radiation can be beneficial, and the overheated season, when radiation should be avoided.

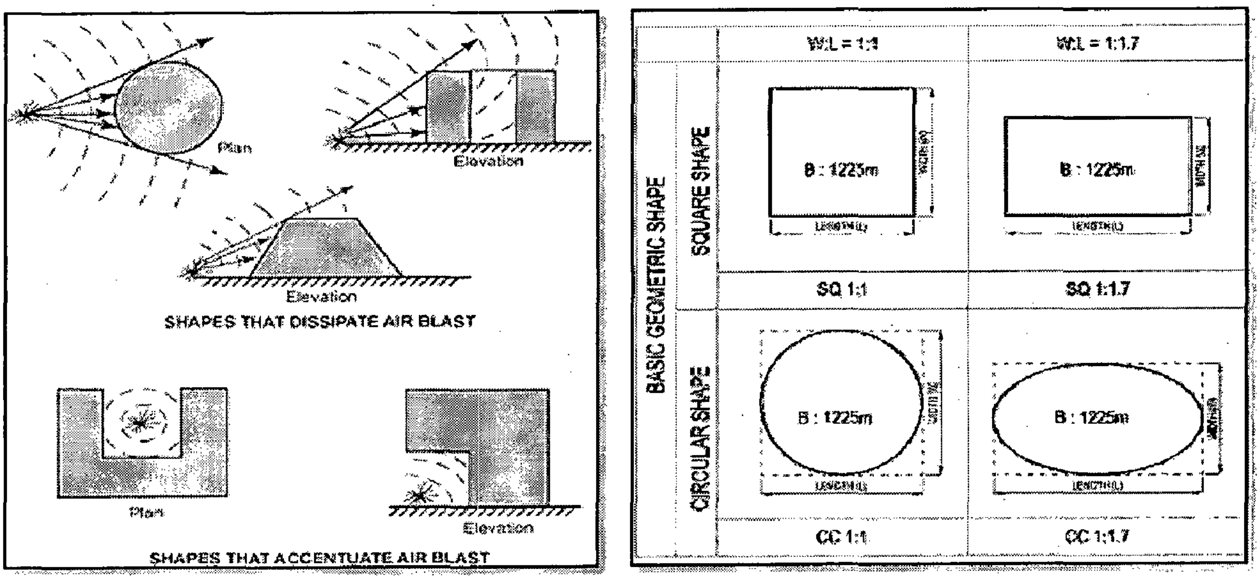


Figure 2.3 Shape of building

Materials selection: The selection of building materials (refer Figure 2.4) greatly impacts the sustainability of a project. By choosing building materials wisely, such as considering the complete life cycle of the materials is required. U value consideration of different materials is important (S Jarmul, 1980).

- U value: Low U value is required to minimize conduction losses
- Resource Efficiency: Natural, plentiful or renewable: Materials harvested from sustainably managed sources and preferably have an independent certification, Reusable or recyclable
- Locally available: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site
- Low or non-toxic., Minimal chemical emissions. Products that also maximize resource and energy efficiency while reducing chemical emissions, Low-VOC assembly

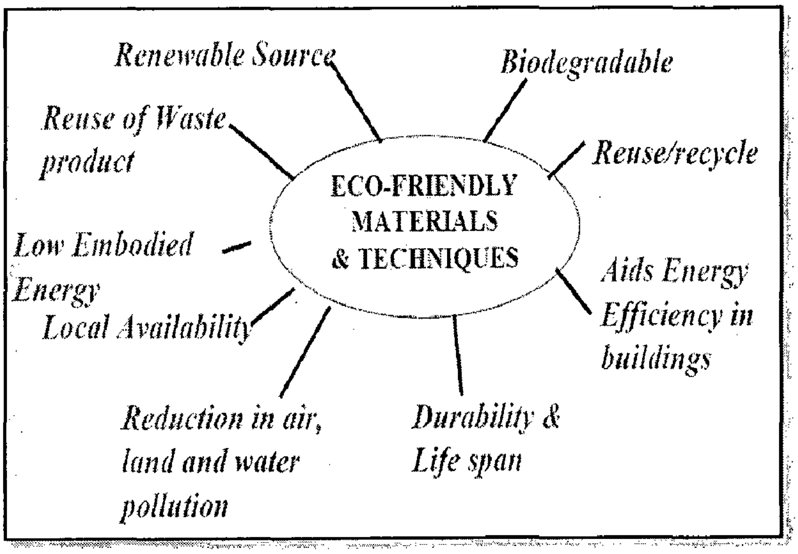


Figure 2.4 Materials selection

- Moisture resistant: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings
- Healthfully maintained: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning
- Low Embodied Energy: Embodied energy of material includes all of the energy required to produce the product, produce the constituents that go into the product, transport it, install it, and in some cases, maintain and dispose of it. Low embodied energy materials are desirable for low Environmental Impact.

Building component: Building component refers to the placing of fenestration windows on a building's exterior. This is part of the architectural design and affects the aesthetic appearance of the building. Natural ventilation, daylighting, solar heat gain etc happen through building fenestration. Example of fenestration systems are Windows & Exterior Doors, Curtain Walls, glazing etc (ECBC, 2007).

- Fenestration Design for library building: Curb glare and localized overheating by using exterior shading to divert direct-beam sunlight. One strategy is facing the glazed areas in educational facilities north and south when possible to provide maximum daylight and maximum shading potential from direct sun is important. Locating glazing strategically but avoid over glazing. Window Shading, Blocking direct beam solar radiation to reduce heat gain, glare and localized overheating is one strategy.
- Indian traditional jali system: The jali work (refer Figure 2.5) provides what is called the Venturi effect (refer Figure2.7) in modern buildings, it helps pre-cool air. Glare free sunlight also come from jail work.
- Environment responsive glazing system: Glass has been used for thousands of years to allow daylight into our buildings, while providing weather protection. The vast majority of new windows, curtain walls and skylights have insulating glazing for energy efficiency (refer Figure2.6) and comfort.

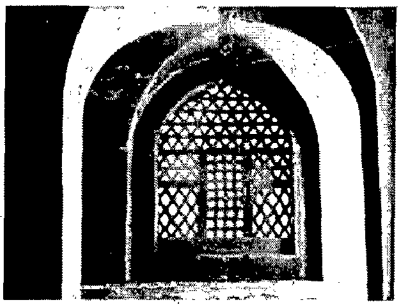


Figure 2.5 Indian traditional jali

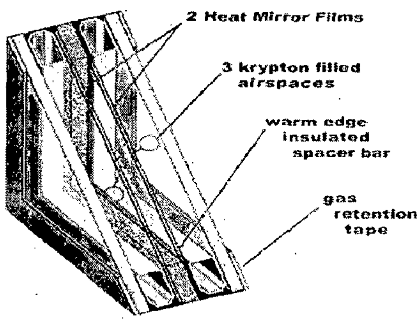


Figure 2.6 Environment responsive glazing

2.3.3.2.3 Passive Proposition:

Use natural energy (sun, wind, etc.) to conserve conventional energy for achieving thermal comfort; Thermal comfort refers to comfortable indoor conditions (temperature, humidity, air movement). In passive solar building design, windows, walls, and floors are

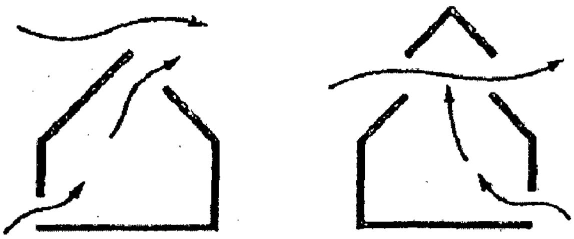


Figure 2.7 Venturi Effect

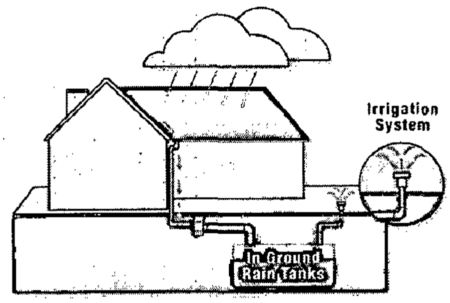


Figure 2.8 Rainwater Harvesting

made to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design (refer Figure2.9) because, unlike active solar heating systems, it doesn't involve the use of mechanical and electrical devices (D Watson, 1973). There are some examples of passive propositions:

Rainwater Harvesting: Rainwater harvesting (refer Figure 2.8) is the accumulating and storing, of rainwater. It has been used to provide drinking water, water for livestock, and water for irrigation or to refill aquifers in a process called groundwater recharge. Rainwater collected from the roofs of houses, tents and local institutions, or from specially prepared areas of ground, can make an important contribution to drinking water. Generally, rainwater is either harvested from the ground or from a roof. The rate at which water can be collected from either system is dependent on the plan area of the system, its efficiency, and the intensity of rainfall (G Bhatia, 1989).

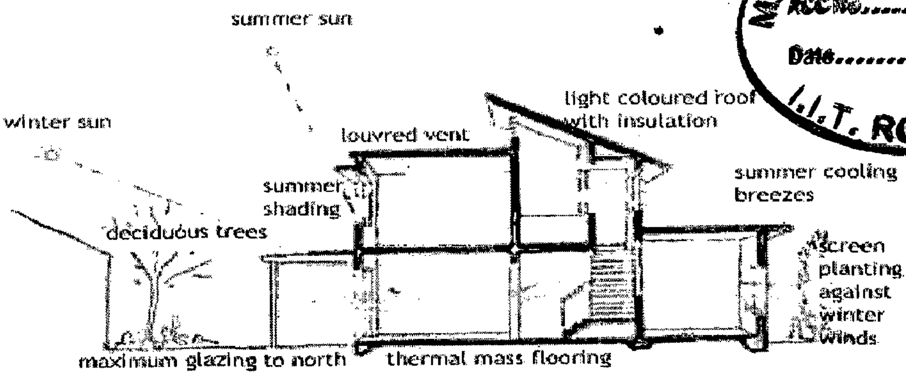


Figure 2.9 Passive Strategies

Green Roofs: Green roofs provide thermal insulation and therefore energy costs savings and consequent reduction in carbon dioxide production. Green roofs (refer Figure2.11 & 2.12) can help to reduce the production of ozone by reducing the heat island effect and by absorbing airborne particles (E Martin, 1980).

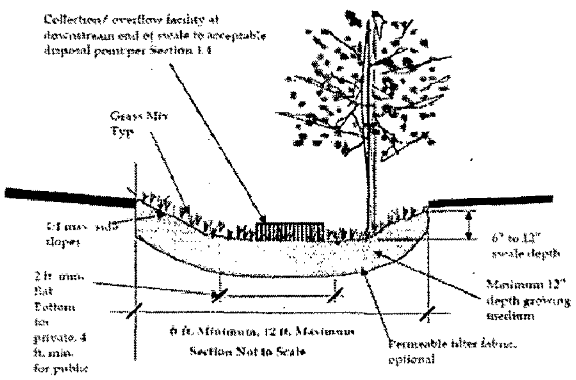


Figure 2.10 Storm water Management

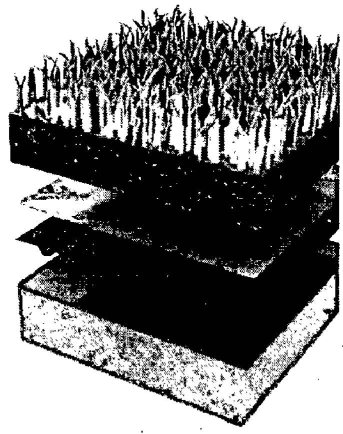


Figure 2.11 Green Roofs

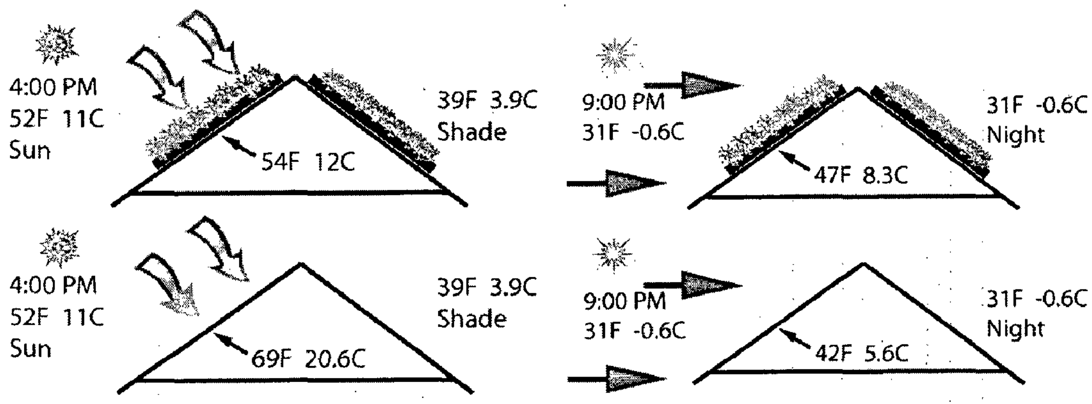


Figure 2.12 Green Roof Temperature

Storm water Management: In addition to delivering higher pollutants from the urban catchment, increased storm-water flow can lead to stream erosion, encourage weed invasion, and alter natural flow regimes. Native species often rely on such flow regimes for spawning, juvenile development, and migration (S Jarmul, 1980). Managing the quantity and quality of stormwater is termed, "Stormwater Management" (refer Figure2.10). Modern drainage systems which collect runoff from impervious surfaces (e.g., roofs and roads) ensure that water is efficiently conveyed to waterways through pipe networks, meaning that even small storm events result in increased waterway flows.

Shading of Roof and Walls: Surface shading (refer Figure2.14) can be provided as an integral part of the Building element or by the use of a separate cover. Highly textured walls have portions of their surfaces in the shade. Radiation absorbing area of such a textured surface is less than its radiation emitting area; therefore it will be cooler than a flat surface. The increased surface area will also result in an increased coefficient of convective heat transfer, which will permit the building to cool down faster at night when the ambient temperature is lower than the building temperature (ECBC, 2007).

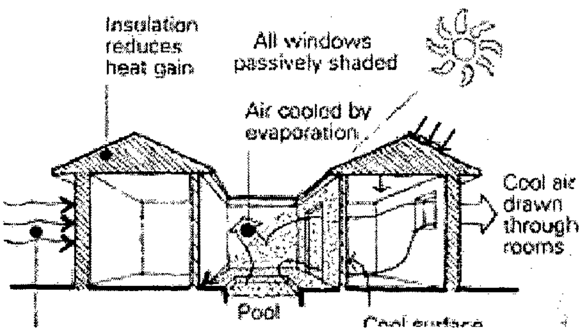


Figure 2.13 Courtyard Effect

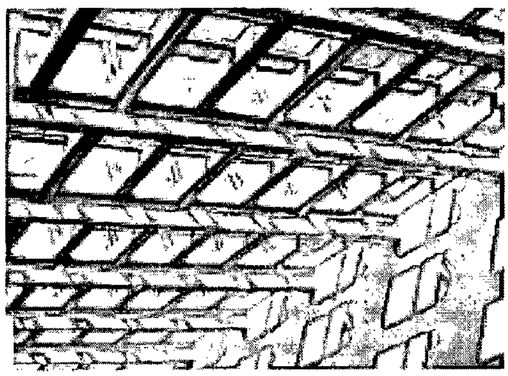


Figure 2.14 Shading of Roof and Walls

Courtyard Effect: Due to the incident solar radiation in the courtyard, the air in the courtyard becomes warmer and rises up. To replace it, cool air from the ground level flows through the louvered openings of the room, thus producing the air flow. During the night the process is reversed. As the warm roof surface gets cooled by convection and radiation, a stage is reached when its surface temperature equals the dry bulb temperature of the ambient air. If the roof surfaces are sloped towards an internal courtyard, the cooled air sinks into the court and enters the living space through the low level openings and leaves through higher level openings. This concept can very well be applied in a warm and humid climate. It is necessary to ensure that the courtyard (refer Figure2.13) gets adequate radiation to produce a draft through the interior (E Martin, 1980).

Wind Tower: The hot ambient air enters the tower through the openings in the tower and is cooled when it comes in contact with the cool tower and thus becomes heavier and sinks down. When an inlet is provided to the rooms with an outlet on the other side there is a draft of cool air. After a whole day of heat exchange (refer Figure2.16), the wind tower becomes warm in the evening (C P Kukreja, 1978).

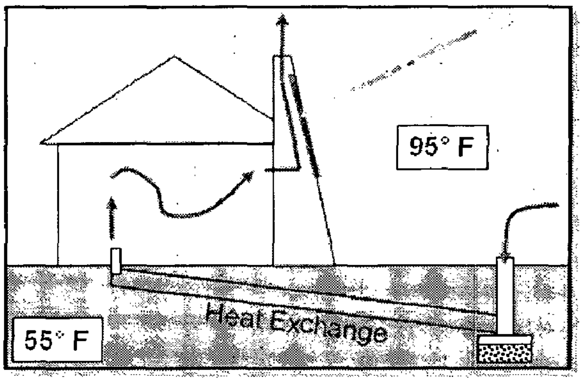


Figure 2.15 Earth Cooling

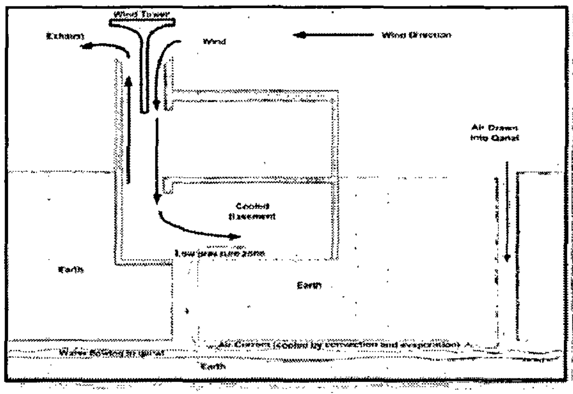


Figure 2.16 Wind Tower

Earth Cooling: Because of the thermal storage capacity of earth, the daily and even the annual temperature fluctuation keeps on decreasing with increasing depth below the ground surface (refer Figure2.15). At a depth of 15 m, the earth has a constant temperature of 10°C. The level of water table plays an important role here. In summer and particularly during the day, the ground temperature is much lower than the ambient air temperature. If a part of the building is earth bermed, the building loses heat to the earth particularly, if the insulation levels are low. The most ancient dwellings were often dug into the ground or covered with earth (S Prakash, 1992).

2.3.3.3 Spatial Quality in Library:

2.3.3.3.1 Thermal quality:

Factors determining thermal comfort include Personal factors (health, psychology, sociology & situational factors), Air temperature, Mean radiant temperature, Relative humidity, Air movement/velocity, Radiant asymmetry. Thermal comfort is affected by heat conduction, convection, radiation, and evaporative heat loss. Thermal comfort is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. Any heat gain or loss beyond this generates a sensation of discomfort. It has been long recognised that the sensation of feeling hot or cold is not just dependent on air temperature alone.

- **Inside temperature condition of a library**

  Dry bulb temperature should be 23 -26 degree c for air conditioned library portion and for non air conditioned portion room temperature is up to 38 degree c (NBC, 2005).

- **Humidity**

Humidity is a term for the amount of water vapor in air, and can refer to any one of several measurements of humidity. While a room temperature between 71° and 77° F may be comfortable for short periods of time under very dry conditions, prolonged exposure to dry air has varying effects on the human body and usually causes discomfort. The moisture content of the air is important, and by increasing the relative humidity to above 50% within the above temperature range, 80% or more of all average dressed persons would feel comfortable.As per NBC 2005 For a library building relative humidity for air conditioned space should be 55 %.Normally relative humidity in the range of 40 to 70% in the workplace environment (NBC, 2005).

- **Natural ventilation**

As in wind, two forces govern ventilation inside the building: (i) Air moves from high-pressure zone to a low-pressure zone if openings are made on the walls of the respective zones in a building.(ii) If the inlet and outlet are placed at different heights, air flows from the inlet to the outlet due to the density difference created by the upward movement of warm air.

Outside fresh air ventilation rate is 15 CFM per person. For an elongated building, the largest pressure differences (which drive cross-ventilation) occur when the building is perpendicular to the prevailing wind. To encourage cross-ventilation and maximize cooling, one-room-deep plans are preferable (NBC, 2005).

Window Placement is important consideration for natural ventilation. When windows are in adjacent walls, the optimum ventilation occurs with the long building face perpendicular to the wind, but a shift of 20 to 30 degrees from perpendicular will not seriously impair the building's interior ventilation. When windows are in opposite walls, a 45-degree incidence angle gives the maximum average indoor air velocity and provides better distribution of indoor air movement. Wind approaching at 90 degrees is 15 to 20 percent less effective. On the south side only deciduous trees should be planted.

Shading by trees and vegetation is a very effective method of cooling the ambient hot air and protecting the building from solar radiation. The best place to plant shady trees is to be decided by observing which windows admit the most sunshine during peak hours in a single day in the hottest months. Usually east and west oriented windows and walls receive about 50% more sunshine than the north and south oriented windows/walls. Trees should be planted at positions determined by lines from.

2.3.3.3.2 Daylighting:

North-facing windows or clerestories admit daylight while excluding direct sunlight. South facing glazing with adequate overhangs can also be effective. Library lighting is to provide enough light to accomplish a visual task such as reading. For daylight, this means tuning the aperture designs to minimize solar heat gain while achieving the foot-candle levels required for visual acuity.

The second requirement is that the contrast brightness of other objects within the field of view must not be excessive .For good daylighting design; low glare lighting is a principal objective in libraries. A lux level of 270 lux at 30" (inch) from ground level at 12 Noon on equinox days with a low Visual Light Transmission (VLT) of the glazing is considered as good or Optimum day lighting (UIA/AIA daylighting design in libraries, 1993).

The three fundamental design issues in daylight design are:

- Sun control, to mitigate any increase in the cooling load and to control direct glare.
- Glare control, to create and maintain comfortable brightness distribution, including no direct views of the bright sky in the normal direction of view.
- Variation control, to avoid any user perception of insufficient local light levels.

Daylight Apertures:

Daylight Apertures in wall (refer Figure2.17) is popular.The perimeter spaces of the library can be effectively daylighted for approximately twenty feet from the exterior wall by using windows and clerestories (high windows). Generally, the taller or higher the window, the deeper will be the daylight penetration into the space. Clear glass is preferred for daylighting, but this in turn requires carefully designed exterior sun control devices to provide adequate shading. The most effective sun control device is the exterior sunshade. An exterior shade will create a reduction of 80% of the incident solar energy. The south-facing window is easiest to protect since the sun is at relatively high angles in the sky for most of the day relative to this orientation.

Daylight Apertures in Roof is professionally has been practiced. There is extensive use of various types of roof apertures, including different types of roof monitors and skylights for library building. The sun-protected roof monitor is a basic design component of roof design for daylighting. Libraries are ideal building types for extensive

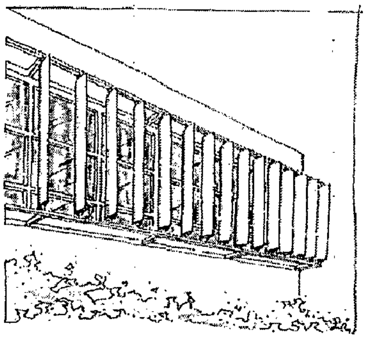


Figure 2.17 Daylight Apertures in wall

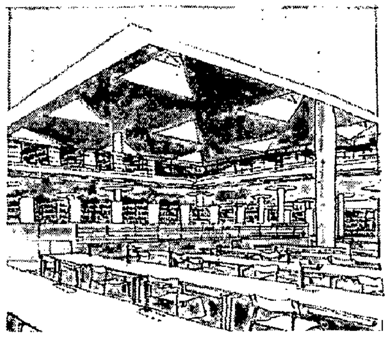


Figure 2.18 Daylight Apertures in Roof

use of roof monitors because of the typical one- or two-story configuration of the floor plan, Daylight easily penetrates the normal 25-30 feet from roof level to first floor level. Roof monitor can introduce daylight at internal circulation and reading areas. A skylight (refer Figure2.18) is a simple technique of protecting from direct sunlight while providing non-directional, comfortable light to the space below.

2.3.3.3.3 Indoor Environmental Quality:

Indoor air quality (IAQ) is a term referring to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. An indoor environment that is not only safe, but healthy and inspiring for occupants will take several environmental factors into consideration: fresh air, light, views or connection to the outdoors, thermal comfort, and the ability of the occupant to control their environment (UIA/AIA Sustainable Library Design, 1993).

IAQ can be affected by microbial contaminants (mold, bacteria), gases (including carbon monoxide, radon and volatile organic compounds), particulates, or any mass or energy stressor that can induce adverse health conditions. House plants together with the medium in which they are grown can reduce components of indoor air pollution; particularly volatile organic compounds (VOC) such as benzene. Plants can also remove CO_2, which is correlated with lower work performance, from indoor areas (ECBC, 2007). One way of quantitatively ensuring the health of indoor air is by the frequency of effective turnover of interior air by replacement with outside air., library are required to have 3 outdoor air changes per hour. In libraries, the ventilation should be sufficient to limit carbon dioxide to 1,500 ppm.

some steps can be taken to improve the indoor air quality (refer Figure2.19) of a library are effective delivery of fresh air is a priority to the design, isolation any sources of chemicals that could be hazardous to occupants, By providing CO^2 sensors in all occupied spaces, the mechanical system can "know" when there are more people needing more fresh air in a space and respond by increasing the rate of outside air into the ventilation and psycho-physiological needs for daylight and views.

Figure 2.19 Indoor Environmental Quality

2.3.3.3.4 Acoustics:

The modern library cannot function without modern technology. Printers, copiers, wireless computers, and espresso machines all contribute to the sounds cape of the typical municipal library (and many academic libraries, too). While some of these noise sources are stationary and can be isolated acoustically, wireless computing has transformed the acoustic experience for the typical library patron. Study carrels and desks used to define the boundaries of study and work areas in libraries, and architects could design spaces accordingly.

All materials have some sound-absorbing properties. Sound energy that is not absorbed must be reflected or transmitted. A material's sound-absorbing property is typically described as a sound absorption coefficient at a particular frequency range. Sound absorbing materials used in buildings are rated using the Noise Reduction Coefficient (NRC), which is basically a type of average of sound absorption coefficients from 250 Hz to 2 kHz, the primary speech frequency range. The NRC theoretically can range from perfectly absorptive (NRC = 1.0) to perfectly reflective (NRC = 0.0).

Therefore, design principles for room acoustics in library spaces typically focus on the locations and extent of sound absorbing material, to reduce reverberation and the interference with speech, as well as the shape of rooms to achieve acceptable acoustic characteristics in meeting and presentation rooms.

One of the most essential techniques in acoustics is reducing the transmission of sound through solid barriers in buildings. Doubling the air space width increases the sound transmission loss (TL)by about 5 Db (UIA/AIA Acoustics for library, 1993).

2.4 INTEGRATION OF ADVANCED BUILDING SERVICES:

Integrated Building Management Systems:

An Integrated Building Management System is a single, cohesive building management system controlling lighting, HVAC, fire, security, energy use and other facilities. Integrated Building Management Systems bring many benefits when trying to squeeze the best performance from a building. The system consists of a central PC Workstation for total area co-ordination of multiple facilities. The time-of-day schedules also are included (for AC, heating and lighting) to turn system to sleeping mode when not needed. Intension is to provide a responsive, effective and supportive intelligent environment within which the organization can achieve its objectives (Walsh. J., 2005).

Advantages:

Better Management and Better control are the main advantages. The system is easily configurable and expandable. It allows a level of control optimization. Security and access systems can instruct HVAC and lighting systems when the building is occupied; fire systems can control lifts; heating systems can interact with cooling systems - the list goes on.

Energy management is also important issue for library building. Building systems, including heating, ventilation and air conditioning (HVAC) use feedback and control mechanisms over the network infrastructure to facilitate the delivery of a highly efficient and comfortable workspace. Data is collated by the building management system to make intelligent decisions as to how is best to meet a defined energy consumption profile.

2.4.1 Access control system:

Access control mechanisms can be used in managing physical resources .The access into the building will be controlled by the intelligent security access system that use a swipe card/finger print scanning/retinal devices (refer Figure2.20) which compares the data that had been previously stored in BMS for to permit/restrict the entry. With the help of anti pass back control provide, it is also take care that unless the person goes out of the building, the same card cannot be used again. It is also possible to control a person's movement area and time through program. In case of any forcible entry, an alarm will be initiated at the security control room and the cameras in the respective area will trigger the event. Passive infra red occupancy sensors would detect any untoward movement in protected areas and would be reported and recorded using camera. This system eliminates unauthorized entry and ensures a sense of security which positively helps in work efficiency. When a credential is presented to a reader, the reader sends the credential's information, usually a number, to a control panel, a highly reliable processor. The control panel compares the credential's number to an access control list, grants or denies the presented request, and sends .The control panel also ignores a door open signal to prevent an alarm (Walsh . J., 2005).

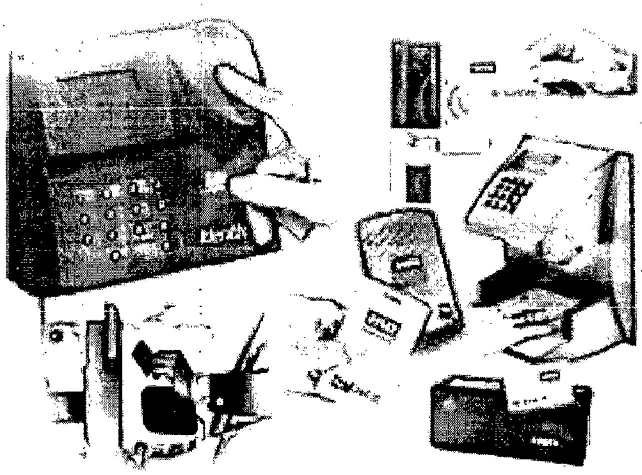


Figure 2.20 Access Control System

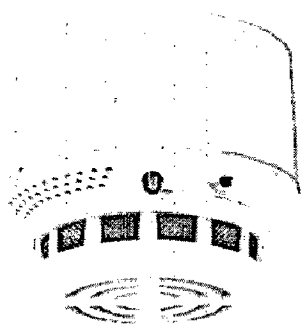


Figure 2.21 Smoke Detector

2.4.2 Fire safety alarms:

A smoke (refer Figure2.21) and fire building control system performs two main functions. The first is protecting the building occupants and property. The second is providing fire-fighting controls used by fire-fighters. Using ventilation and containment principles well can get the job done. The fire safety system includes smoke sensors, fire alarms and fire sprinklers. Smoke and fire control designs should adhere to the highest level of life safety possible. Most smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while others use both detection methods to increase sensitivity to smoke. Detectors will indicate the possibilities or the occurrence of smoke as the case may be. Based on the intimation received from smoke deduct or smoke alarm will produce the loud noise so that necessary precautionary arrangements can be made soon to escape from the fire accident and thereby stay protected from the touch.

The BMS activates various devices to deal with the emergencies like starting smoke exhaust fans, unlocking fire escape doors, starting staircase pressurization fans, bringing elevators down to ground floor, Auto dialling fire station, tripping air handling unit of affected floors, operating smoke dampers etc.This is the very effective way to control fire as well as to prevent any damage to the properly (Walsh . J., 2005).

2.4.3. HVAC system:

Temperatures sensors are suitably mount on walls of a space which measure rise of fall in temperature of that area with varying number of occupants, send information to the BMS and accordingly temperature is set. In case of no occupancy, air flow into that section will automatically shut off controlling to power savings.

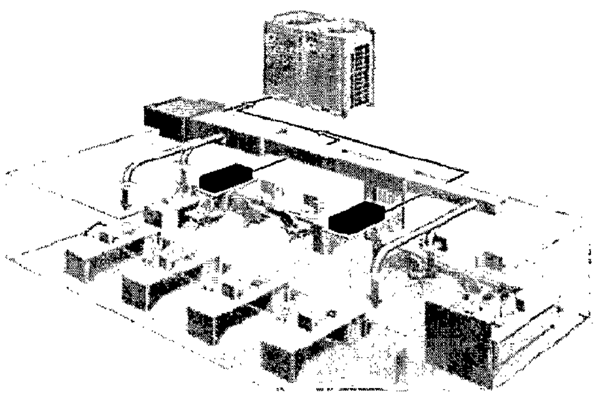


Figure 2.22 VRV System

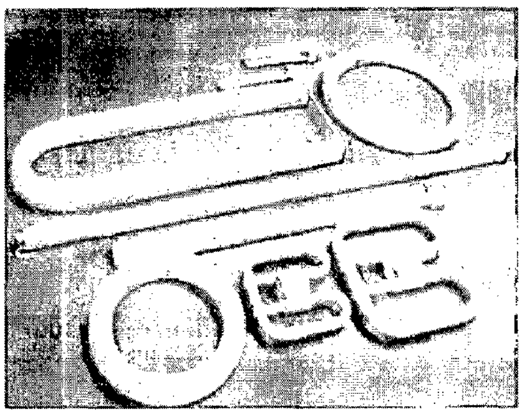


Figure 2.23 Energy Efficient Light

VRV system (refer Figure 2.22) is centralized unitary system in which refrigerant low changes according the building load (ECBC, 2007).

2.4.4. Lighting system:

The lighting systems will be controlled through BMS, which swatches on/off the lights according to the occupancy information sent by occupancy sensors mounted at ceiling. This maximizes energy efficiency (refer Figure2.23). It is also possible to dim the lighting systems of a particular area through BMS if it's found enough daylight available there with the help of light intensity measuring device or it can be kept manually operated especially in restaurant and apartments in the building (Lonix, IBMS).

2.4.5. Elevator & stairway control:

The BMS monitors all elevators in the building to have a faster access to the various floors. if they are stuck up anywhere for any reason like power failure or any other faults ,it will be detected immediately and informed. In case of fire, all elevators will be brought down to the ground floor. It is also possible to control the access to users; only to those floors they have valid access to, through the access control system installed in it. Every emergency stairway will be provided with pressurization fans, which will blow air into the stairwell, thus making it free from smoke or fire in such situations. This is automatically controlled by the BMS (Walsh. J., 2005). The locks in exit-ways will be opened on detecting such hazards.

2.4.6. Water supply and sewerage treatment control:

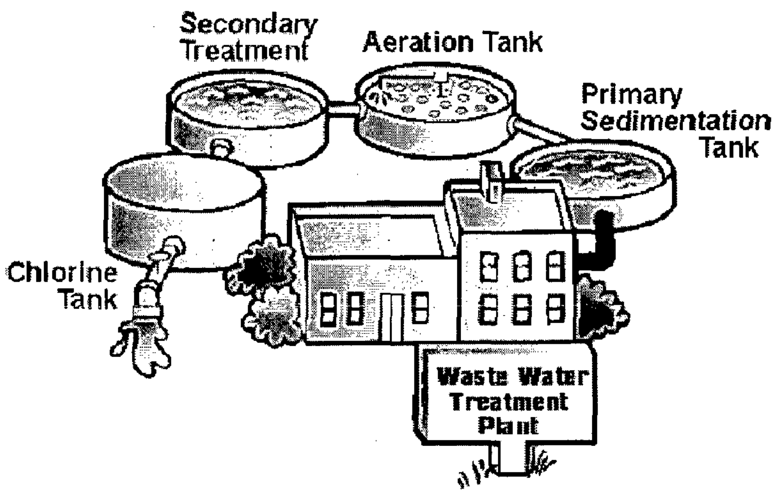


Figure 2.24 Waste Water Treatment

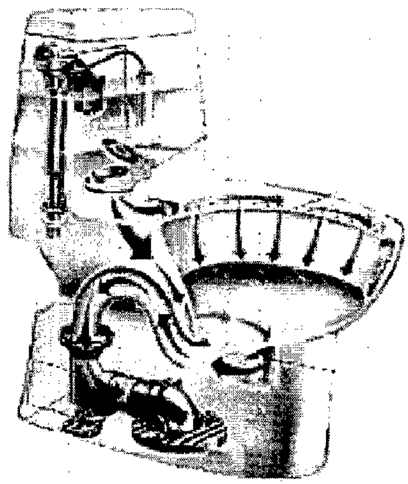


Figure 2.25 Water Efficient Fixtures

A BMS controlled pumping system can be provided for supplying water to various domestic purpose and also a sewerage treatment plant for the purpose of reducing the load over public treatment plant. The treated water can be reuse for flushing toilets (refer Figure2.24 & 2.25) thereby reducing the monthly bills over water consumption.

2.4.7. Mechanical and electrical systems noise control:

When designing a building, it is important to control the noise and vibration of its mechanical and electrical equipment (refer Figure 2.26). Without adequate consideration during design, the very equipment that provides thermal comfort and electrical power can generate annoying noise and vibration. Proven techniques are available for mitigating noise and vibration from this equipment. The recommended acoustical design sequence for a building project is: Selection noise criteria for each space, Organization of spaces to avoid adverse adjacencies of noisy equipment with quiet spaces, provision of adequate noise and vibration control for equipment (UIA/AIA Acoustics for library, 1993).

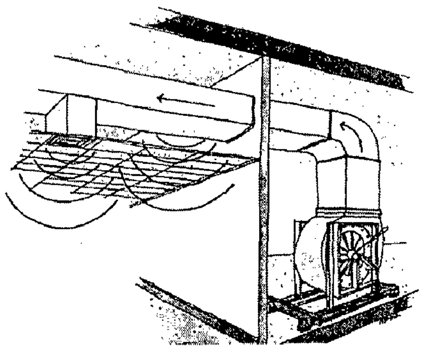


Figure 2.26 Duct borne noise and breakout noise (through the walls of the duct).

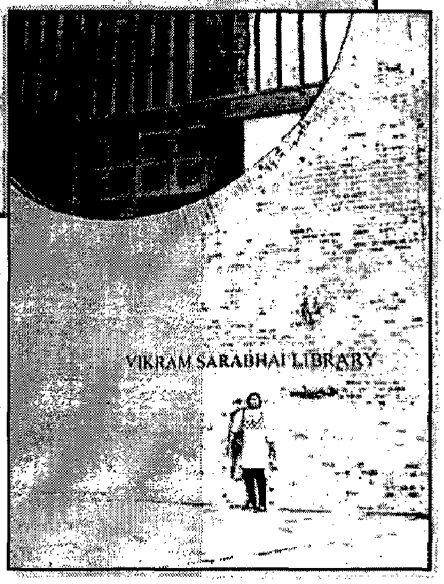
Fan noise transmitted into a room is generally either duct borne noise or breakout noise. Duct borne noise can be described as fan noise that is carried within a duct and then transfers into a room through a register. Breakout noise is fan noise that passes through the walls of a duct and through the ceiling into a room.

Absorption of fan-generated noise and mitigation of air turbulence are the strategies for reducing unwanted mechanical noise in a building. To reduce fan-generated noise, provide long duct lengths between fans and the nearest air register serving a room and treat the duct internally with duct liner. Fifteen feet of lined duct inserted after the fan can reduce fan noise by 10 dB.

2.5 SUMMARY:

The literature review has been done based on data collection regarding the present scenario of library design, new importance of architecture and design, paradigm shift in library design and planning issues. Literature review also done related to environment responsive library design. Passive and active strategies of environment responsiveness have been studied in this chapter. This literature review is the basic study; from secondary source of information have help to understand the library design. After literature survey, primary source of information will come in the next chapter. Next chapter deals with literature and live case studies from which practical approach of environment responsive modern library design can be learnt.

CHAPTER 3: CASE STUDIES



CHAPTER 3: CASE STUDIES

3.1 INTRODUCTION:

For a modern library, the user friendly functional planning, building services, on addition to that integration of digital technology has become the essential requirement. Modern libraries have been move out of the current model that optimizes storage to one that makes sense for group work. Preferences of young generations are like favouring learning functions in the space's mix of academic and social functions. Integration of new information technology has actually become the catalyst that transforms the library into a more vital and critical intellectual centre of life at colleges and universities today. Making a library environment responsive is also an important issue. There are several kind of passive technique adopted in library building for energy saving purpose. For the considerable 'green' outcomes achieved, modern library building can win several awards in recognition of its environmental friendliness, These cases study are done for learning from practical issues and experience.

LITERATURE CASE STUDYs

3.2. NATIONAL LIBRARY BUILDING, SINGAPORE

3.2.1. Design brief:

Architectural Design: T.R. Hamzah & Yeang Sdn Bhd

Project Architect: DP Architects Pte Ltd

Size : 102.8 m (building height)

6,000 – 8,000 m2 (green space)

58,783 m2 (total GFA)

For the considerable 'green' outcomes achieved, the National Library Building (NLB) has also won several awards. In recognition of its environmental friendliness; it was awarded the ***Green Mark Platinum Award*** in May 2005. This is the highest honor for 'green' buildings in Singapore bestowed by the local Building and Construction Authority (BCA).In August 2007, it also won **First Prize** in the ***ASEAN Energy Efficiency Award*** under the 'New and Existing Building' category. In 2007, the National Library Building (refer Figure 3.1) won the ***Singapore Silver Award*** in the ***Universal Design Award*** from BCA, for its wide spaces, good lighting, accessibility and clarity in way finding (Singapore's new National Library, The Arup Journal, 2008).

Facility: It has a collection of over 200,000 books, It also has a collection of 726 magazines, 74 newspapers as well as audio books on CDs. Central Lending Library has the largest number of foreign newspaper titles in her collection of newspapers.

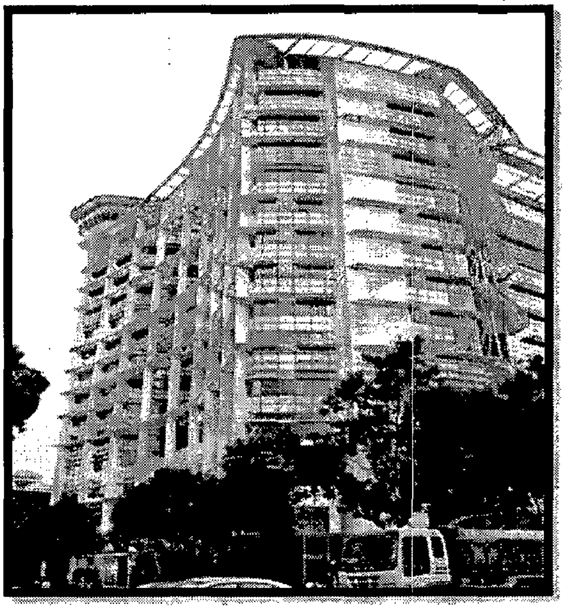


Figure 3.1 Exterior View of National Library Building, Singapore

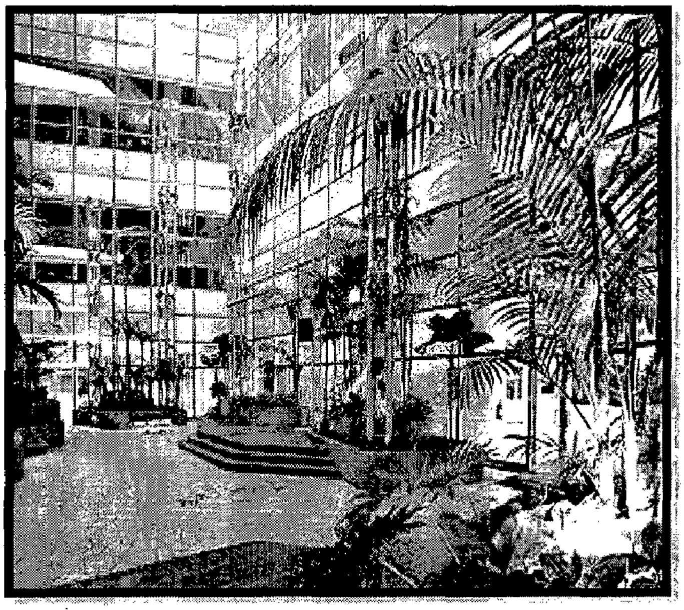


Figure **3.2 Building Courtyard, Integrated With Nature**

3.2.2 Design approach:

The building consists of two 16 storey blocks, with three basements. The blocks are linked by sky bridges on every floor. It houses two libraries, the Central Lending Library in Basement 1 and the Lee Kong Chian Reference Library from Levels 7 to 13. It also houses the Drama Centre from Levels 2 to 5, which is managed by the National Arts Council. On the 16th floor, there is a closed viewing point called The Pod. It is only used for functions and events, and is not a viewing gallery. From the Pod, it has a panoramic view of the island of Singapore, outlying islands, and also neighboring countries such as Malaysia and Indonesia. There are also many gardens in the building but only two are opened to the public. They offer a good view of the city, and one is the Courtyard (refer Figure 3.2) on Level 5 and the Retreat on Level 10. The building has three public panoramic elevators with a city view. The National Library Board headquarters is on the

14th floor of the building. The building has escalators from Basement 3 to the 14th storey. It has a car park with 246 lots. On the first floor are the main entrance, and a cafe, with a big space the Plaza (refer Figure 3.2) and is sometimes used for exhibition space. A number of old bricks from the old building are in this new building.

3.2.3 Spatial quality:

Climate consideration-Design for tropical conditions: Solar heat, humidity, and light could potentially make it very uncomfortable for its occupants and threaten the important collection. The façade design was crucial in both respects. The building had to be heavily shaded (refer Figure 3.3) to reduce solar heat gain through the façade, and so a 30° solar cut-off was adopted, ie there should be no direct sunlight visible in the building when the sun was 30° and more above the horizon. This gave the design team an unusual challenge: though almost no direct sunlight should enter the building between 10am and 4pm, as much useful daylight as possible still had to penetrate so as to allow artificial light

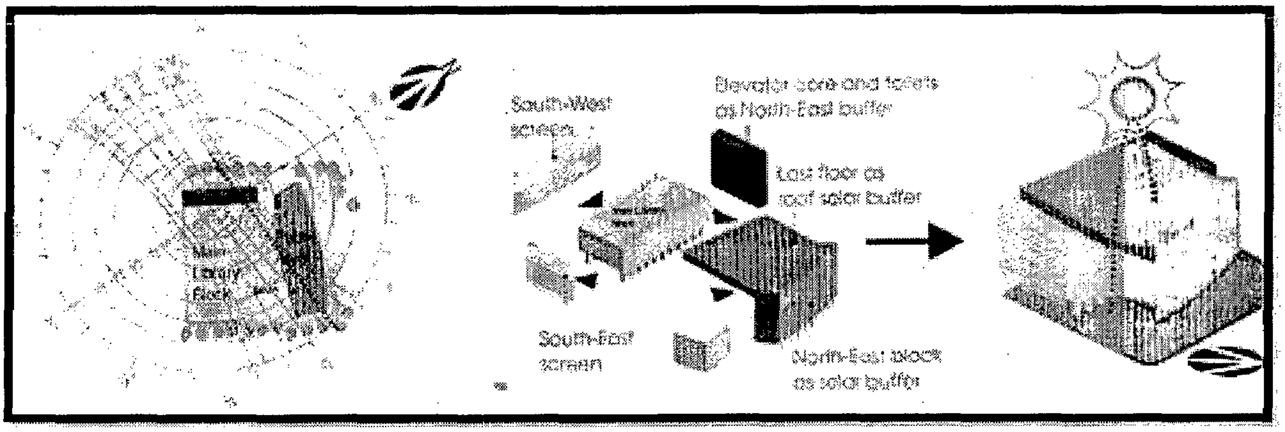


Figure 3.3 Climate Consideration-Designs for Tropical Conditions

to be reduced. In response, the team designed what are probably some of the world's biggest sunshades on a curtain wall, projecting up to 1.8m from the face of the glass, these wrap around the building and control solar radiation and glare, yet maximize daylight. To speed installation and to avoid the difficulty of fixing in mid-air, they were attached to the curtain wall before erection. The need to support the sunshades and the 5.4m storey height led to the curtain wall mullion being 250mm deep - the maximum available for most aluminium extrusions.

3.2.4 Green features:

The National Library Building is an innovative 'green' building designed as a "Library for the Tropics" using bioclimatic design techniques. Internationally recognised as an architectural icon and designed as a 'green' building, its deployment of various innovative 'green' features helps to keep the building operating in an energy-efficient way and to do its part for a more sustainable environment. Key 'green' features include the use of bioclimatic vegetation and landscaping to improve the indoor thermal environment and a lighting control system that switches off lighting when there is sufficient natural light to illuminate the building interior, as detected by light sensors. The building is also heavily shaded to reduce solar heat gain through the facade. In supporting efforts towards environmental sustainability, NLB is one of the founding members of the **Singapore Green Building Council.**

Passive strategies:

i. **Planning and site layout:** A vast atrium sits as a thermal stack over the internal street to create passively cool, breezy transition spaces, thus reducing the demand for air-conditioning.

ii. **Landscaped areas/gardens:** About 10% of total GFA is designated as "green spaces" to create urban "sky courts". Fourteen landscaped areas/ gardens are also located throughout the building. Thus, the surface temperature of the roofs and heat transfer into the building interior is reduced. The indoor thermal environment and thermal performance of the building is also improved.

iii. **Design of facades:** To reduce solar heat-gain through the façade, a 30° solar

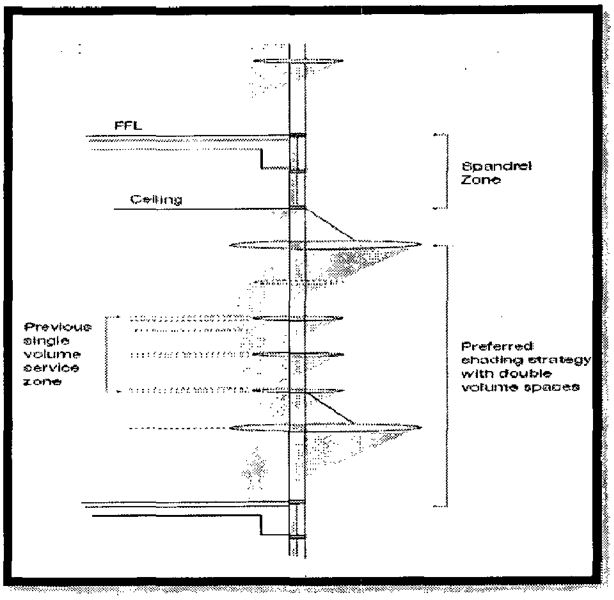


Figure 3.4 Laneway sunshades

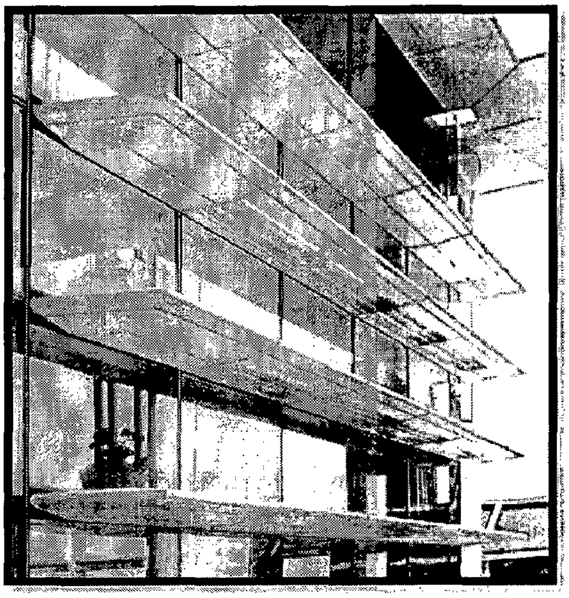


Figure 3.5 Shading device

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cut-off was adopted (no direct sunlight into the building when the sun is 30° or more above the horizon) to heavily shade (refer Figure 3.5) the building. Some of the world's biggest sunshades on a curtain wall, projecting up to 1.8 m from the face of the glass, wrap around the building and control solar radiation and glare, yet maximize daylight.

iv. **Double-glazed glass façade:** About two-thirds of the building façade is double-glazed with high quality low emissivity glass to minimize heat transfer while permitting visible light transmission without glare problems.

v. **Laneway sunshades:** The pattern of shades continues around the building. Between the two main blocks, they span up to 6m wide and 14m long, but only 400mm deep (refer Figure 3.4). Together with natural breezes, the shades here create a dramatic enclosed environment which, though in a humid tropical climate, remains comfortable.

vi. **Efficient chiller and plant configuration:** The chiller plant is configured with large non- essential chillers and small essential chillers serving different parts of the building. Depending on load demands, the small chillers automatically double up to support the large chillers. The chilled water system employs a primary and secondary chilled water circuit with variable speed drive installed for the secondary chilled water pump.

vii. **Variable air volume (VAV):** The air distribution to the library interiors, offices and commercial spaces use VAV boxes that allow for better zone temperature control. The temperature is modulated with a variable speed fan installed with the cooling tower, based on the condenser supply and return temperature. **Night setback** allows an increased air-conditioned temperature to be maintained in the building during unoccupied hours.

Active strategies (Building management system)

i. **CO2 sensors & Carbon monoxide monitoring:** CO2 sensors installed at the Air Handling Units (AHUs) ensure that the percentage of fresh air in the supply air is maintained at acceptable levels in all areas. When the level of carbon monoxide exceeds the standard limit, the car park ventilation system is activated where fresh air is pumped in while the exhaust air is extracted.

ii. **Displacement ventilation system:** The Drama Centre in the building is equipped with a displacement air-conditioned system that supplies conditioned air through a supply vent below each of the circle seats at a slightly higher temperature and at a lower velocity to the areas where the audience is seated.

iii. **Start-stop escalators:** The escalators are stationary when not in use. At the same time, pressure sensors located underneath the escalator mat, will detect human traffic towards the escalators, and initiate their movement accordingly.

iv. **Rain sensors:** As part of the auto-irrigation system, rain sensors are installed so that the irrigation system is not operated during rainy days.

v. **Automatic blinds:** The north-west side of the reference library reading area is automated with roller blinds. These blinds will roll up or down with the help of automated lux sensors to prevent glare and solar radiation in the library space.

vi. **Lighting control systems:** Besides lighting sensors to switch off the lights in some of the public spaces during the day, daylight sensors at the perimeter of the library areas also monitor the amount of natural light entering the building, allowing the artificial lighting to switch off. The libraries, exhibition and office spaces are largely naturally lit. A sophisticated Integrated Lighting Control System allows for strategic programming of internal and external lights.

3.2.5 Inference from case study:

Lessons learnt:

- ***Financial Savings:*** The 'green' concept fulfils NLB's corporate social responsibility in being environmentally friendly. Saving is an average of about 33% on the monthly energy bill compared to a similar building without the 'green' features. 31% energy savings, Electricity Energy Savings 31 % which is lower than the national average of 220 kWh/sqm/annum for non-green buildings and Energy Efficiency Index (EEI): 151kW/hr/m2
- ***Green features:*** Low environmental impact for climate consideration while designing and green features like Laneway sunshades, Double-glazed glass façade
- ***Landscaping:*** Integration of natural element from the design stage is key feature.
- ***Educator of environment responsiveness:*** Example for other building to incorporate sustainable features. Active strategies like building management system are a reason for efficient building services.

Critical review:

Initial Cost of project: Cost of intelligent building network system is very high, the building also required high level of maintenance.

3.3 FREDERIC LANCHESTER LIBRARY, COVENTRY UNIVERSITY, UK

3.3.1 Design brief:

Architects – Short And Associated

Energy Consultants IESD, De Montfort University and University of Wales

Structural Engineering Consultants Taylor Boyd and Hancock

Floor area: 9100 sq m (four floors + basement area)

Opened In September 2000

Aim is to provide an exciting and highly effective centre for information access, study and learning; this will affirm the University's commitment to the student learning experience, to offer the highest quality information service delivery, in support of teaching, learning and research for users. To develop an exciting focal point for students which will attract and delight users and in which staff and students will find it a pleasure.

Figure 3.6 Exterior View of Frederic Lanchester Library

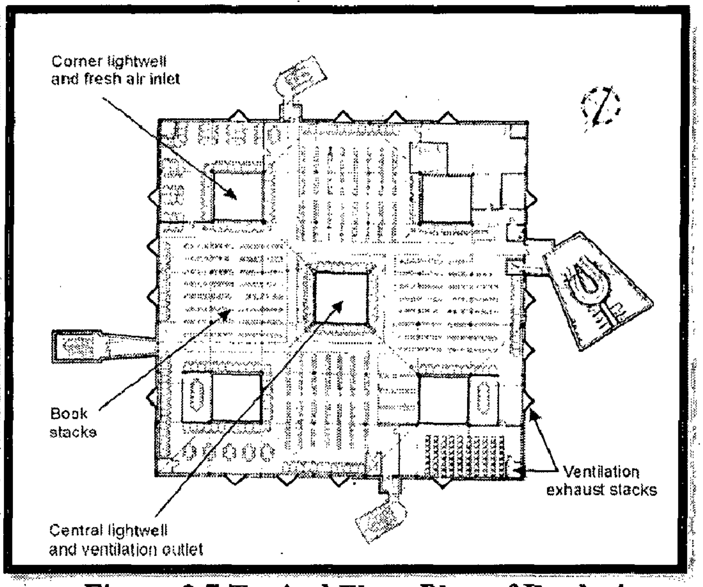


Figure 3.7 Typical Floor Plan of Frederic Lanchester Library

This design got 2002 Sconul Design Award and 6 other prestigious awards. Building Magazine and the Brick Development Association awarded this building their 'Public Building of the Year' .And overall 'Building of the Year' prizes in December 2000.UKCSA Award for Excellence "Best New Commercial Project" 2002. (WBDG a program of National institute of building sciences, 2010).

Facilities: The Lanchester Library (refer Figure 3.6), named after the engineer Frederick Lanchester, offers a range of modern study environments. It accommodates over 300 PCs and a wireless network which is available to all University members. Attracting over 700,000 visitors a year it offers more than 1,200 study places. With over 350,000 books, 2,000 print journal and 8,000 electronic journal titles and a range of multimedia resources, we provide a focal point for student learning and information access.

3.3.2 Design approach:

The Frederick Lanchester Library forms part of Coventry University. It has a gross floor area of 9 100 m^2 and is unusual in that, although it is a deep-plan building occupying a 50 m by 50 m footprint, it is ventilated naturally with no artificial cooling, except for a separate basement area which is air-conditioned. By its nature the building has a large number of transient occupants. At the design stage 2 500 entries per day were anticipated. In practice, this has increased to 5 000. In addition a number of staff works permanently in the building. The building is open for use for approximately 4 000 hours per year.

Site: Climate of the site is like usually unpredictable weather, winters are cold, wet and at times frosty, Summer months have plenty of sun shine. Close proximity to a raised ring road, Potential noise which can cause disturbance, Air pollution also needs to be checked, Gusty and unpredictable wind conditions prevalent. Site surrounded by no of buildings of different heights which could affect air flows. Area limited by surrounding buildings and hospital.

The deep plan (refer Figure 3.7) of the building is broken up by multiple light-wells to provide both daylight and air flow paths. Heavyweight construction is used with exposed concrete ceilings. Apart from air-conditioning for the basement, summer temperatures are controlled by a combination of internal blinds, deep window reveals, fixed screens and night cooling by ventilation. High-frequency lighting is provided with daylight linked dimming.

Structure: Steel framed structure, Principal cladding material is facing brickwork, predominantly cream coloured, but include reds. Facade is Simple but finely crafted brick patterning which embeds it culturally into the West Midlands region.

Spatial analysis: Maintain good spacious entrance and circulation desk, Simple floor layouts-rectangular and straight lines , layout is consistent within the floors, Desks were the first thing to be visible, Flexible plan-all internal walls were partition and not structural . All staircases and toilets have been located outside-plumbing outside. Simple furniture in modules: Two seat module-900 X 1800 cms .

Flexibility space design: No internal structural walls, Rectangular footprint, Stairs and toilets outside the library space, flexible furniture and flexible cabling infrastructure (refer Figure 3.9).

Raise floor system: Instead of expensive and space hungry raised floors, power and data cabling across the floors in channels .channels cut into the floor screed fed from the four corners of the building. The channels were topped by a high tensile steel cap. Channels could stand the weight of loaded book shelves (refer Figure 3.8) possible to move book shelves anywhere in the building and to exchange bookshelves for PCs space in any part of the building.

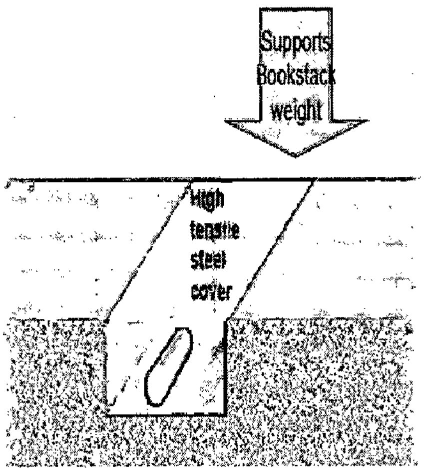


Figure 3.8 Raised Floor System

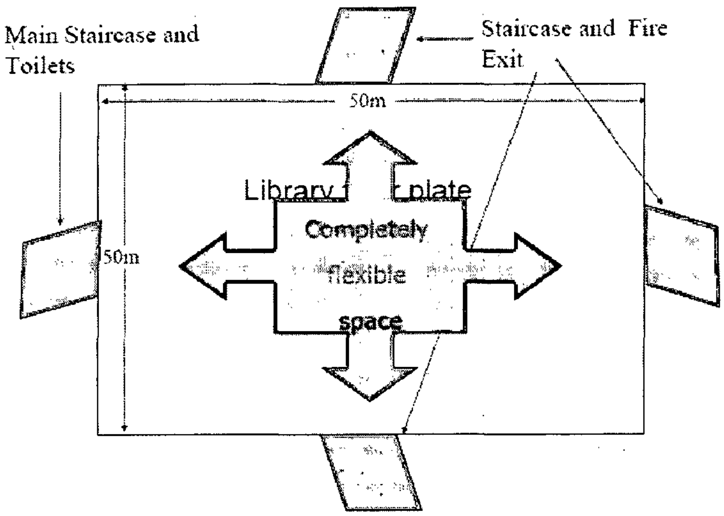


Figure 3.9 Flexibility space design

3.3.3 Spatial quality:

Natural lighting: Maximum use of natural light , Light-wells to draw in daylight, Dynamic lighting system to react to natural light levels.

Ventilation: Apart from a basement, comprising about 12% of total gross floor area and containing central computer equipment, the building is naturally ventilated. The award winning building is of interest to many visitors due to its highly energy efficient design. Occupying approximately 10,000 square metres it is completely naturally ventilated and employs natural light with innovative lighting technology to significantly reduce energy consumption compared to traditional air conditioned buildings.

Air circulation: Air introduced into a plenum below the upper ground floor, it is fed upwards through four atria extracted via perimeter stacks and a large central atrium. The motive power is entirely provided by the natural buoyancy effect of warming air.

Artificial lighting: artificial lighting was provided by strips that ran diagonally across the ceiling enabling book-shelves to be placed almost anywhere on the floor and at almost any angle.

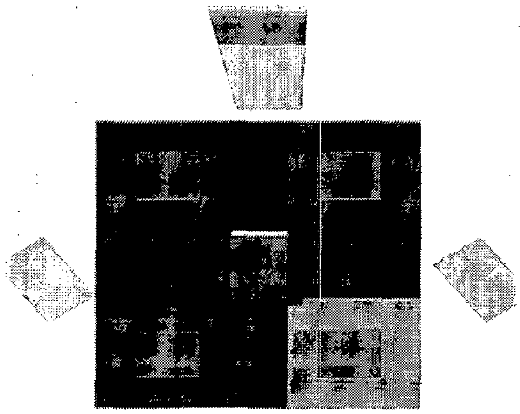


Figure 3.10 Basic Space Zoning

Red : Functional area

Yellow : Circulation area

Blue : Auxiliary area (activities concerning the building but not its operation – heating, lighting, ventilation as well as open spaces

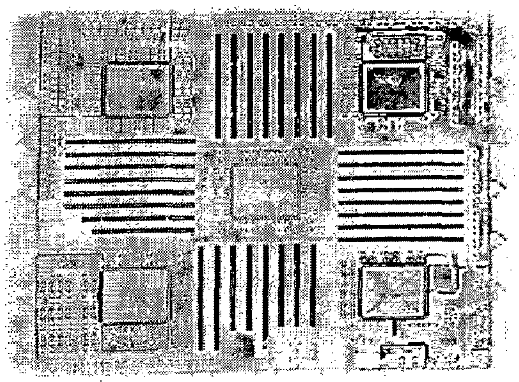


Figure 3.11 Planning Scheme

Orange : Collective workspaces

Green : Group Study Area

Mustard : carrels for individual studies

Purple : Lecture and seminar room

Red : office+Photocopy

Yellow : Lightwells area

3.3.4 Green features:

i. **Natural Ventilation and daylighting :** In order to provide natural ventilation a tapering central light-well provides extract ventilation (refer Figure 3.10-13), supplemented by 20 perimeter stacks with a 1.8 m by 1.8 m cross section. The stacks terminate 6 m above roof levels with fittings to prevent reverse flow due to wind pressure. Air entry is via a plenum under the ground floor to the base of four 6 m by 6 m square corner light-wells (refer Figure 3.16). Under the

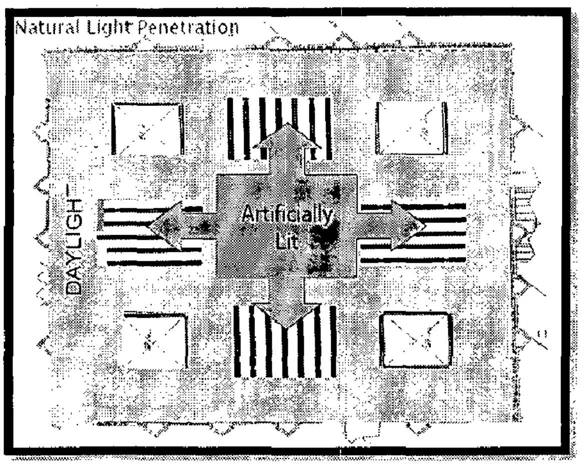


Figure 3.12 Natural Light Penetration

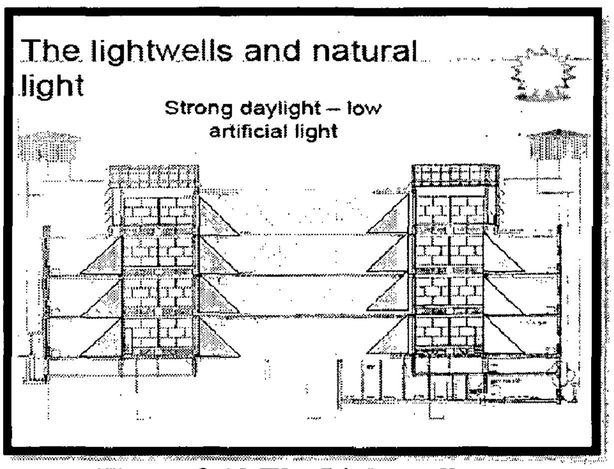


Figure 3.13 The Light wells

of stack effect air is drawn via light-wells into each floor and extracted via the central light-well and smaller perimeter stacks. Cooling is provided passively by thermally heavy-weight exposed concrete ceilings (Lomas, K.J., 2007).

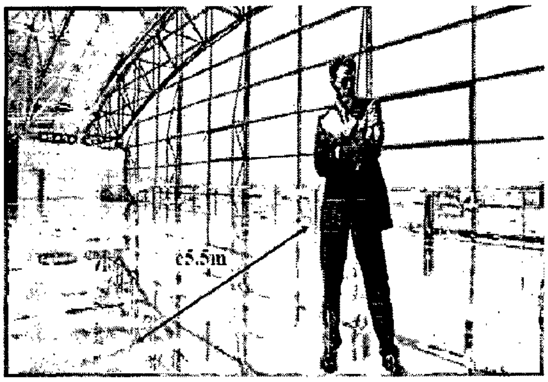


Figure 3.14 Daylighting

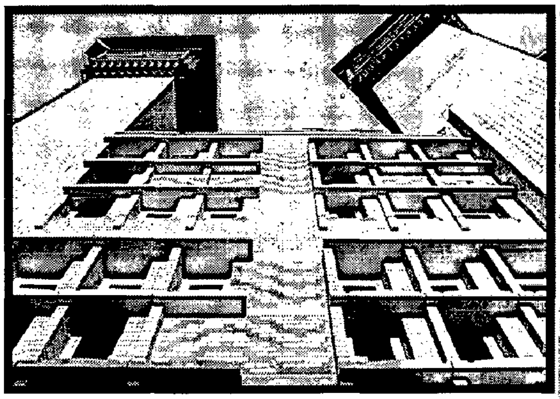
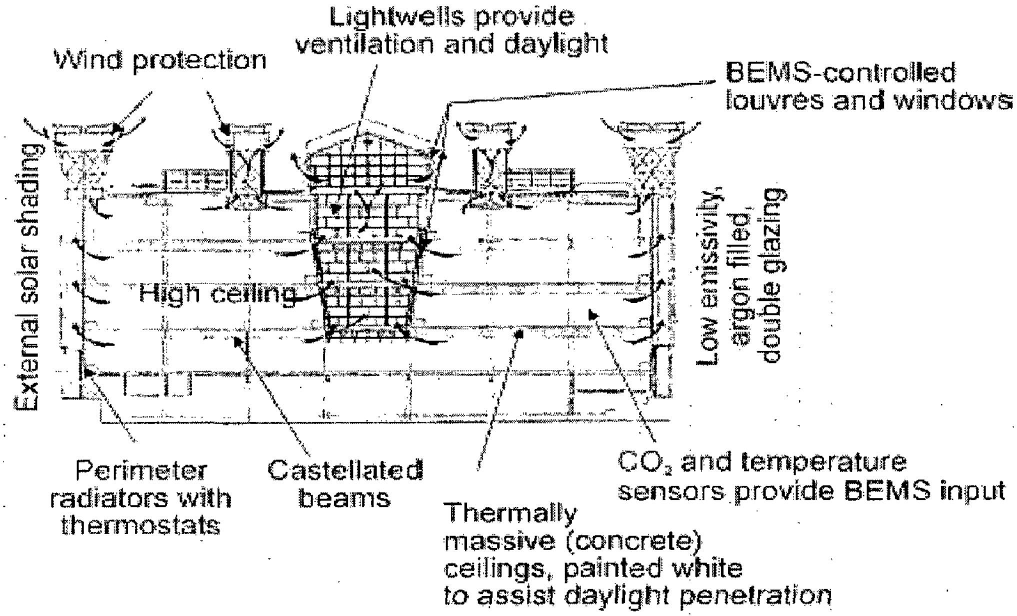


Figure 3.15 Shading system

(a)



(b)

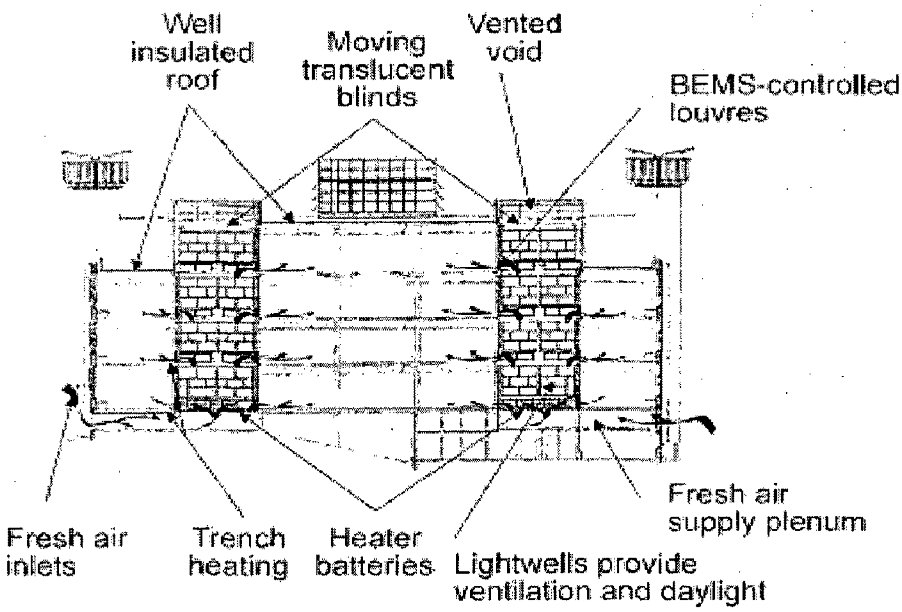


Figure 3.16 Advanced Ventilation Technique

Active strategies

i. **BEMS (building energy management system):** This System is a single, cohesive building management system controlling lighting, HVAC, fire, security, energy use and other facilities (refer Figure 3.17).

ii. **Thermal:** Indoor air temperatures measured over a full year from June 2004 to June 2005. The data were taken from 8 BEMS sensors situated at two positions

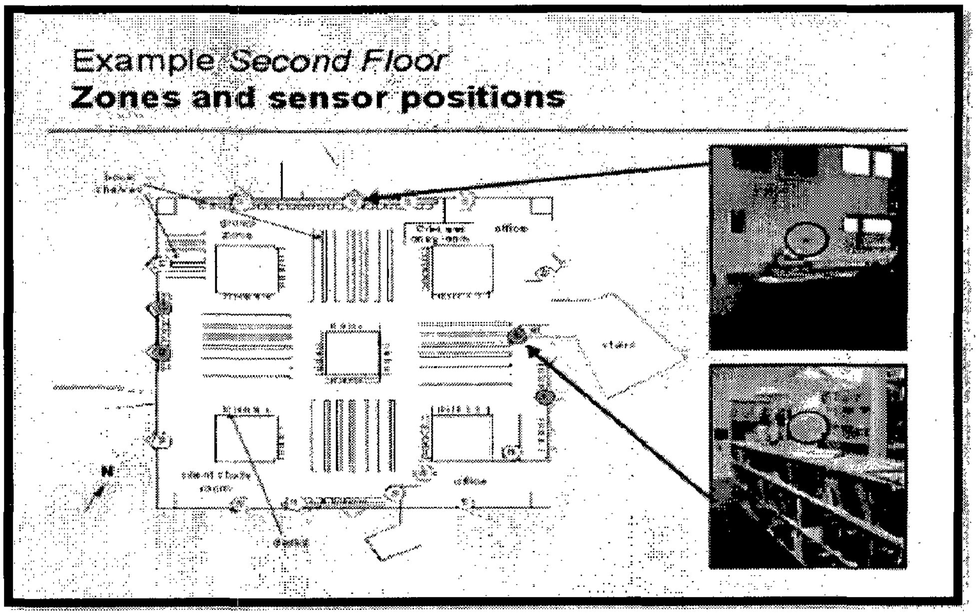


Figure 3.17 Sensors Positions

on each floor, located on different walls at a height of 1.5 m. Temperatures were measured at hourly intervals and averaged over all eight measuring locations. The survey results are satisfactory about indoor temperature condition. Current national benchmark figures (CIBSE 2006) for a naturally ventilated building requires that an operative temperature 28°C should be exceeded for less than 1% of occupied hours.

iii. **CO2 sensors:** Carbon dioxide concentrations were measured over a representative six week period at four locations on one floor. There are no specific UK standards for carbon dioxide concentration in library or office buildings, although a maximum of 1000 ppm is used for schools. In the Coventry Library carbon dioxide did not exceed 350 ppm above ambient during the measurement period.

3.3.5 Inference from case study:

Lessons learnt:

- ***Advanced ventilation technique:*** A deep-plan, multi-storey building can be adequately ventilated naturally, using appropriately placed light-wells and stacks. This means the architectural design has to be integrated with the ventilation design from the very beginning of the design process.
- ***Flexibility space design:*** No internal structural walls, Rectangular footprint, Stairs and toilets outside the library space.
- ***Daylighting:*** Light wells to draw in daylight, light is penetrated up to 5.5 m from glass facing. No glare problem due to shading device.
- ***Raise floor system:*** Appropriate for modern library building which should have provision for digital media. Instead of expensive and space hungry raised floors, power and data cabling across the floors in channels .channels cut into the floor screed fed from the four corners of the building.

critical review:

A summary of the results of a sample survey of building users and full-time occupants, carried out in 2008. Occupants are satisfied with conditions in the summer but are less so in the winter. Dissatisfaction is primarily with thermal comfort in the winter with complaints of cold and draught, particularly by occupants located on the north-east and North West sides of the building.

3.4 PHILOLOGICAL LIBRARY –FREE UNIVERSITY, BERLIN, GERMANY

3.4.1 Design brief:

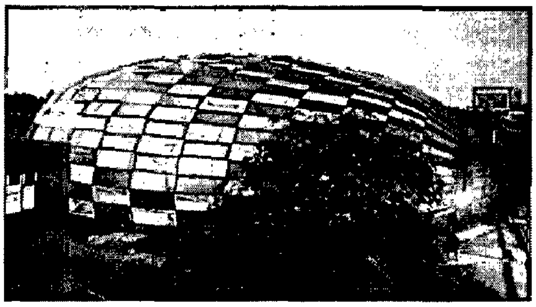


Figure 3.18 Philological Library Building Exterior

Completion	: 2005
Architect	: Fosters and Partners
Floor Area	: 6300 sqm
Floor Levels	: 4
Budget	: 18 million Euros

This building is nicknamed the Berlin Brain because of its cranial shape. The form is known to be developed from Buckminster Fullerene (c64) cups, cut at the middle.

3.4.2 Design Approach:

Corresponds to human brain curved textile skin gives space impression (refer Figure 3.19).A double-layered skin supported by a wide-span steel structure encloses the five-storey concrete structure of the library. The outer casing consists of light aluminium panels and 40% glass elements. On the inside will be a - lightly translucent -curved skin of glass-fibre fabric panels, this spatial separation of reading room and library administration is characteristic of the architecture of the library. Nevertheless, the two buildings are of course connected through a passage in the basement. This tunnel will also allow users access to a group study room, the computer training room and reader-printer facilities located in the basement of the administration building. Materials used in the building are Aluminium, Steel, Glass panels. The building's outer shell is fitted with alternating glass and aluminium panels, which slide open and work as ventilation elements. A steel frame separates the double-layered skin .(Philological library, (Philological library, 2008).

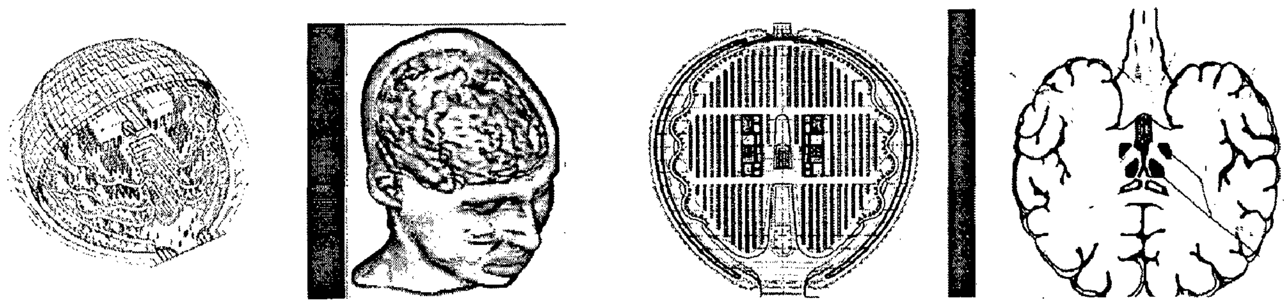


Figure 3.19 Evolution of shape

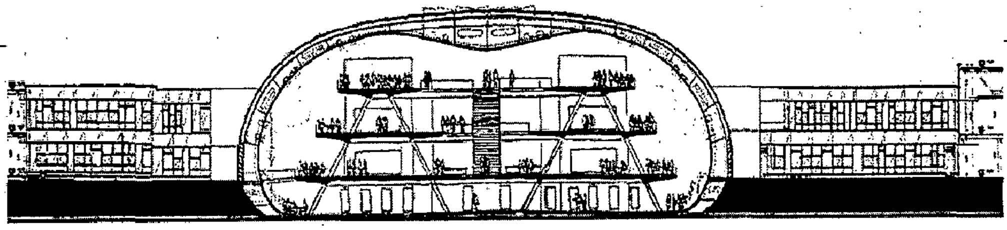


Figure 3.20 Philological Library_Building section

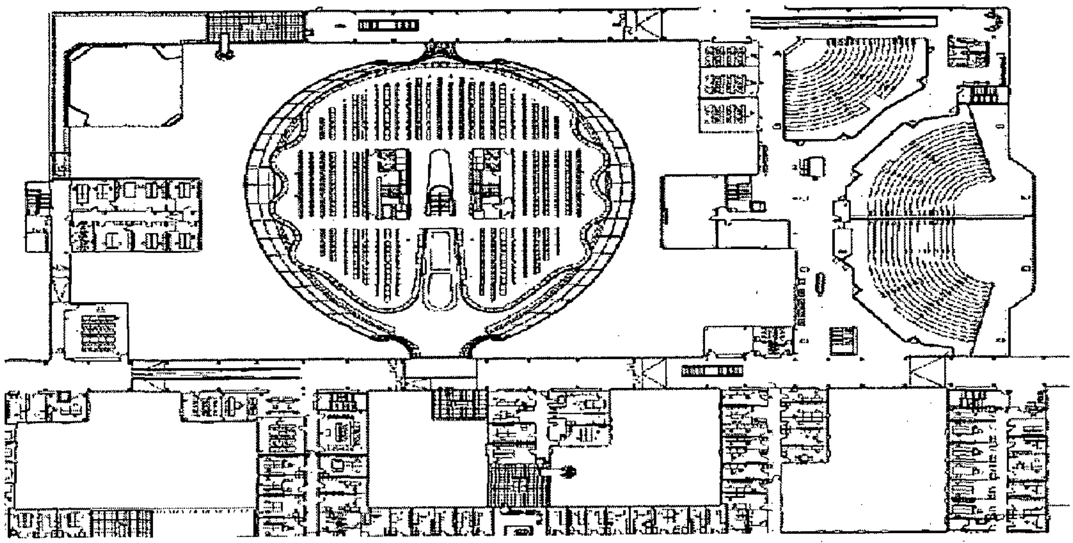


Figure 3.21 Philological Library_Building plan

Circulation: The different floor levels (refer Figure 3.20 & 3.21) are connected by a central open staircase and the two adjacent central building cores. The cores are parallel structures with emergency staircases, a lift, sanitary rooms and rooms for technical equipment. Galleries round the atrium of the library in spite of its compactness, as a spacious, clearly structured building.

Sitting Arrangement: The book stacks are located and structured in an ordered manner (refer Figure 3.23), in the centre of each floor, with reading desks placed along the perimeter of the floors. Readers will sit next to each other at continuous desks without facing one another. The only exceptions will be those seats on the galleries round the atrium, which offer a more lively space in the centre of the brain.

Interiors: The inside of the skin is made of a translucent glass fabric. Transparent openings spaced at intervals provide direct sunlight. Classic wood chairs by German

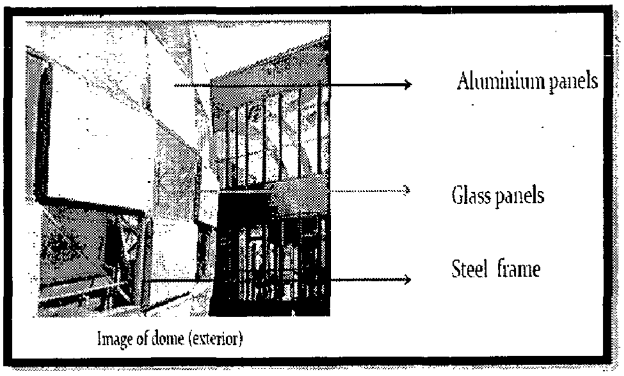


Figure 3.22 Building Materials

Figure 3.23 library interiors

architect Egon Eiermann and rectangular aluminium task lamps, designed by Foster and Partners, are integrated with their serpentine desk system, which lines the perimeter of each balcony.

3.4.3 Spatial quality:

i. Thermal quality: fully air conditioned building. Temperature maintained as 2 degree c and humidity 55%.the building is thermally comfortable.

ii. Natural Ventilation: The space between the inner and outer skin serves as a sort of air-canal for the natural ventilation of the building. The flow of air can be regulated through controllable flaps. on the 60 percent of the year the library is ventilated by simply opening panels in the dome membranes or using controlled fresh air drawn from below.

iii. Natural Lighting: Glazing is used to provide views for natural light. The outer skin is aluminium panels with staggered glass openings (refer Figure 3.22), The inner membrane of translucent glass fibre filters sunlight .The lighting is fixed at the ceiling in the middle of the aisles, except on the uppermost level, where the lighting is fixed to the shelves themselves (as there is no ceiling).

iv. Acoustics: To avoid noise, keyboard free zones are required. Once the new technology of silent keyboards has become affordable for the average reader these restrictions will hopefully become superfluous. The beeping of barcode scanners, the clapping of locker doors and the communication among library staff will have to be kept in check .the fabric of the inner skin and the filled bookshelves will help reduce noise. All copying facilities are located in soundproofed areas. There is also an extra quiet work space on level zero, closed off by a glass wall and available to readers with special needs.

3.4.4 Green features:

Passive features:

- The building is not only known for its external look but also it by itself known to be a green building. Foster used solar panels in the roof such that the power generated can be used as the electricity.
- More ventilation is provided by making use of the translucent material on the interior skin. The double layered dome shelters a concrete structural core and

together these features heat and cool the space using solar- driven convection currents. Its four floors are contained within a naturally ventilated, bubble-like enclosure, which is clad in aluminium and glazed panels and supported on steel frames with a radial geometry.

- An inner membrane of translucent glass fibre filters the daylight and creates an atmosphere of concentration, while scattered transparent openings allow momentary views of the sky and glimpses of sunlight.

3.4.5 Inference from case study:

Lessons learnt:

- ***Building form:*** optimum SAV ratio to make it energy efficient.
- ***Aesthetics:*** the building can attract passers' by's attention.
- ***Green features:*** solar panel, Natural ventilation through open able glazing, Day lighting through glass.

Critical review:

- ***First, the issue of flexibility:*** Not able to re-arrange all the shelves or take them away in order to install extra desks some day.
- ***Extensibility:*** Library is not laid out for extension, and yet a stock increase of about 10,000 books per year. Consequently, the library will be full in 10 years.

CASE STUDY FROM PRIMARY SOURCES

3.5 INDIAN INSTITUTE OF MANAGEMENT (IIM) LIBRARY, AHMEDABAD

3.5.1 Design brief:

The Vikram Sarabhai Library, considered as one of the best management libraries in the country, is committed to providing access to its resources for students, researchers and faculty of the Institute. In 1962, Indian architect Balkrishna Doshi invited Louis Kahn, one of the most influential architects of 20th century, to design the building for the Indian Institute of Management (IIM) in Ahmedabad. Through his massive yet austere brick forms, Kahn offered these architects a spiritual experience that made them believe they could effectively build the new nation and achieve a balance between modernity and tradition. Built between 1962 and 1964, the IIMA complex now sits on a 60-acre campus. The library is named after the Institute founder, Dr. Vikram Sarabhai, world renowned physicist and founder Director.

Architect: Louis Kahn

Year of completion: 1962

Area: 20,120 sq. ft.

Figure 3.24 IIM Ahmedabad Library Reading area

Facilities: The Vikram Sarabhai Library (refer Figure 3.24), is an invaluable resource for students, researchers and faculties of business and management. The library has over the years built a robust collection of over 1,71,046 books, 42,004 bound volumes, 527 current subscription to journals and news papers, 2191 working papers, and many other resources like thesis (260), student's project reports (1709), CDs (1755) and videos (128).

3.5.2 Design approach:

It is located between the classroom building and the administrative building and connected to them by an ambulatory, overlooks the picturesque Louis Kahn Plaza, named after the world famous architect. The four storied building is divided into two wings by a central staircase. One wing is stack area (refer Figure 3.26) and another wing has a reading hall.It was to comprise a main building with teaching areas, a library and faculty offices around the main courtyard, separate dormitory units for the students that were to be interconnected with a series of arched passages, and houses for the faculty and staff.

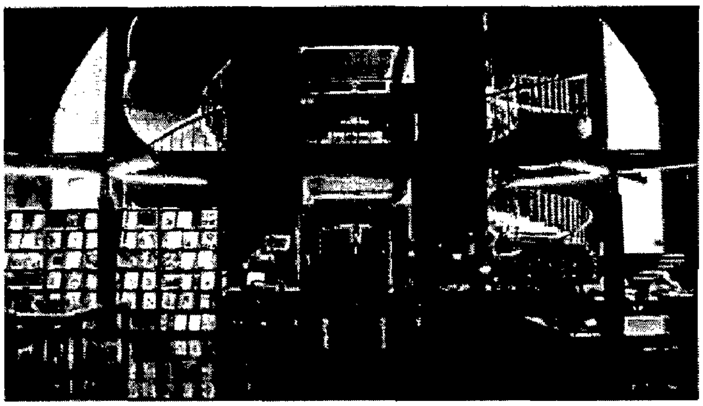


Figure 3.25 Daylighting through central core

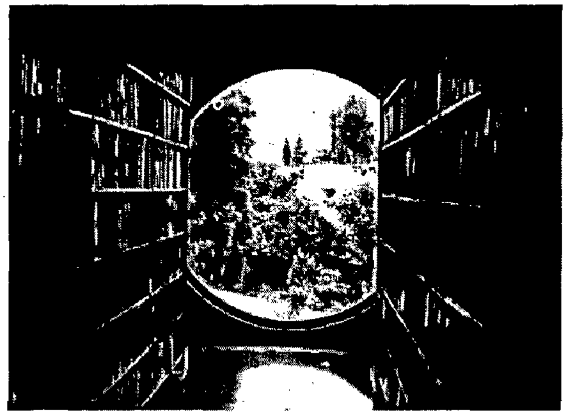


Figure 3.26 Daylighting at stack area

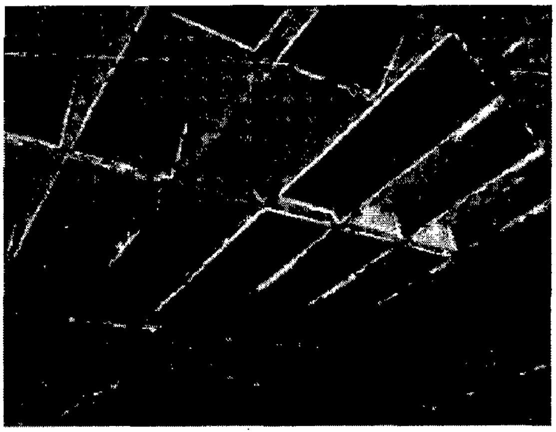


Figure 3.37 Duct from beam area

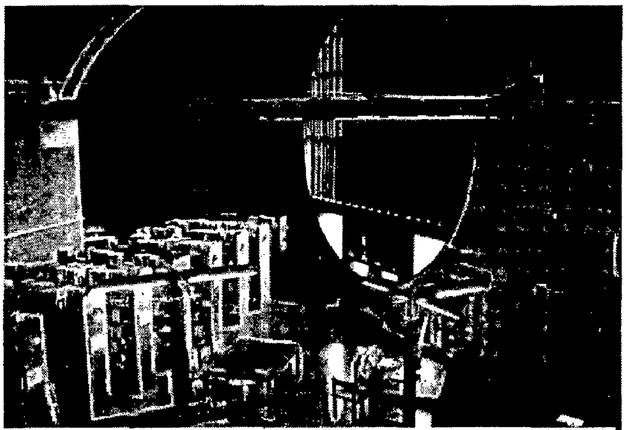


Figure 3.28 Grand opening

Library Layout:

Ground Floor: Acquisition and Processing Sections

First Floor: Circulation Counter, Photocopy, Newspapers, Electronic Resources Access, Librarian, Dy. Librarian and staff. Lending Books and Carrels

Second Floor: Reading Hall, Periodicals Display, Reference Collection Lending Books

Third Floor: Reading Hall, Periodicals Display, and Carrels

Fourth Floor: Bound Volumes of Periodicals / Newspapers and Carrels

3.5.3 Spatial quality:

Part of building is air-conditioned. Temperature maintained 23 degree c and humidity is 55 %.part of building is non air-conditioned. Comfortable reading environment is there by natural ventilation and design innovations.

Indoor environmental quality: No chemical wall painting is there, no GHG emission. Grand reading area with daylight and ventilation. Indoor environment quality is comfortable for users.

Acoustics: ground floor & first floor is acoustically proof by sound absorbing materials, so reading rooms are quite.

3.5.4 Environment responsive features:

i. **Integration with nature:** Incorporated with nature, natural elements IIMA library building has view to green lawn and LK plaza (refer Figure 3.30).

ii. **Daylighting:** Massive circular openings for daylighting.

iii. **Natural ventilation:** Through grant openings (refer Figure 3.28 & 3.29).

i. **Building material:** Massive brick wall reduce heat gain, optimum shading. Manually operable louver system is very significant for grant opening.

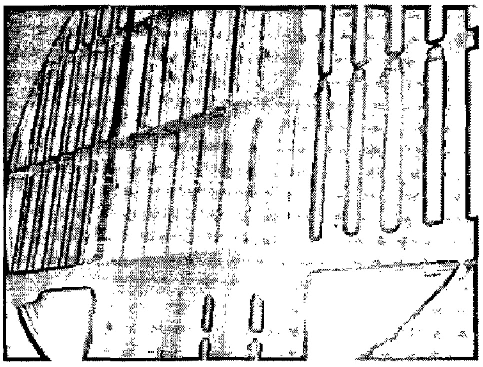


Figure 3.29 manually operable fenestration system

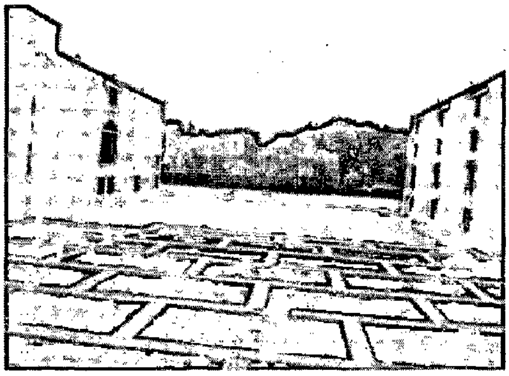


Figure 3.30 LK plaza

3.5.5 Digital technology:

The library provides access to the best of business and management related digital resources through its subscription to various databases consisting of scholarly and industry relevant content. The library has set up 3i (Information Infrastructure for Institution) network to provide business, industry environment, agricultural and economic information to the users.

The library has been automated using LibSys - an user-friendly library package. The software facilitates automated circulation (issue - return) of books and speedy access to bibliographic, location & availability information of the books.

The strength of the library is its digital collection that can be accessed campus-wide through its website http://www.iimahd.ernet.in/library/. The website links its in-house catalogue in addition to the 60 databases that provide scholarly, company and industry information. The Vikram Sarabhai Library also has the i3 programme with CMIE (Centre for Monitoring Indian Economy) that provides 12 databases along with specialist support for using the resources. The library also has a hosted terminal for Reuters 3000 Xtra and Reuters Knowledge database which gives access to global financial markets information and research reports related to industry.

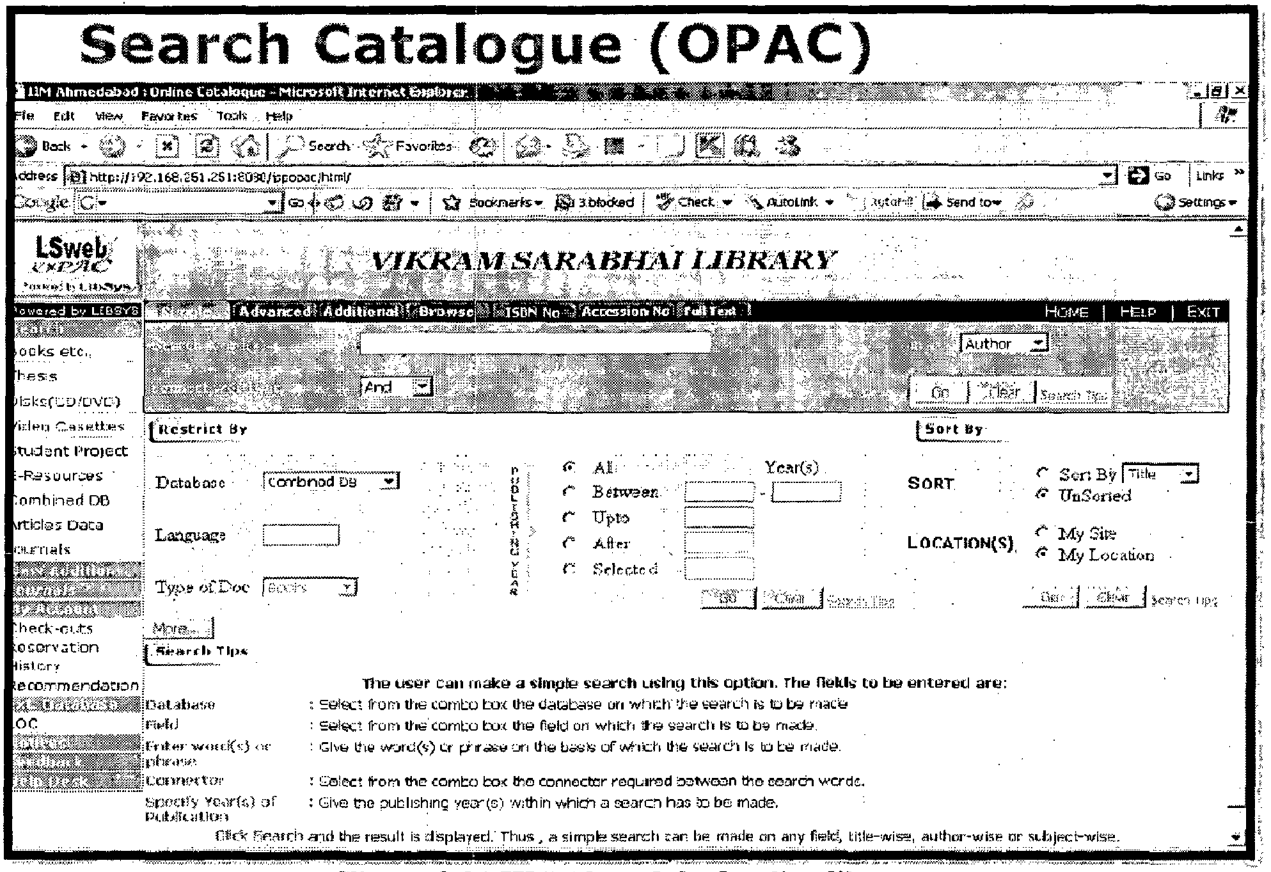


Figure 3.31 IIM Ahmedabad online library

The Vikram Sarabhai Library has a strong inter-library cooperation programme that provides access to collections of other leading libraries in the country through various library networks. The library is committed to fulfilling its mission by facilitating access to current, global and relevant information by identifying, acquiring, organizing and retrieving information in various formats (print & non print) to serve the information needs of the IIMA fraternity for teaching, research, consulting, training and learning requirements. There are more than 90 high end manageable network switches which handle the internal data traffic.

The campus network is supported by a large server farm with more than 30 high speed servers, running on a wide variety of platforms. Many servers on this network make use of Linux and open source software for providing the necessary services. For every workgroup (faculty, students, staff, MDC participants, etc.), there is a set of dedicated servers which provide a core layer of services like Internet access, and file/ print services. The Institute has 45 MBPS bandwidth to the Internet. It is technologically equipped to increase it up to 100 MBPS as and when the need for more bandwidth arises. In addition IIMA also has a dedicated line of 10 MBPS. Every reading areas are equipped with a projector, a PC, and a DVD player. Many of the reading areas are also equipped for ISDN based video conferencing capability.

3.5.6 Inference from case study:

Lessons learnt:

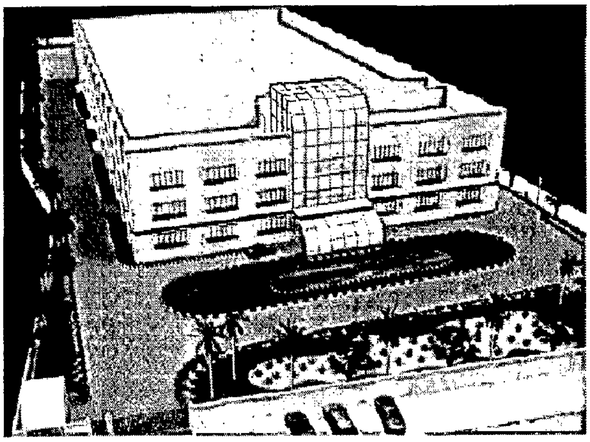
- ***Grand civic space:*** The grandness (refer Figure 3.28) having the articulation of the perimeter wall, the introduction and control of natural light, and the placement of core areas for stairs, toilets, and heating, ventilation, and air conditioning make the Students feel that "bigger than they are." A significant majority of students still considers the traditional reading room favourite area of this library—the great, vaulted, light-filled space, whose walls are lined with books they may never pull off the shelf.
- ***Future expansion:*** Provision for vertical and horizontal future expansion is there due to rectangular plan and separate central staircase. Large spaces were designed to be reconstructable, so that they could be reconfigured to meet future needs.
- ***Daylighting and natural ventilation:*** comfortable thermal indoor environment due to grant openings.
- ***Integration the building with nature:*** Green lawn, trees and exposed brickwork, exposed structural element, wooden furniture have a feel of closeness to nature.

Critical analysis:

- ***No energy efficient features:*** Modern green features like green roof, solar pv panels or geothermal earth tunnel system or building management system are not incorporated to reduce electricity load.
- ***Wastage of space:*** no need of such grandness at modern era where space and money are so valuable. Negative spaces created for aesthetical purpose.

3.6 AQUAMALL, WORLD'S LARGEST MANUFACTURES of DOMESTIC UV WATER PURIFICATION SOLUTIONS, DEHRADUN

3.6.1 Design brief:



3.32 Exterior View of The Aquamall

Plot area: 11,535 sq. mtrs.

Built-up 45% of plot area

office (g+2): 12,000 sq. ft.office: 722 + 649 + 649 sq. mtrs.

Plant room 1st floor: 3,489 sq. mtrs.

Factory (g+1): 60,000 sq.ft.

3.6.2 Green features:

i. Building orientation: Orientation of major facades of this building along north and south axis (refer Figure 3.32), which is environment responsive.

ii. Building material: Fly ash as pollution control equipment, in building blocks for the walls. Construction using fly ash based bricks, cement and concrete blocks. While the fly ash works for better thermal insulation, it increases the physical comfort of the people. use of fly ash-based bricks/blocks ,in both 100% load-bearing and non-load-bearing wall systems, which utilize a minimum of 40% of fly ash by volume of building blocks.

iii. Pre-fabricated steel structure: The building developed with minimum site disturbance and the materials used by adopting the design specification based on the internal load requirements (refer Figure 3.35).

iv. Roof insulation: Roof insulation can reduce heating cost by approximately 13 percent; saving you money and greenhouse gas emissions. Recycled cellulose fibre which is made from newspaper and other paper product. Recycled cellulose fibre comes in sheets, but in roof applications, it's usually sprayed on using compressed air.

v. Natural light harvesting: The building has been designed with 90% daylight view and adequate daylight harvesting in the factory area. Energy saving by energy efficient lighting fixtures is considerable (refer Figure 3.34).

vi. Geo-thermal air ventilation system: The building designed with an air cool system (refer Figure 3.39).The unique design supply the conditioned air to the office building without energy requirement saving energy and reducing the GHG.

vii. Turbo ventilators: Turbo ventilators installed in strategic locations to maintain the air circulation. Turbo-vents (refer Figure 3.37) works up the hot air from inside the building by natural convection. This roof-top wind driven ventilator is cost effective and run without electricity.

viii. Efficient water use during construction is taken care off to minimize use of potable water during construction activity. Things had been done for this are: use of materials such as pre-mixed concrete for preventing water loss during mixing, use recycled treated water for construction, control of the waste of curing water by -use of curing chemicals, covering concrete structures with cloth/ gunny bags before spraying of water.

ix. Storm water drainage: help to reduce; landscape water requirement and building water requirement. It helps to reduce the landscape water requirement so as to minimize the load on the municipal water supply and depletion of groundwater resources.

x. Reed-bed waste water treatment system: Specially selected plants made to combine their aeration strength with highly efficient microbial cultures. The treated water recycled/reused for water in the landscape gardens. It reduced fresh water requirements (refer Figure 3.36).

xi. Rainwater harvesting: In areas where there is inadequate groundwater supply or surface resources are either lacking or insufficient, rainwater harvesting offers an ideal solution. It helps in utilising the primary source of water and prevents the runoff from going into sewer or storm drains, thereby reducing the load on treatment plants. Reduces urban flooding. Recharging water into the aquifers help in improving the quality of existing groundwater through dilution.

xii. Efficient water fixtures: Exemplary performance on water efficiency: the building fitted with water efficient gad gets that can save up to 70% water usage-designed with preset flow and timer, auto stop in 6seconds.

Water efficient toilets: conventional toilets use 13.5 litres of water per flush. Low flush toilets are available with flow rate of 6.0 litres and 3.0 litres of water per flush.

- Dual flush adapters can be used for standard flushing for solid waste and a modified smaller flush for liquid waste.
- Flush valves with 20–25 mm inlets can be used for restricting the water flow.
- Water-efficient urinals: the conventional urinals use water at a rate of 7.5–11 litres per flush. Use of electronic flushing system or magic eye sensor can further reduce the flow of water to 0.4 litres per flush.
- Aerators and pressure inhibitors for constant flow. Use of aerators can result in flow rates as low as 2liters per minute, which is adequate for washing hands.

Savings for green features:

- Day light views for 100% regularly occupied area, reduction in energy use 45% in lights.
- Regional materials usage by 65.26%
- Recycled materials content by 15.6%
- Resource reuse : 10.6%
- Green power by more than 50%
- Reduction in water usage by 35%
- Reduction in irrigation water by 65%

3.6.3 Inference from case study:

Lessons learnt:

Educator of environment responsive building: The aim is that the building itself will stand as environment responsive building which can increase the awareness of people. Green features like building orientation, use of energy efficient building materials, geothermal earth tunnel system, insulation, turbo ventilator; natural lighting, rain water harvesting, storm water management, etc are the reason for LEED gold rating(refer Figure 3.33).

Critical analysis:

No natural landscaping area. Artificial landscapes in front of building.

LEED - INDIA
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

	Max. Possible Rating	Documented
Sustainable Sites Total	13	9
Water Efficiency Total	6	5
Energy & Atmosphere Total	17	3
Materials & Resources Total	13	8
Indoor Environmental Quality Totals	15	12
Innovation & Design Process Totals	5	5
TOTAL	69	42
Potential LEED Rating Certified : (26 to 32 points) Silver : (33 to 38 points) Gold : (39 to 51 points) Platinum : (> 52 points)		Gold

Figure 3.33 LEED certification

Figure 3.34 natural lights in factory

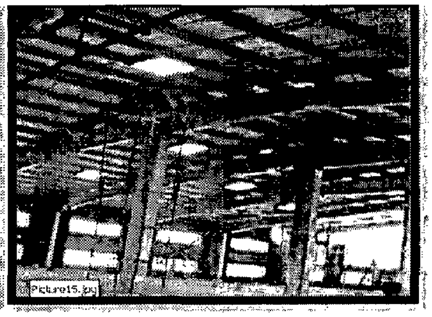


Fig 3.35 Prefabricated Structure And Roof Insulation

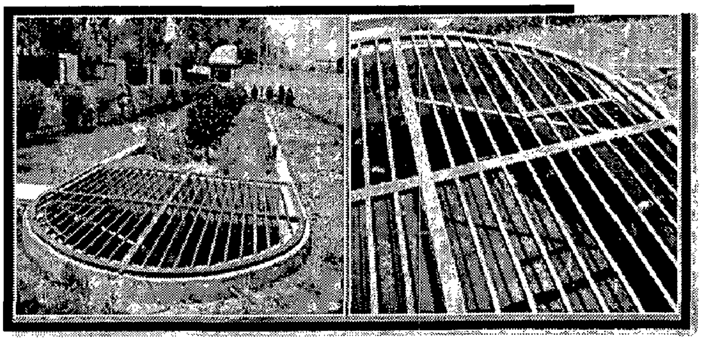


Figure 3.36 Reed-bed waste water treatment

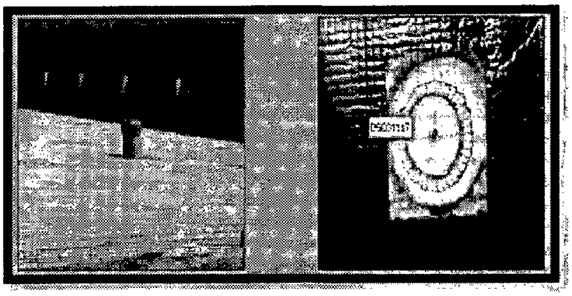


Figure 3.37 Turbo Ventilator

Figure 3.38 environment responsive paving

Figure 3.39 Natural Earth Tunnel

3.7 TERI DIGITAL LIBRARY, NEW DELHI, INDIA

3.7.1 Introduction:

The TERI University is situated at Plot No. 10, Institutional Area, Vasant Kunj, New Delhi in a modern green building (refer Figure 3.40). Besides an innovative, energy saving architectural design, the building is equipped with a number of other cutting edge technologies that help reduce the energy consumption by 60% and potable water use by 25%.The campus is equipped with three types of cooling systems: the Earth Air Tunnel (EAT), Variable Refrigerant Volume System (VRV) and Thermal Mass Storage (TMS).The EAT used in the hostel block uses the heat sink property of the earth to maintain comfortable temperatures inside the building, saving up to 50% energy as compared to the conventional system.In New Delhi, India, the Energy and Resources Institute (TERI) is involved in research into energy, the environment and sustainable development. It publishes a good number of books, reports, databases, journals and magazines, and also procures large numbers of CD-ROMs, subscribes to various online databases and journals and has free access to various online reference resources (such as commercial CD-ROMs, web databases, and bibliographic databases developed in-house). In 1998 TERI established an electronic library in the Library and Information Centre, and then in 2003 the Centre took the initiative to create a digital library through the digitization of all its knowledge resources published since 1974 (Deb, 2006).

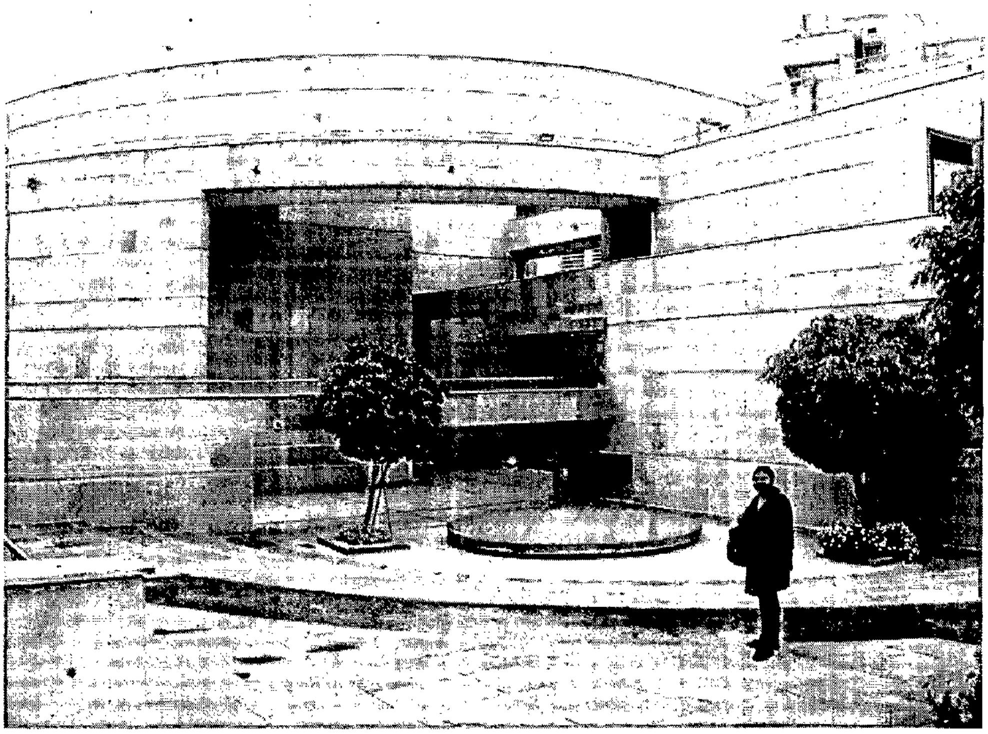


Figure 3.40 TERI Library Building

Hybrid digital library: A hybrid digital library (HDL) is essentially a digital library that holds only metadata with pointers to holdings that are "one click away" (refer Figure 3.41).

TERI had a number of needs to be fulfilled by its HDL – basically it wanted to (Deb, 2006):

- provide multi-user and all-time access;
- enable faster service;
- enable search and display of different information resources in a single window
- ease the library management process and save resources (e.g. manpower, time);
- maximize the use of information, since they will be in digital form;
- reduce the physical space requirement for bookshelves;
- help researchers to avoid repeating work;
- introduce and keep pace with technological advancement and implement the latest IT applications;
- Provide remote access to TERI centres in India and enable offices abroad .

3.7.2 Planning the HDL:

A digital library requires a digital object (e.g. documents, photographs, sound recordings, multimedia, etc.) as the source. In developing its digital library, TERI started with the following information resources:

i. **Already available internet resources**: virtual library: With the advent of the internet and internet technologies, TERI made its first leap towards developing a virtual collection in the areas of Energy (oil and gas, power, renewable energy – biomass energy and technology, solar energy, wind energy), Policy, Economy, Environment (pollution, climate change, global warming, natural resources), Plant Biosciences, Biodiversity, Forestry, Regulatory Issues (related to telecommunication, energy, water, transport, insurance, oil and gas, etc.), and Urban Transport.

ii. **Digitally born documents in the organization: Physical Digital Library**

The purpose of the Physical Electronic Library is to provide fast, uninterrupted access to the resources available through the TERI intranet or to remote users beyond the local building of the organization but to select groups of person(s) through extended intranet using the Citrix application software. Depending on the policy of the organization these collections may also be provided access through the internet without violating the rules. The collection of the Physical Digital Library comprises:

- Downloaded online full-length documents available on the internet
- Journals downloaded from the internet and/or available in CD-ROMs; at present out of 100 TERI core journals 25 have been downloaded while three journals are received on CD-ROMs.
- CD-ROM collections accessible through TERI net or the intranet
- in-house bibliographic/news clippings/external library membership/reference or referral service databases
- Library catalogue (OPAC);TERI uses the Libsys software for library management.

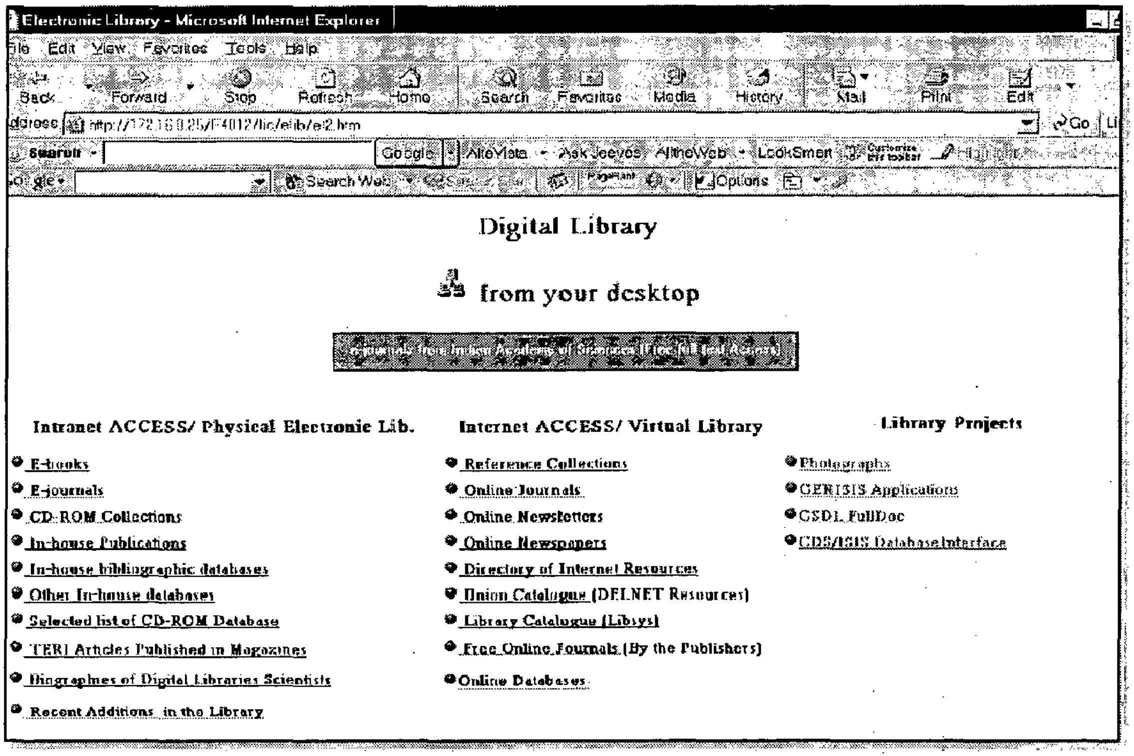


Figure 3.41 Digital Library

3.7.3 TERI resources: digitization

Various sources of pertinent information are digitized specially within TERI's digital library. There is requirement of Print form to digital form. These are discussed below.

- TERI news clippings. The TERI Library maintains an archive of clippings of "TERI in the news" as a database maintained in CDS/ISIS.

- Photo library.
- TERI publications.
- TERI reports.

3.7.4 Digitization problems and solutions:

Web OPAC. The first thing that occurred to the Library was how to make the OPAC web-enabled so that users could access it online. TERI's Library catalogue is maintained in LIBSYS software. Software, GENISIS is useful to reach a search output like internet search engines along with lots of navigators, GENISIS was found to be ideal and the Library was able to easily interface all CDS/ISIS databases with linkages to various types of objects. This was most suited to databases. For webOPAC (catalogue), database and database with linkages to the websites and files, GENISIS is quite useful.

LibSys is integrated multiuser library management software that caters to the needs of an advanced library and information professionals. It provides a tree structure system with each system comprising of several sub-systems having unmatchable depth in functionality. It has a powerful and user-friendly WEB-OPAC along with Windows-based OPAC.

Search through the documents using Lotus DOMINO., in which the search can help wade through the full length documents and after finding the search terms will display the relevant documents.

GreenStone Digital Library (GSDL). For any given full length document database there is a demand for greater interactivity. The search engine should enable not merely finding out the full length document but also be able to scale the selected chapters and paragraphs where users' required information are contained. At the same time one should be able to display and read the whole document and the content as well. For such interactive search and display of the document each document needs to be formatted which is a time-consuming process.

Scanning and OCR: The software for OCR provided along with the scanner HP Precision Pro 1.01 facilitates generating both a PDF and text form to editable text format. Conversion from printed form (analogue) to digital textual form depends on good paper quality as well as good print quality.

Library is integrating software like *Web 2.0*[(2)] which allows flexible, modular applications to insert into various sites for facilitating communication among community;

also enables to find greater use of more obscure and unknown sources. It has the opportunity to push its content, services and expertise to places that are designed according to web 2.0 principles. Desktop computers, laptops and I-Pads are used as platforms for audio-visual media.

3.7.5 Integrated search and retrieval system:

The Library wanted to provide the maximum possible integrated search of resources existing in TERI from a single window. For this purpose the whole catalogue was converted to WWWISIS and a link from this was provided to the other information resources main page. Apart from this, other databases with identifiers have also been included to differentiate where the resources are coming from and their links for full-length documents.

3.7.6 Storage and problems:

Digitization involves a huge storage space and photographs and other high-end resources involve even further storage problems.

3.7.7 Accessibility problems:

For simple flat files there is no problem of retrieval. However, large files of more than a few hundred resources or records would create problems for users as well as for the content manager. For better management of huge resources a database is the perfect solution. Further, for digital library purposes, special software is better suited. As the first step towards retrieval, a web-based information retrieval system WWWISIS (or more precisely GENISIS) has been designed.

TERI believes in cheaper but at the same time sustained growth of its resources with minimum taxing of its financial resources. It has also taken into consideration the full-length documents for searching and browsing at its length and breadth with hierarchical display, using the open source software of the GSDL.

3.7.8 Servers:

To make resources available for internet access, a high-end server is recommended.

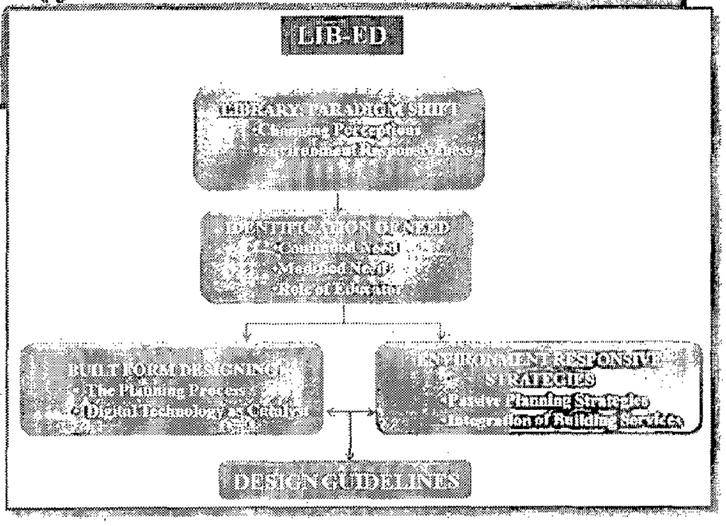
3.8 INFERENCES FROM CASE STUDIES:

- Library building should be environment responsive. Passive green features should be part of the design like integration with nature, proper building orientation, use of energy efficient building materials etc. Climate consideration while designing is essential. And also spatial green features like geothermal earth tunnel system, insulation, turbo ventilator, Laneway sunshades, Double-glazed glass facade etc, to reduce electrify consumption and for financial savings, should be implemented.
- Integration of active strategies for advanced building service system should be integrated in modern library. Building management system can be implemented to facilitate building services.
- Spatial quality like daylighting without glare is essential for all libraries reading area. Natural ventilation, acoustical treatment also important. Thermal comfort is always desirable for library users.
- The library space should be flexible in spatial and structural terms. Library should be laid out for extension.
- Digital technology should be integrated in library. Proper service facility should be there for this. The raise floor system for cable layout is significant. Computer workstation should be a part of modern library building.
- Hybrid digital library is a solution for fulfillment of needs of modern library. Solutions of digitization problems: software like LIBSIS, GENISIS, and Lotus DOMINO etc are the solutions.
- Integrated search and retrieval system should be implemented to enable faster service. To make resources available for internet access, a high-end server is recommended.
- The building itself should be an educator in terms of environment responsiveness and it should be aesthetically pleasant to attract young generations.
- Building aesthetics is considerable factor for attracting library users.

3.9 SUMMARY:

In these chapter case studies from primary and secondary sources has been done to gain practical knowledge regarding the library designing. Case studies selected from secondary sources are environment responsive modern library buildings from abroad: Philological Library from Berlin, National Library Building of Singapore and Frederic Lanchester Library from UK. Libraries visited by the present researcher from Indian campuses are: Indian Institute of Management, Ahmadabad and Teri University. Environment responsive strategies of Aquamall, Dehradun- a factory building has helped a lot to develop a firsthand understanding of how-to-do-it issue. These cases have helped a lot to learn from practical issues and experience. The inferences of all literature and live case studies guide to analyse and indentify the needs for designing a library of 21^{st} century. The positive lessons should be part of library designing guidelines and lessons from critical review will not be implemented in the design guidelines. The next chapter is analysis and synthesis. LIB-ED, Structured Model for Future-Proof Library Design, is discussed in the next chapter.

CHAPTER 4: ANALYSIS & SYNTHESIS



CHAPTER 4: ANALYSIS & SYNTHESIS

4.1 INTRODUCTION:

Growing interconnectivity of social phenomena, technological innovations are important aspect where the perceptions have been changed for new generations. There is increased expectation to access physical collections and tools for thinking in new ways. Generally, developments in technology facilitate and encourage interdisciplinary research. The expectation that scholars will expand the purview of their research because of the availability of technology and resources leads them to expect new things from library services, tools, materials, and forms of organization as well. Library as a space to be rethink due to roles of modern library have been changed.

LIB-ED is a model for evolving design guidelines of library building designing in modern era. In this structure, all issues regarding library design have been discussed.

4.2 OBSOLESCENCE CRISIS OF TRADITIONAL LIBRARIES:

Physical libraries are in crisis due to changes in culture of teaching and learning. Providing access to information is prime function of any library traditionally; only change is that the print media is not the most sought after source to get information for younger generation. The very traditional instruction-cantered models of pedagogy where good teaching is conceptualized as the passing on of sound academic, practical, or vocational knowledge are being replaced with student-cantered approaches which emphasize the construction of knowledge through shared situations (Barr & Tagg, 1995). This shift to a 'learning paradigm' has changed the role of different learning environments to a place to share information, exchange ideas, and participate in the experience of learning. Traditionally library was a contemplative place; the temple for readers/ learners. Silence, quietness were most distinguishing features of any library. Now, it is moving from the elite intellectual space to a public collaborative space. Traditional appreciation of grand reading rooms with high windows, light-filled space, walls are lined with number of books, book cataloguing system, are aspects of appreciation till date (CLIR, 2005). But in future, interior of library will house fewer books and quiet reading rooms; and will see increase in space for people and teams, more desktop terminals, digitized cataloguing systems, plasma screens to facilitate collaborative activities among small groups.

Principle component of learning has not changed much, but the expectations among students to receive the same have undergone a sea-change. So basically the traditional concept of library design is in crisis. At the same time, some principal design elements like the grand central reading hall, naturally-lit spaces, user friendliness, comfort, flexibility, will continue to be there for quite some time.

Changing patterns of student learning is the main reason of crisis in traditional library. The expectation of students will swell as availability of technology and resources provides new and friendly options of library services, materials and forms of organization as well. Psychosocial aspects of new-age learners should be satisfied in present-day library building (Shill and Shawn, 2003). In the past, expanding collections of books and other hard copies reduced user space for reading. On the contrary, modern library is placing reduced demand on physical space requirement due to digital technology. If the library has to overcome its static character, the space must flexibly accommodate evolving technologies. Purpose is not only to circulate books, but to make the students inspired and knowledgeable. The librarian also has a new role in this changing scenario.

Beyond general changes to the spatial design of the library in the regime of paradigm shift, there is a need for change in the traditionally understood role of the same. The role of the library is to create an environment that inspires creativity in learners and to reinforce their sense of participation (Kranich, 2004). Users need sources of inspiration. That inspiration comes from casual or formal conversations which help to make connections. Emerging need for collaborative study space is basically against the traditional library design concept.

Prediction is that may be internet become the future library; some also opined that physical library is in a way of obsolescence (CLIR, 2005). Traditionally library building was a building that houses valuable collection for learners. Library would be able to find spaces for learners of every age using books and digital media as catalysts. The digital technology is beneficial for library users as it tremendously improve access to a greater variety of resources, enhance communication and interaction, and reduce the barriers of place and time thus increasing universal accessibility (Smith, 2001). So in addition to traditional book stacking, collections, storage, hard copy preservation, facilitating services related to digital technology is required.

The appropriate emphasis on sustainable concept shall be mandatorily followed for buildings of 21st century. Generally, traditional library buildings are devoid of any conscious efforts in providing environment-responsive features. The building itself should have a roll of educator and promoter of environment responsiveness built experiences in this modern era. The Internet has tended to isolate people from real world; but library as a physical place, should fulfil the expectations of students, teachers and society. Connecting to both real and virtual world in right proportion would be the serious duty of today's libraries to dispense.

4.3 LIB-ED: STRUCTURED MODEL FOR LIBRARY DESIGN:

From the literature review and case studies, this analytical model for library design has been evolved. **LIB-ED** (refer Figure 4.1) is the model where the paradigm shift, changing perceptions have been discussed. From analysis needs for modern library design have been identified. Some needs are still constant from the past and some are modified new needs. Built form designing, environment responsive strategies are important part of this structure. After analyzing these issues the guidelines for library building can be evolved.

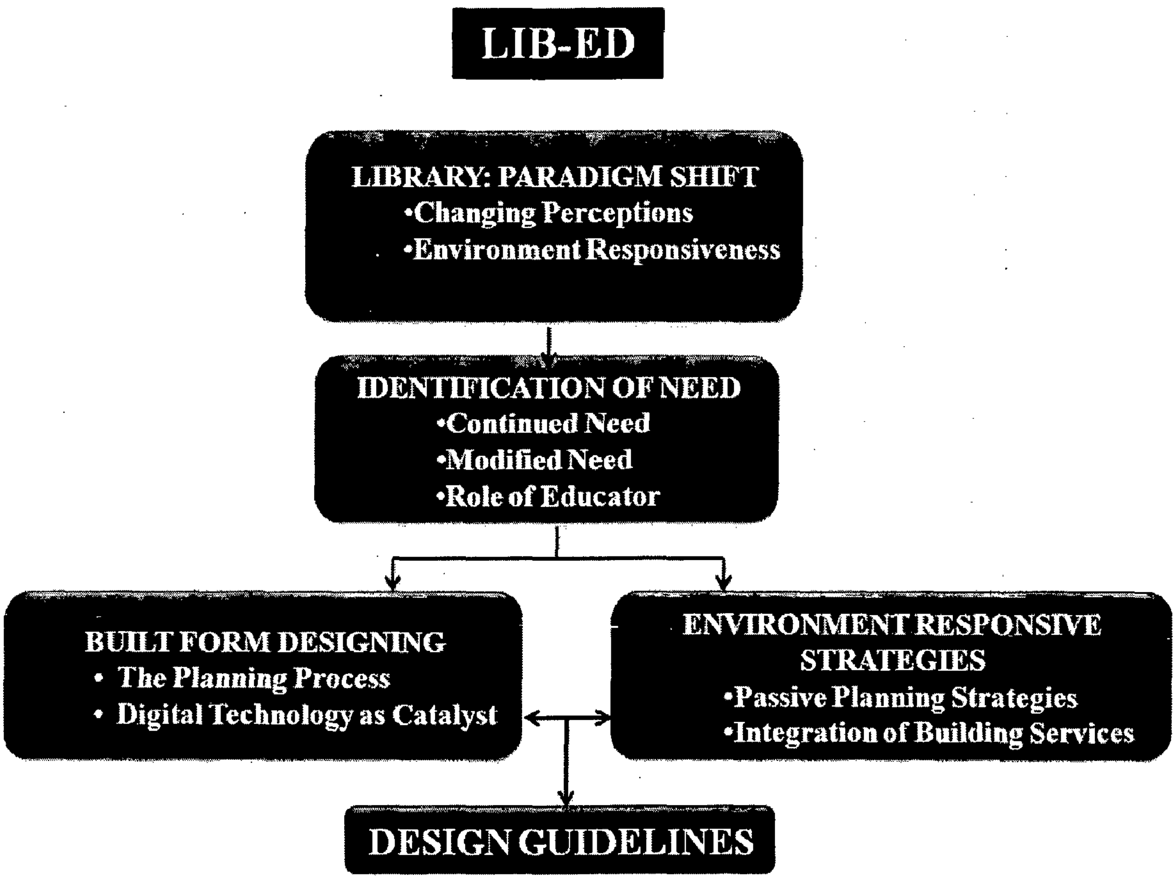


Figure 4.1 LIB-ED: Structured Model for Library Design

4.3.1 Changing Perception and Role of Library in New Paradigm:

For a library building, traditional design issues are collection & storage of resources in book and CD form, ergonomic space and furniture design, efficient connectivity, advanced building services, and universal accessibility. New paradigms have emerged out of changing perceptions and preferences of new generations. Most important changing perceptions are emerging collaborative and interactive learning environment and integration of digital technology. One of the perception, somewhat quieter but no less profound, is move in higher education away from a teaching culture and toward a culture of learning; that has brought major shift from independent study mode to more collaborative and interactive learning (Marcus et al., 2007).

Libraries have historically served as repositories of books, papers, manuscripts and important documents, but that role is changing in the 21st century. With advent of digital technology, the young users are habituated to use computers; laptops have provided them the wider freedom to get information anytime anywhere. Declining number of visitors to library establishes a shrinking need to visit the library. The library design perspective emergently needs to be reviewed with a new understanding. The present dissertation topic discusses the new dilemma, and reviews probable design solutions towards future-proof library facility (CLIR, 2005).

Stacks browsing, traditional discovery process in research is one of the most beloved activities in library. The introduction of electronic resources has made the same experience less thrilling but even more crucial. There are obvious benefits to a digitization, but it is hard to replicate the chance of standing in front of a physical book stack. The digitization processes enables faster service and ease the library management process and save resources like manpower and time. It reduces physical space requirement for bookshelves (Deb, 2006). Presently, it is not necessary and practical to physically browse the stacks of the library while planning the designers should allow the library flexibility to constantly experiment, learn, and pushing thinking beyond traditional boundaries.

Library: Paradigm Shift

- **Supporting Collaboration and Sharing:** The library should move out of the current model that optimizes storage to one that makes sense for group work. Preferences of young generations are like favouring learning functions in the space's mix of academic and social functions, providing choices of place, ranging from personal seclusion to group study, that variously reinforce the discipline needed for study.

- **Integration of Digital Technology:** The use of electronic databases, digitized formats, and interactive media has fostered a major shift from the dominance of independent study to more collaborative and interactive learning. The ubiquity of the personal computer, and the need for physical spaces that accommodate laptops, Internet access, and other technological devices used by individuals, is also a dominant need. The transformation of the library from the old catalogue technologies to the new digital technologies can occur with a minimum of pain and a maximum of gain. In the digital age, what makes a library high-end will pertain more to the quality of information management and presentation than to the mere quantity of information stored locally. Internet, data base control system have a major role in new paradigm of today's library building.

- **Environment Responsiveness**: The building should have the qualities to impart less impact to natural and manmade environment. Because there is need to create more comfort and health conditions for its occupants and society. Elimination of negative environmental impact through skilful, sensitive design is an important consideration for a library building which is a place for community, contemplation.

4.3.2 Need Identification following New Paradigm:

In attracting people to the new library of the digital age important role of architectural design in creating spaces that are functional and, even more important, inspirational. The library, which is still a combination of the past (print collections) and the present (new information technologies), must be viewed with a new perspective .some requirements for library design are constant forever which can be called continued need and some requirements need modification that can be called modified need. It should meet the goal of creating hybrid and high-end digital workspaces.

4.3.2.1 Continued need:

Grand civic space with emphasis on the sitting, orientation, design, and decoration of the library are continued need. In the age of cyberspace, real space made of bricks and mortar, still matters. Library is a social gathering centre on campus. It not only has meeting rooms, classrooms, and faculty offices but also provides enough book storage for an anticipated 50 years of service. Majority of students still considers the traditional reading room their favourite area of the library which is great, vaulted, light-filled space. Libraries remain valued places of community which offer security, comfort, and quiet; which are free and commercial-free; which provide a place to be with other people in a learning/cultural environment; who offer opportunities to learn, search, inquire, and recreate; and which afford opportunities for choice and serendipity. So these aspects of a library building are still constant, these are the continued need.

- Grand civic space
- Traditional reading room
- Comfort & quiet
- User friendly design
- Flexibility and extensibility
- Aesthetics

4.3.2.2 Modified Needs:

- **Group learning:**. These typically include large worktables with seating for three to six students, white boards, and network connections. Moveable partitions and furniture that allow students to create their own study spaces adjacent to stack areas they use and in proximity to network connections and printers.
- **Digital Technology**: Integration of new information technology has actually become the catalyst that transforms the library into a more vital and critical intellectual centre of life at colleges and universities today.
- **Building Management System:** Building management system is a computer controlled unit with the purpose of controlling various operations in most efficient way. The function of building management system is to control, monitor and optimize building services.

4.3.2.3 Educator of Environment Responsive Building:

Library is one of the world's greatest social and intellectual spaces. So the built environment should be comfortable, aesthetically pleasing, and welcoming as well as making the building as an example of environment responsiveness is important. The aim is that the building itself will stand as environment responsive building which can increase the awareness of people.

4.3.3 Built form designing:

Built form designing has two parts to discussed for analysis.. Analysing these two parts, the guidelines of built form designing can be evolved.

The parts are:

- The planning process (refer Figure 4.2), in which the physical planning issues are concerned.
- Digital technology as catalyst (refer Figure 4.3), in which integration of digital technology and physical space required for digital technology are concerned.

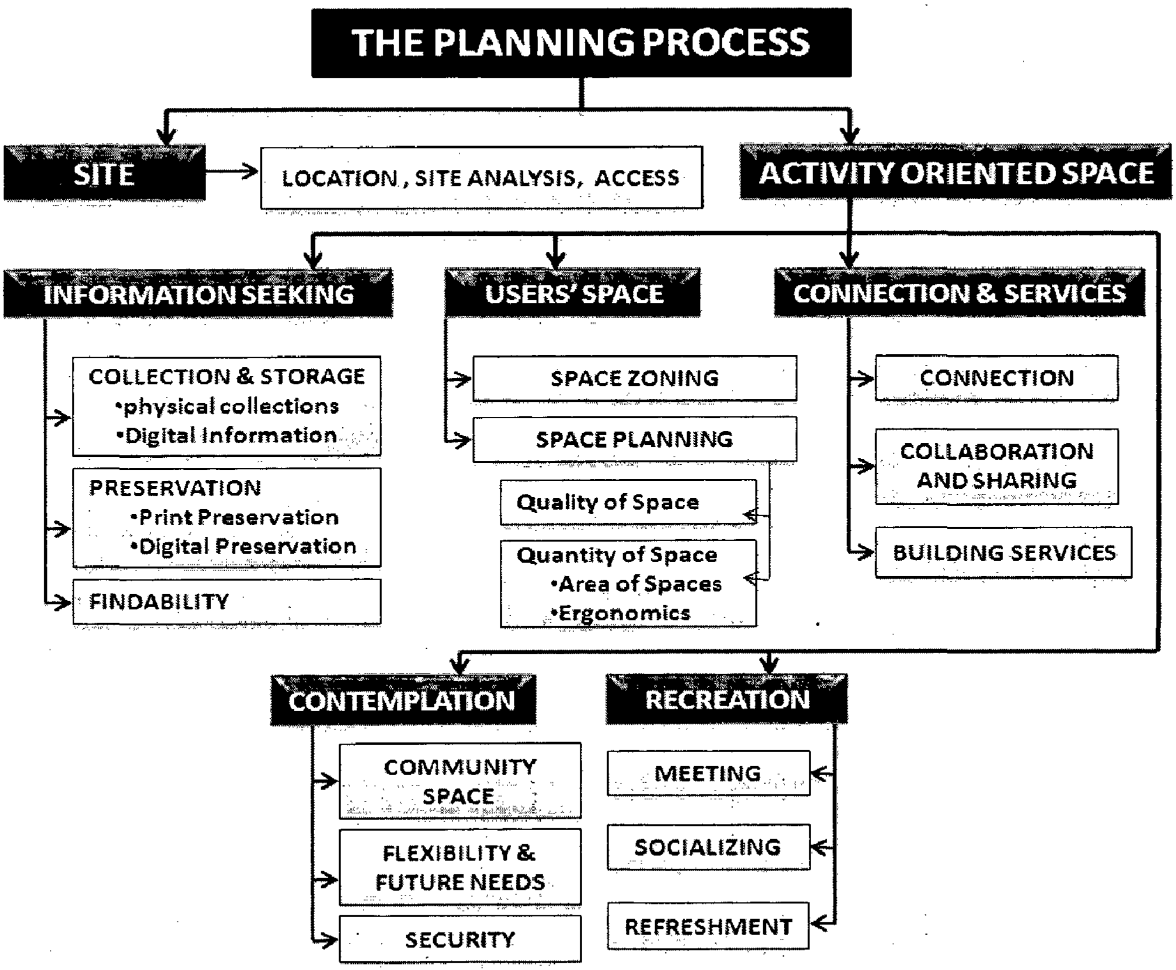


Figure 4.2 The Planning Process

Digital Technology as Catalyst:

With the emergence and integration of information technology, many asserted that the virtual library would replace the physical library. Traditional libraries are limited by storage space; digital libraries have the potential to store much more information, simply because digital information requires very little physical space to contain it. (Deb, 2006).

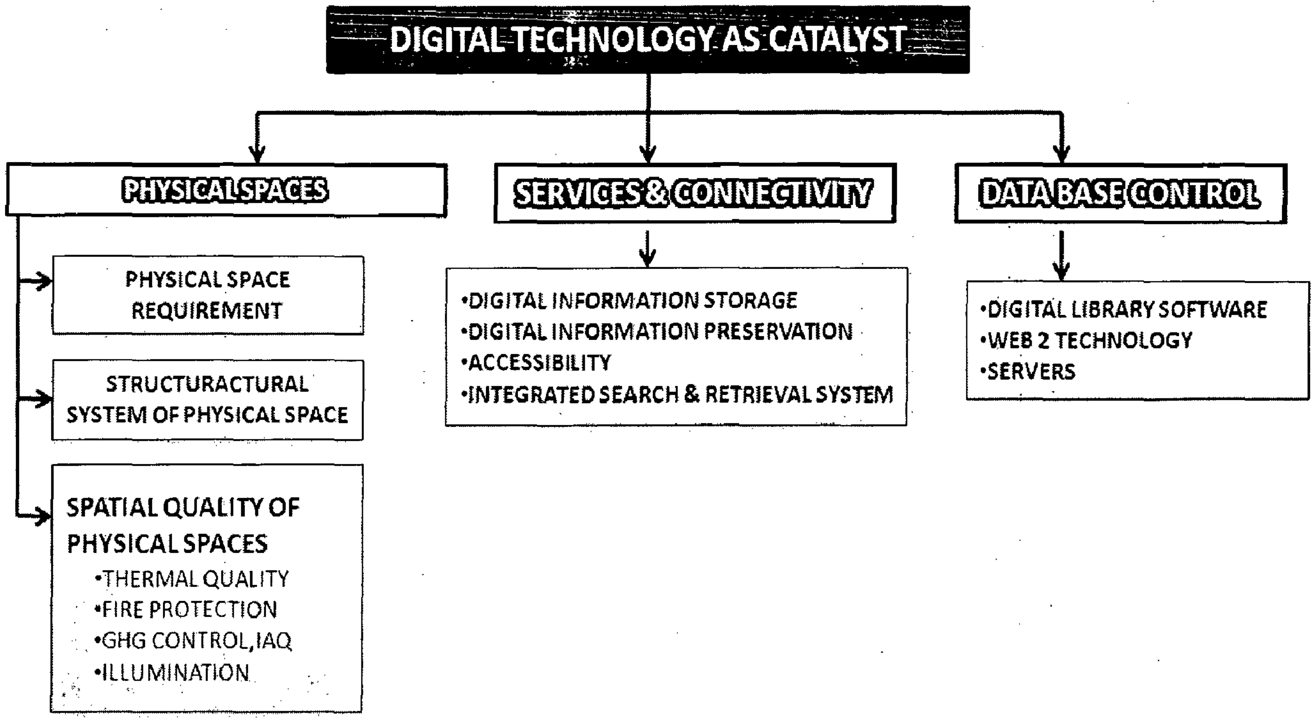


Figure 4.3 Digital Technology as Catalyst

Advantages:

- No physical boundary: The user of a digital library need not to go to the library physically; people from all over the world can gain access to the same information, as long as an Internet connection is available.
- Round the clock availability A major advantage of digital libraries is that people can gain access 24/7 to the information.
- Multiple accesses: The same resources can be used simultaneously by a number of institutions and patrons.
- Information retrieval: The user is able to use any search term (word, phrase, title, name, and subject) to search the entire collection.
- Space: Digital information requires very little physical space to contain them and media storage technologies are more affordable than ever before.
- Added value: Digitization can enhance legibility and remove visible flaws such as stains and discoloration.
- Easily accessible.

4.3.4. Environment responsive strategies:

An environment friendly library building can act as open source information to society on good practices in design profession. It may mix appropriate passive and active strategies (refer Figure 4.4) for optimum use of natural resource to create users' comfort from the design stage itself. Building orientation maximizing north and south façade exposure for daylighting and reduced heat gain, creation of buffer spaces on east and western portions of the building to control heat gain and glare, appropriate building configuration in terms of aspect ratio and solid-void ratio, eco-friendly materials selection, suitable fenestration design to allow daylight and natural ventilation and apt maintenance of indoor air quality to avoid sick building syndrome etc. are some of the aspects to be resolved through design. Landscaping i.e. proper selection and placement of vegetation and surface covers for lawn, garden, roof, pavement, driveway and parking, efficient outdoor lighting would help to mitigate environmental encroachment adversities brought by the buildings' construction.

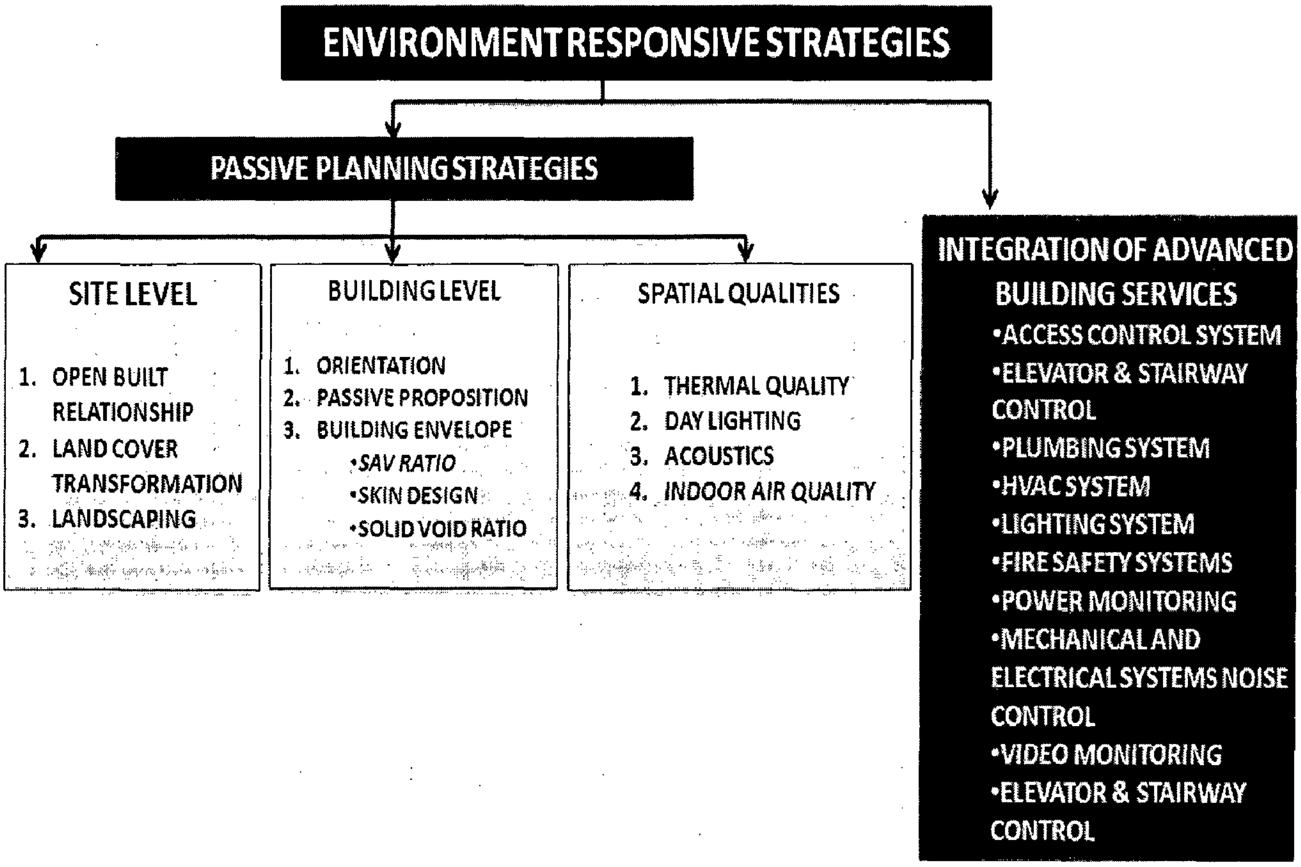


Figure 4.4 Environment Responsive Strategies

Passive and active strategies both are covered in Environment responsive strategies. passive planning strategies coves three different aspects starting from site level passive planning strategies and then building level and finally indoor spatial quality like thermal quality, daylighting, acoustics and indoor environmental quality. Total built environment is concerned in environment responsive strategies.

Then integration of advanced building services is important part of active strategies. Building Management System is a computer-based control system which controls and monitors the building's indoor environment quality, mechanical and electrical services, and safety measures. It helps to manage the environment within the building. Advanced building services like access control system, elevator & stairway control, plumbing, HVACs, lighting, fire safety systems, digital data security system, should be installed in a modern library building.

4.4 SUMMARY:

Model for Future-Proof Library Design has been discussed here. LIB-ED is the basic analytical model which leads to evolve design guidelines of modern library buildings. LIB-ED is the basic structure covering multi-design criteria of modern library design to address new paradigm, like environment responsive built form planning issues, enabling digital environment and advanced building services. This is followed by 3 flowcharts, namely: "The planning process", "Digital technology as catalyst" and "Environment responsive strategies". Design guidelines are discussed in next chapter. The design guidelines which can be applied for any library design, deals with main four issues like physical planning process of library designing ,enabling digital technology, environment responsive passive planning strategies , active strategies & advanced building services.

CHAPTER 5: DESIGN GUIDELINES

5.1 Introduction

5.2 Physical Planning Process of Library Designing

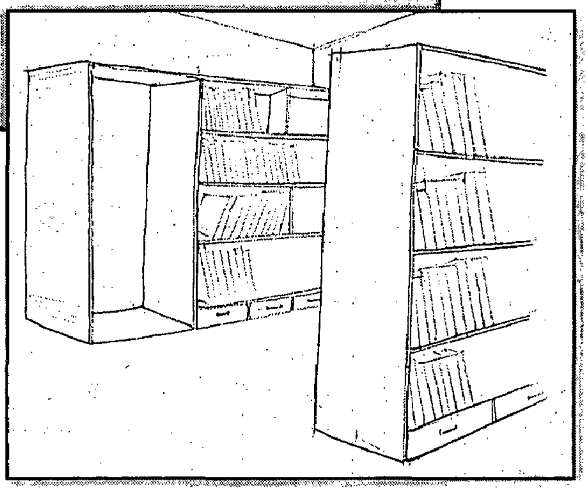
5.3 Environment Responsive Passive Planning Strategies

5.4 Futuristic Approach

5.4.1 Enabling Digital Environment

5.4.2 Active Strategies & Advanced Building Services

5.5 Summary



CHAPTER 5: DESIGN GUIDELINES

5.1 INTRODUCTION:

Library planning should be more entrepreneurial in outlook, periodically evaluating the effective use of space and assessing new placements of services and configurations of learning spaces in response to changes in user demand. As laboratories that learn, these spaces are designed to be easily reconfigured in response to new

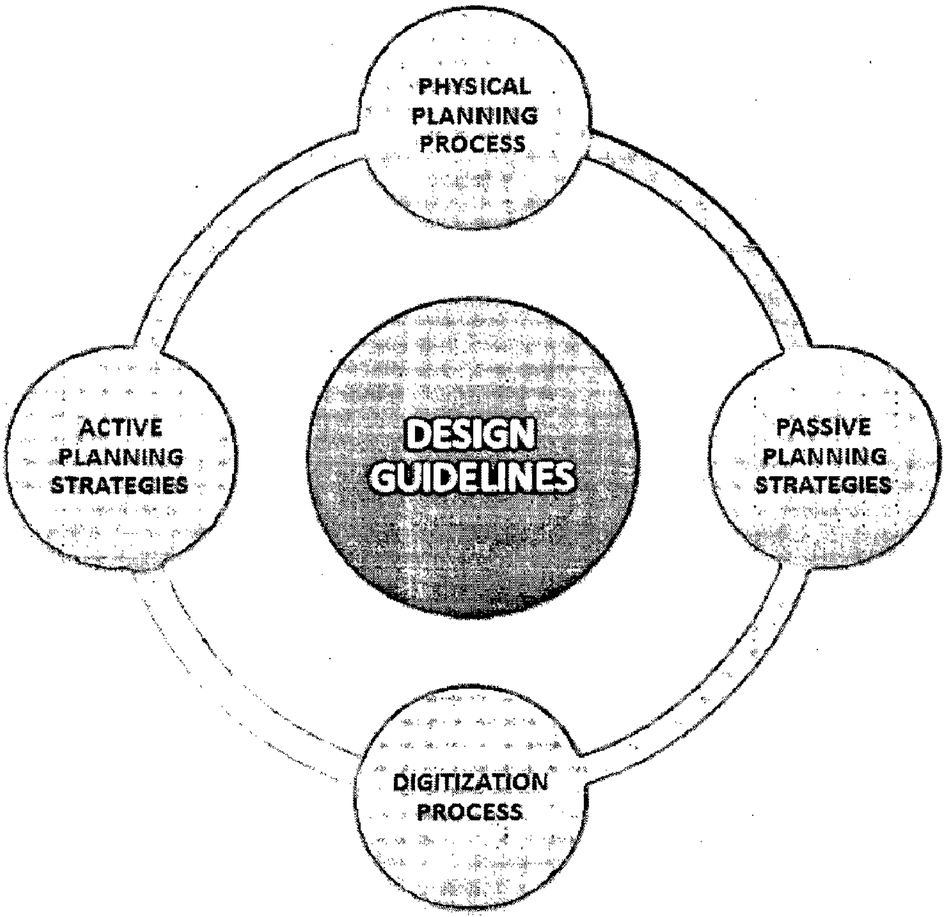


Figure 5.1 Library Design Guidelines

technologies and pedagogies. While evolving guidelines, the architect should not lose sight of the dedicated, contemplative spaces that will remain an important aspect of any place of scholarship. These guidelines have been evolved following Indian standards and norms (ECBC 2007,NBC 2005,SP-41,other bureau of Indian standards, and green building rating system- LEED,GRIHA) ,detailed literature study, case studies from primary sources and analysis.

Design guidelines for modern library building are discussed in main four parts (refer Figure 5.1). First is the physical planning process and second are environment responsive strategies regarding library building. The futuristic approaches for library designing have been discussed in this chapter. The digitization processes for future-proof library designing and active strategies are the third and fourth parts of guidelines.

5.2. PHYSICAL PLANNING PROCESS OF LIBRARY DESIGN:

Library planning historically has involved the organization and protection of collection storage space to allow ready access to users and easy serviceability by staff. While planning stage of library, some factor should be taken care off like the design should offer security, comfort, and quiet, commercial-free environment, offer opportunities to learn, search, inquire, and recreate and afford opportunities for choice and serendipity. The goal of effective planning is to make the experience and services of the library transparent to the user. The library planning process deals with site level and building level planning issues.

5.2.1. Site level:

- **Zoning:**

Site selection: Site selection should be carried out in light of a holistic perspective of land use, development intensity, social well-being, and preservation of natural environment.

Infrastructure: connectivity to infrastructures (refer Figure 5.2) like power source, waste management, telephone and internet should be there. Codes and requirements for water, sewer, and electrical/telecommunication lines should be considered.

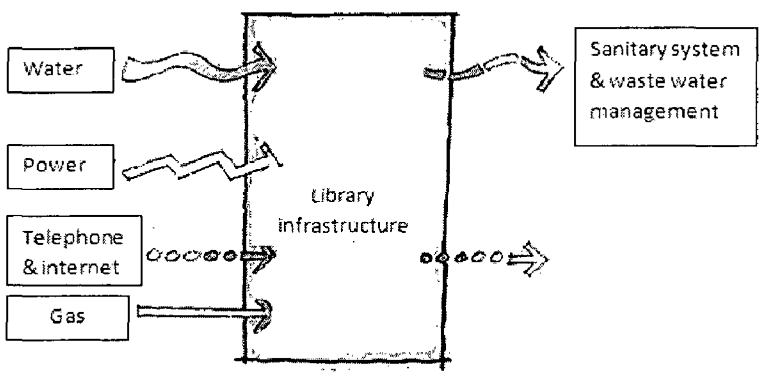


Figure 5.2 Library Infrastructure

- **Location:**

Position: Proximity to academic blocks as well as residential area of an intuitional campus is recommended. . Public library should have a central position as the heart of a space—both symbolically and in terms of its physical placement. Library should always be placed around facilities like residential blocks, community hall, museum, park, educational institutions, performing arts centre etc.

Connectivity: It should be well connected to pedestrian and vehicular access .The selected site should be located within ½ km radius of existing bus stop or rail station.

- **Universal Design principles:**

- **Barrier free design: The design is useful and marketable to people with diverse abilities.**
- The minimum walkway width would be 1200 mm and for moderate two way traffic it should be 1650 mm - 1800 mm.
- Longitudinal walk gradient should be 3 to 5% (30 m - 50 mm in 1 meter)
- Surface parking for two care spaces shall be provided near entrance for the physically handicapped persons with maximum travel distance of 30 M from building entrance. Entrance should be indicated by proper signage. This entrance shall be approached through a ramp together with the stepped entry.
- Ramped Approach: Ramp shall be finished with non slip material to enter the building. Minimum width or ramp shall be 1800 mm. With maximum gradient 1:12, length of ramp shall not exceed 9.0 M having double handrail at a might of 800 and 900 mm on both sides extending 300 mm, beyond top and bottom of the ramp. Minimum gap from the adjacent wall to the hand rail shall be 50 min.
- Stepped Approach: For stepped approach size of tread shall not be less than 300 mm. And maximum riser shall be 150 mm. Provision of 900 mm high hand rail on both sides of the stepped approach, similar to the ramped approach.
- Entrance Landing: Entrance landing shall be provided adjacent to ramp with the minimum dimension 1800 x 2000 mm.
- Attention should be given to dimensions of wheelchairs used locally. Standard size of wheel chair has been taken as 1050mm x 750mm (refer figure 5.3).

- For locking and opening controls for window and doors should not be more than 1400mm from the finished floor usable by one hand.
- Switches for electric light and power as well as door handles and other fixtures and fittings should be between 900mm - 1200mm from finished floor.
- Width of entrances and exits (clear 900mm)

- **Access:**

Pedestrian access: pedestrian access should be segregated with vehicular access. Pedestrian path should be permeable for ground water recharge and welcoming to the building entry.

Vehicular Access: The relationship between parking (whether open lot or in a parking structure) and the library entry is an important aspect in site planning. Connection with vehicular road is recommended due to facilitate proper loading unloading activity. The students should feel safe and secure while entering.

Parking: The minimum requirement is one accessible space for every 25 parking spaces, up to 500, with no less than one space; beyond 501 total spaces, a minimum of two percent of the total is required. Accessible parking spaces must be at least 9' wide served by an access aisle at least 5' wide for a total of a 14' wide area.

Total surface parking (refer figure 5.4) should not exceed the area as permissible under the local by-law and more than 50% of the paved area to have a minimum 50% of the paved area (including parking) to have shading by vegetated roof/pergola with planters or a minimum 50% of the paved area (including parking) to be opped with finish having solar reflectance of 0.5 or higher.A minimum number of accessible parking spaces, typically denoted with a blue-painted curb and an International Symbol of Accessibility, are required for library building, depending on the total number of parking spaces provided as part of the project.

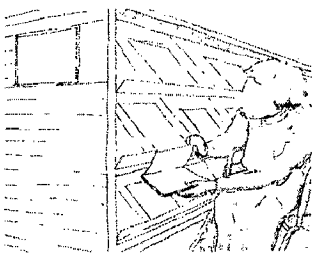


Figure 5.3 Barrier-free design

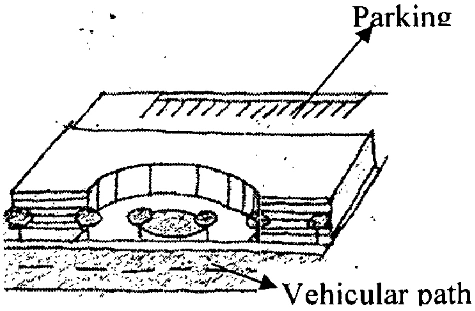


Figure 5.4 Parking

5.2.2. Activity oriented space:

Five types of user activity for which space would need to be designed in a new library: information seeking, reader's space, connection & services, contemplation and recreation.

5.2.2.1. Information Seeking:

Library is a space where people come for getting information, getting knowledge. Collection, data preservation .

i. Collection & Storage: collection storage is still one of the principal space uses of libraries, even as electronic media and online access to information has changed the nature of information storage. Traditional book stacks can occupy over 50% of a library's space and are still the preferred method of collection storage and access for high-use material. Efficient space planning of stack areas is an essential design objective for library design.

- ***Print collections:*** Books, journals, magazines, reports, papers manuscripts etc.
- ***Digital information collection:*** For a modern library, huge storage space are required for CD,DVD or any other digital content storage area .Space and facilities for IPad, Laptop and desktop computers, services for these digital technologies like internet server system, adequate power supply, service room, work stations, are required.

ii. Data preservation:

- ***Hard copy preservation:*** The environment around books is a major concern because unacceptable levels of temperature and humidity will accelerate deterioration.
  - Direct sun-light, with a large ultraviolet (UV) component, will fade leather and cloth. Blue leather fades to dull green and red leather to brown, especially along the spine of the book.
  - Placing of similar sized books, next to each other on the shelf vertically, packing them neither too loosely or tightly, is recommended.. This will help to prevent warping of a tall book next to a short book.

- ***Digital preservation:*** Digital preservation is defined as: long-term, error-free storage of digital information, with means for retrieval and interpretation, for the entire time span the information is required for. "Retrieval" means obtaining needed digital files from the long-term, error-free digital storage, without possibility of corrupting the continued error-free storage of the digital files. Some software like GENISIS, LibSys , Lotus DOMINO are helpful for digital preservation.
- ***Seismic Issues, Bracing and Anchorage:*** All freestanding shelving sections over five feet in height must be floor anchored; overhead bracing of shelving is no longer acceptable (refer Figure 5.5). Because shelving is required to be anchored in place, it is considered to be part of the building structure.

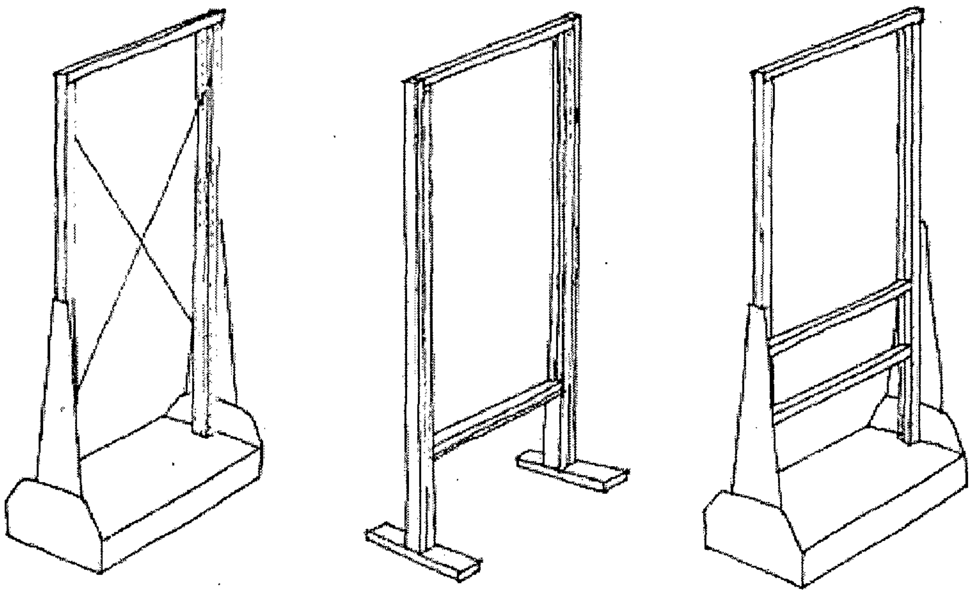


Figure 5.5. Types of seismically braced frames for fixed shelving units

iii. Findability:

A Library contains chiefly books, other printed matter, digitised storage, seating accommodation, space for library staff, catalogues and non-assignable space .All areas should be easily accessible. Thoughtful advanced cataloguing system of collections for disciplinary and interdisciplinary research is highly recommended. The library should create ways to facilitate increased personal control, efficiency, and transparency to create a more powerful discovery process. Technology produces new ways of finding, organizing, and sharing information and ideas.

5.2.2.2. Readers' space:

i. Space Zoning:

Zoning of library in future have a significant role. Students may have different perception and preference about ideal workspace. The designer needs to serve to these disparate requirements by establishing different zones.

- ***Zoning divisions:*** For a library building, there are three types of zones like noisy areas which include entrance, lobby, and cloak room etc, low-noise areas which include administration area, control area, catalogue etc and quite area which include reading area. For a library there are several types of activity areas, for that proper zoning should be required.
- ***Vertical Zoning*:** This option is derived from national and international case studies that lower floor level are noisy area and upper floor levels are quiet area.

  Basement: store & services

  Lower floor level: offices, group study room & non library activity, computer workstations

  Upper floor levels: space for printed collections, reader's space .
- ***Interactive Space:*** Interactive Space like atrium, a central organizing space of the library building, can be emerged as the symbol of the library. While the atrium is not only the source of inspiration for scholars, it is also the heart of the building. Interactive floors at libraries may create a new attraction in the physical library by creating a place where people may playfully meet and interact with digital materials.
- ***Individual study area:*** The preferred configuration for library study seating is shifting from individual study carrels to table-and-chair ensembles. The Nationally, the traditional library reading room is enjoying a renaissance as a place to study in the presence of others, it is a place to see and be seen while working privately. Individual quiet study area should be there for students.
- ***Group study area:*** The library should plan for more group study rooms to facilitate collaborative learning. Library users prefer tables equipped with socket outlets for laptops and wireless internet connections. In a

comparatively enclosed discussion spaces can have conducive environments to use handheld devices like phones, I-Pods, e-boards, and so. Group study is popular and increasingly encouraged by faculty through assignments. In response, libraries are providing more group-study rooms. These typically include large worktables with seating for three to six students, white boards, and network connections. Moveable partitions and furniture that allow students to create their own study spaces adjacent to stack areas they use and in proximity to network connections and printers.

ii. Space Planning:

Librarians and scholars still care deeply about the more traditional roles of the library: collection development, research space, assistance, preservation and access. (Refer Figure 5.6 – 5.21).

Quality of space:

- ***Built environment:*** Built environment of future library should be comfortable, aesthetically pleasing, as well as an example for environment responsiveness. They should be as model for green buildings using green technologies in facility design. Spatial quality or the quality of space is typically considered from two perspectives: comfort and flexibility.
- ***Design elements:*** A significant majority of students still considers the traditional reading room their favourite area of the library—the great, vaulted, light-filled space, whose walls are lined with, books, they may never pull off the shelf. While certain principal design elements like the articulation of the perimeter wall, the introduction and control of natural light, and the placement of core areas for stairs, toilets, and heating, ventilation, and air conditioning, will remain relatively constant, the majority of space must be capable of adapting to changes in use.
- ***Comfort condition:*** Reading is the most important task in libraries. Proper lighting is crucial to the overall success of a library. The use of natural light, or daylighting, has traditionally been a desirable building feature. Illumination with natural light, providing glare-free light in reading spaces is required. The space should be thermally comfortable. Acoustical design for library building is an important component of the project program.
- ***Aesthetics:*** Any important building, especially buildings like library, which have historically responsibly carried the wand for land mark buildings,

Quantity of Space:

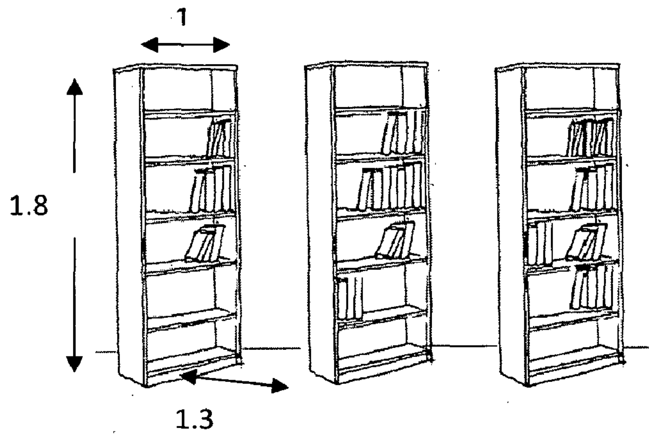


Figure 5.6. Shelf Units (Narrowest width)

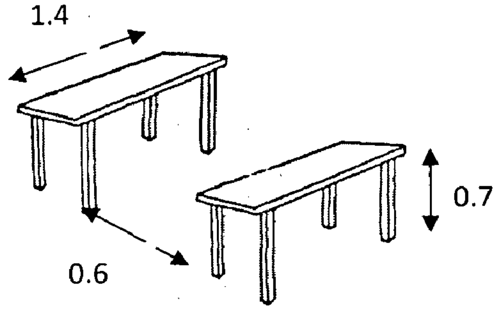


Figure 5.7 Minimum distances between tables

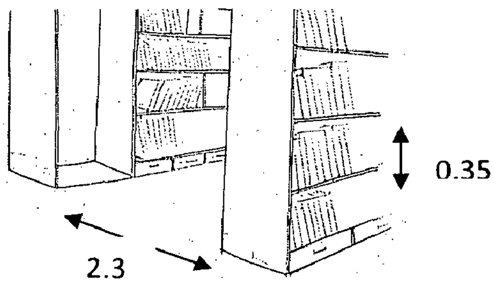


Figure 5.8 Normal distances between shelves

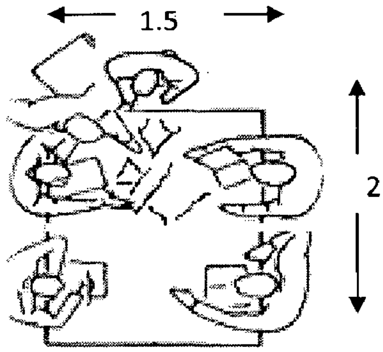


Figure 5.9 Group study booths

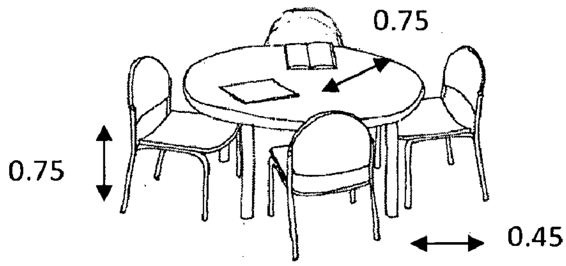


Figure 5.10 Circular group study booth

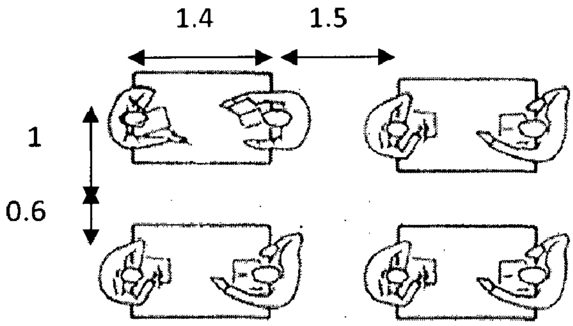


Figure 5.11 Minimum floor space in reading area

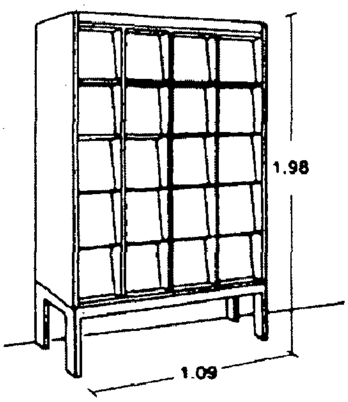


Figure 5.12 Periodical Rack

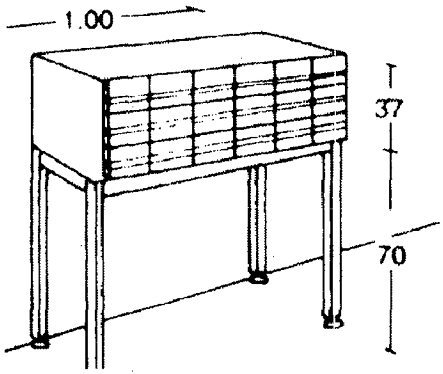


Figure 5.13 Traditional Card Index

Dimensions are in Metric units

5.2.2.3. Connection & Services:

i. Connection:

- ***Indoor connection***: being a public space library should have proper connectivity between all functional spaces. All services, all reader spaces, collection and storage area, offices and computer workstations should be well connected. Horizontal and vertical circulation area should be well defined. All staircases, lifts or other vertical circulation media should be designed considering norms and regulations.
- ***Outdoor connection***: Outside the building, vehicular and pedestrian circulation should be well defined and segregated. Service road, with have a connection to vehicular access, should be there for the library building.

ii. Services:

- **Building services:** Integration of building services like Illumination, Thermal environment, Acoustics, Vertical circulation, HVAC, Electrical, Safety management is important. For that purpose building management system is helpful. Building management system is a computer controlled unit with the purpose of controlling various operations in most efficient way. The function of building management system is to control, monitor and optimize building services. The library building should have proper security system.
- **Internet services:** proper internet services should be there for digitized system in library building.

5.2.2.4. Contemplation:

Designing of library space on the psychosocial aspects of an academic community is a requirement. Upon entering the library, the student becomes part of a larger community—a community that endows one with a greater sense of self and higher purpose. Students inform us that they want their library to feel bigger than they are. They want to experience a sense of inspiration.

- **Flexibility and Future needs:** It should take care of growth problem. Academic library collections grow at the rate of 4 to 5 percent a year and double in around

.16-17 years. Rather than hide resources, the library should bring them to the user. One key concept is that the library as a place must be self-organizing—that is, sufficiently flexible to meet changing space needs. Several principal design elements like articulation of the perimeter wall, the introduction of natural light, and placement of core areas for stairs, toilets, and heating, ventilation, and air conditioning will remain relatively constant. May be large, open spaces can offer easy re-constructability, so that they could be reconfigured to meet future needs. Its space requires accommodation of evolving information technologies or change of learning culture like collaborative interactive learning flexibly enough.

- **Supporting collaboration and sharing:** It is a place to access and explore with fellow students information in a variety of formats, analyze the information in group discussion, group study rooms and project-development spaces. As laboratories that learn, In this interactive learning environment, it is important to accommodate the sound of learning, group discussions or intense conversations over coffee, while controlling the impact of acoustics on surrounding space.

- **Security System:** The goal of the security system should be to provide a safe and secure facility for library employees, library resources and equipment, and library patrons. To mitigate the risks specifically associated with library facilities, three aspects should be evaluated like Physical security including architectural considerations, staffing, and hardware such as door and window protection, Electronic systems such as building alarm systems and access control systems and Security policies, procedures, and plans.

5.2.2.5. Recreation:

Space should be there in library for meeting and socializing, eating and collaboration. Libraries remain valued places of community, so the library should

- offer security, comfort, quiet and commercial-free
- provide a place to be with other people in a learning/cultural environment
- offer opportunities to learn, search, inquire, and recreate
- afford opportunities for choice and serendipity

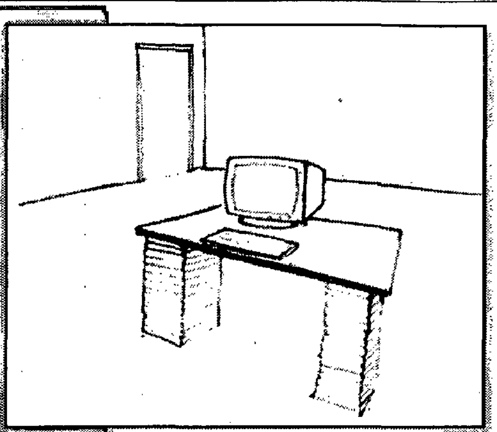
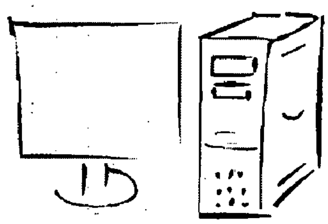


Figure 5.14 Digital technology

Digital technology as catalyst..........................Connecting to both real and virtual world in right proportion would be the serious duty of today's libraries to dispense.



Daylight & natural ventilation

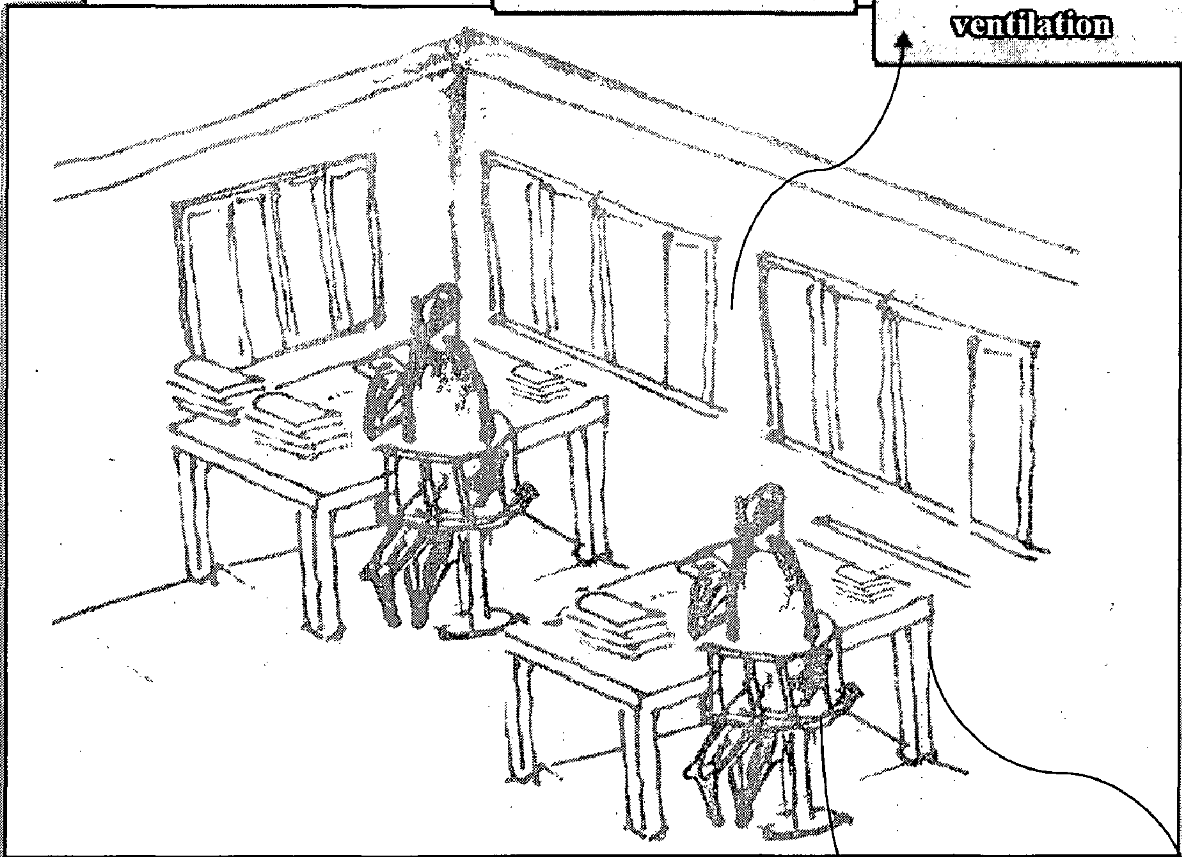


Figure 2.15 Individual study area

Opportunities to learn, search, inquire, and recreate

Place to be with other people in a learning/cultural environment

Security, comfort, quiet and commercial-free

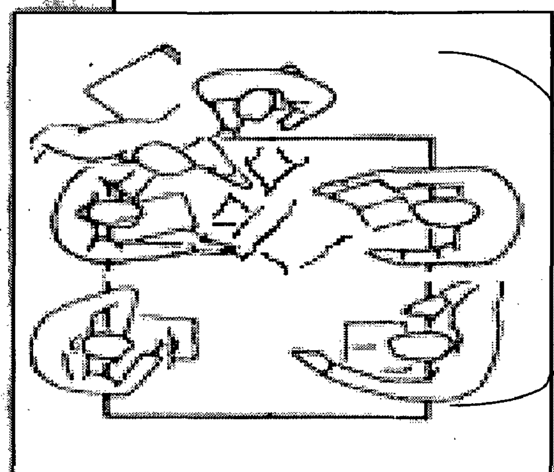


Figure 5.16 Collaborative Study

The library should move out of the current model that optimizes storage to one that makes sense for group work

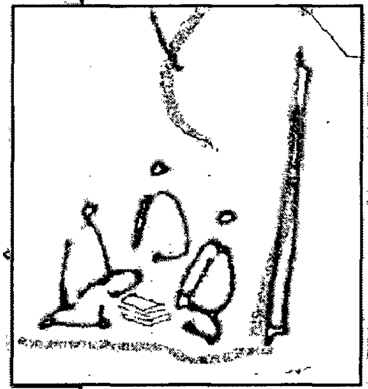


Figure 5.17 Informal Reading

Opportunities for choice and serendipity

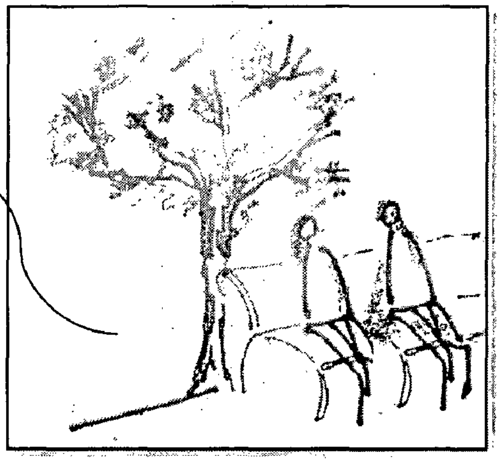


Figure 5.18 Recreation

Indoor environment that is not only safe, but healthy and inspiring

The preferred configuration for library study seating is shifting from individual study carrels to table-and-chair ensembles.

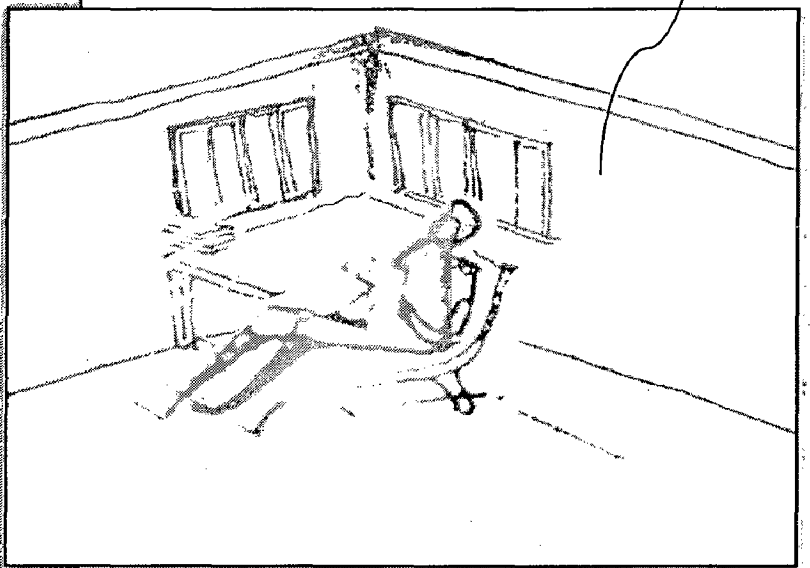


Figure 5.19 comfort, security

Expert and thoughtful cataloguing of collections like books, journals, and archives for disciplinary and interdisciplinary research is essential.

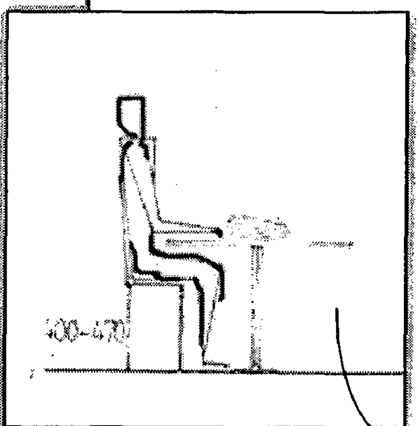


Figure 5.20 individual study area

Individual quiet study area should be there for students

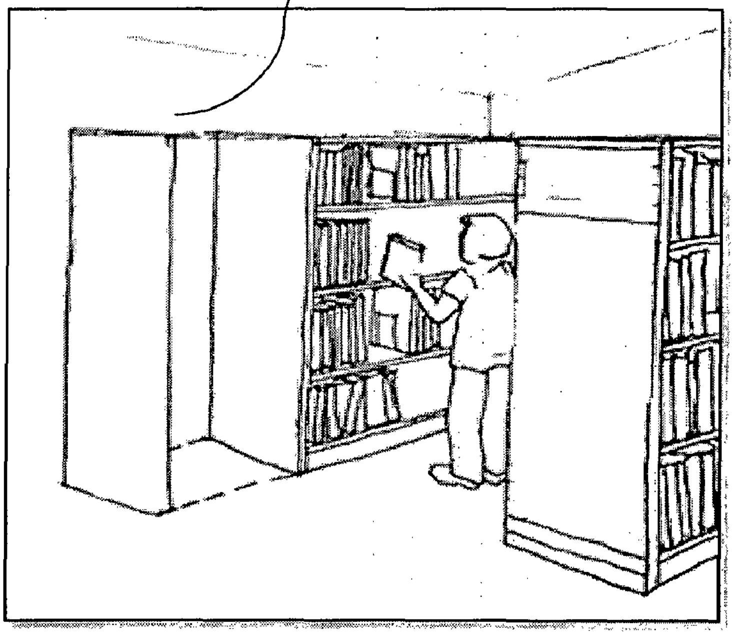


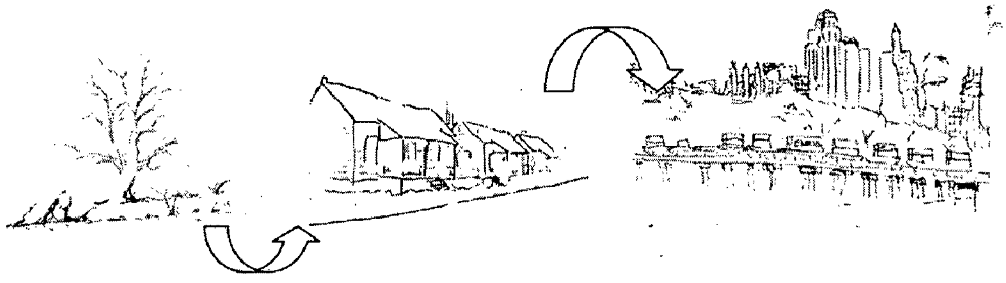
Figure 3.21 powerful discovery process

5.3. ENVIRONMENT RESPONSIVE PASSIVE PLANNING STRATEGIES:

In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun. Passive systems are simple, have few moving parts, and require minimal maintenance and require no mechanical systems.

5.3.1. Site level:

i. **Land cover transformation:** When there is a vacant land, then the environmental impact is natural or there is no negative environmental impact, but if the land is transformed into any artificial footprint like building, paving, any other structure etc. then some environmental impacts will be there. The intrusion of any structure is basically natural surface intervention. The intension is to minimize negative environmental impact through an environment friendly and user friendly design (refer Figure 5.22).



ii. **Landscaping:**

- **Preservation of existing landscaping:** Existing landscaping or existing trees is required to preserve while construction for environment responsive planning strategies.

- **Plant selection:** Selection of plants is important for landscaping. Local plant, which has adapted to local climate conditions, will require less work on the part of some other agent to flourish. Selection and placement of plants can help control sunlight (refer Figure 5.23).

Plant selection	**Maximize ecological Function**
Native Plants Hold Soil, Water	Reduce/ prevent Pollution
Look attractive	Conserve natural Resources
Plant for the Long Term	Energy Conservation / Cooling
Diversity and Biomass	Storm Water Retention

- **Environment responsive paving:** selection of *paving* materials, garden walling and edging, brick pavers, tiles, decorative aggregates, cobbles, boulders should be environment responsive. Paving should be permeable.

- **Area for plantation:** Area for plantation (refer Table 1), is measured on the basis of land area distribution for lawn and shrubs and canopy area for large trees. Water saving Comparison between different combinations of areas;

100% Lawn	water saving 0%
50% lawn: 50% native	water saving 32%
50% native: 25% mixed: 25% lawn	water saving 42%
75% native: 25% lawn	water saving 48.5%

Table 1 Area for plantation

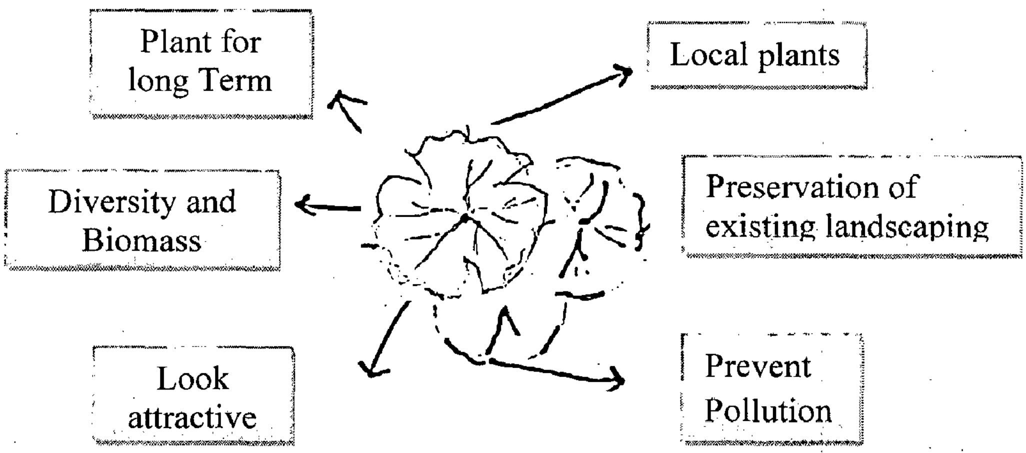


Figure 5.23 plant selection

5.3.2. Building Level:

i. **Orientation:**

- Site's orientation with respect to wind patterns
- Maximize the use of natural light and to allow for natural ventilation
- Major facades of building along north and south axis (refer Figure 5.24)

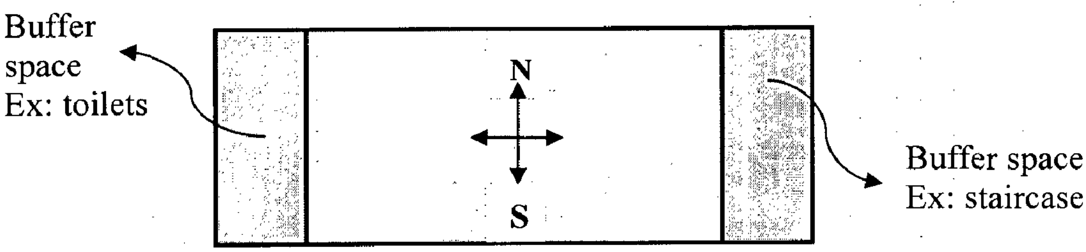


Figure 5.24 Building Orientation

ii. **Passive Proposition:**

- **Green roof:** Green roofs provide thermal insulation and therefore energy costs savings and consequent reduction in carbon dioxide production.

- **Storm water Management:** Managing the quantity and quality of storm-water is termed, "Stormwater Management."Modern drainage systems which collect runoff from impervious surfaces (e.g., roofs and roads) ensure that water is efficiently conveyed to waterways through pipe networks, meaning that even small storm events result in increased waterway flows (refer Figure 5.26).

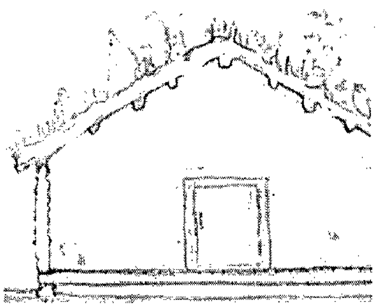


Figure 5.25 Green Roof

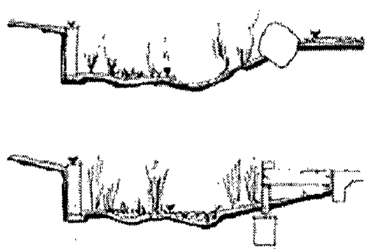


Figure 5.26 Storm water Management

- **Rainwater Harvesting:** Rainwater collected from the roofs of houses, tents and local institutions, or from specially prepared areas of ground, can make an important contribution to drinking water. Generally, rainwater is either harvested from the ground or from a roof.

- **Shading of Roof and Walls:** Surface shading can be provided as an integral part of the Building element which should be considered at the design stage (refer Figure 5.28).

- **Courtyard Effect:** Due to the incident solar radiation in the courtyard, the air in the courtyard becomes warmer and rises up. To replace it, cool air from the ground level flows through the openings of the room, thus producing the air flow (refer Figure 5.27).

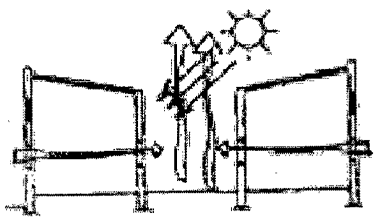


Figure 5.27 Courtyard Effect

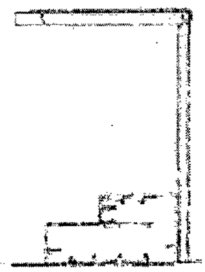


Figure 4.28 Shading

- **Wind Tower:** The hot ambient air enters the tower through the openings in the tower and is cooled when it comes in contact with the cool tower and thus becomes heavier and sinks down. When an inlet is provided to the rooms with an outlet on the other side there is a draft of cool air. After a whole day of heat exchange, the wind tower becomes warm in the evening (refer Figure 5.30).

- **Earth Cooling:** At a depth of 15 m, the earth has a constant temperature of 10°C. If a part of the building is earth bermed, the building loses heat to the earth (refer Figure 5.29).

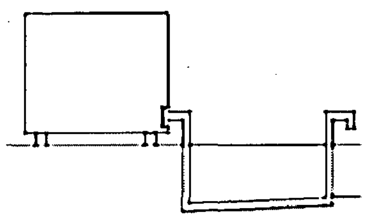


Figure 5.29 Earth Cooling

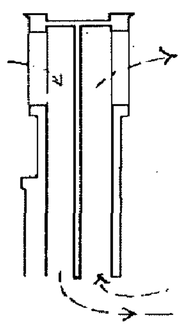


Figure 5.30 Wind Tower

iii. Building Envelope :

- **Surface Area To Volume (SAV) Ratio:**

The influence of solar radiation on vertical surfaces of high-rise building shapes and the effect of geometric shapes with variations of W/L ratios and building orientation towards minimizing the total solar insulation. Greater surface area is the reason of more the heat gain/ loss through it. So small S/V ratios imply minimum heat gain and minimum heat loss (refer Table 2).

Climatic Region	S/V Ratios	Description
Hot Dry Climates	As low as possible	Minimize heat gain
Cold-Dry Climates	As low as possible	Minimize heat losses
Warm-Humid Climates	Not necessarily minimize the S/V ratio.	Concern is creating airy spaces

Table 2 S/V Ratios for Different Climatic Regions

Compact shape*:* To minimize the losses and gains through the fabric of a building a compact shape is desirable. The most compact orthogonal building would then be a cube. This configuration, however, may place a large portion of the floor area far from perimeter daylighting. Contrary to this, a building massing that optimizes daylighting and ventilation would be elongated so that more of the building area is closer to the perimeter. While this may appear to compromise the thermal performance of the building, the electrical load and cooling load savings achieved by a well-designed daylighting system will more than compensate for the increased fabric losses. Here the orientation of the building as well as the relative dimensions of surfaces facing different directions would have to be considered (refer Figure 5.31).

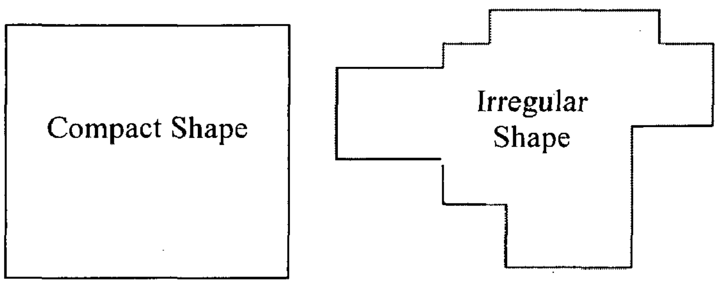


Figure 5.31 Compact shape building is desirable

- **Window Wall Ratio:**

The window to wall ratio is limited to a maximum of 60% of gross wall area and the skylight to roof ratio is limited to a maximum of 5% of gross roof area .

The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area. Window to Wall Ratio (WWR) –40% equally distributed on all elevations is

- **Skin Design:**

Material selection:

a) U-Value: U-Value is the measure of the rate of heat loss through a material. The calculation of U-values can be rather complex - it is measured as the amount of heat lost through a one square meter of the material for every degree difference in temperature either side of the material. U-values (refer Table 3) are provided as a guide for selecting material.

Components	U-Value (Conventional Case)	U-Value (Energy Efficient Case)	b) Saving
Wall	0.335 Btu/hr-ft^2 -F	0.077 Btu/hr-ft^2 -F	c) up to 40% reduction in cooling load
Roof	0.417 Btu/hr-ft^2 -F	0.072 Btu/hr-ft^2 -F	
Glazing	1.087 Btu/hr-ft^2 –F SC= 0.29/0.23	0.58 Btu/hr-ft^2 –F SC=0.95	

Table 3 U-Value for Material Selection

d) Resource Efficiency: Natural, plentiful or renewable: Materials harvested from sustainably managed sources and preferably have an independent certification, Reusable or recyclable.

e) Locally available: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site.

f) Low or non-toxic., Minimal chemical emissions. Products that also maximize resource and energy efficiency while reducing chemical emissions.,Low-VOC assembly.

g) Moisture resistant: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.

h) Healthfully maintained: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.

i) Use of low-energy materials/efficient technologies in structural application clearly

j) demonstrating a minimum five per cent reduction in the embodied energy like Pre-stressed slabs; Hollow floor/roof slabs; Pre-cast reinforced brick/tile panels; Micro-concrete roofing; Composite columns; Pre-cast concrete blocks etc.

Component design:

Building component refers to the placing of fenestration windows on a building's exterior. Natural ventilation, daylighting, solar heat gain etc happen through building fenestration. One strategy is facing the glazed areas in educational facilities north and south when possible to provide maximum daylight and maximum shading potential from direct sun is important. Locating glazing strategically but avoid over glazing. Window Shading, Blocking direct beam solar radiation to reduce heat gain, glare and localized overheating is one strategy.

- **Indian traditional jaali system:** The jaali work provides what is called the Venturi effect in modern buildings, it helps pre-cool air. Glare free sunlight also come from jail work (refer Figure 5.32).
- **Environment responsive glazing system:** Certain Double-glazed windows bring in 7-8 times more heat inside the building as compared to a well-insulated wall. some of the most energy efficient glass available in the market has U-value ranging from 1.4-1.9 W/sq.m.- deg C. That means even some of the best available glass allows 3-4 times more heat transfer as compared to a well-insulated wall.

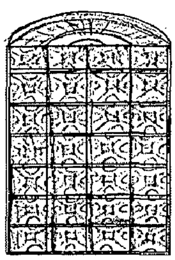


Figure 5.32 Jaali System

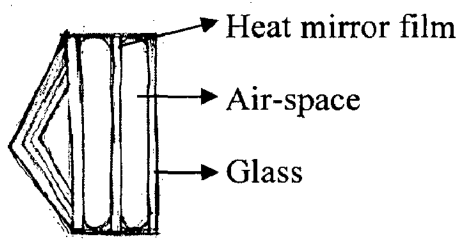


Figure 5.33 Glazing System

5.3.3. Spatial Qualities:

5.3.3.1 Thermal Quality:

Temperature: Inside temperature condition of a library should be comfortable for readers. Dry bulb temperature should be 23 -26 degree c for air conditioned library portion and for non air conditioned portion inside temperature is up to 38 degree c.

Natural ventilation: Outside fresh air ventilation rate is 15 CFM per person.For an elongated building, the largest pressure differences (which drive cross-ventilation) occur when the building is perpendicular to the prevailing wind. To encourage cross-ventilation and maximize cooling, one-room-deep plans are preferable.

Humidity: For a library building relative humidity for air conditioned space should be 55 %.Normally relative humidity in the range of 40 to 70% in the reading

5.3.3.2 Day Lighting:

North-facing windows or clerestories admit daylight while excluding direct sunlight. South facing glazing with adequate overhangs can also be effective. Library lighting is to provide enough light to accomplish a visual task such as reading.

Ideal ratios of brightness levels within the field of view are often described at 10:3:1, for brightness of visual task to brightness of the immediate surround to brightness of the general surround. A lux level of 270 lux at 30" (inch) from ground level at 12 Noon on equinox days with a low Visual Light Transmission (VLT) of the glazing is considered as good or Optimum day lighting.

The visible light transmittance is an optical property that indicates the amount of visible light transmitted. VT varies between 0 and 1.most values among double and triple-pane windows are between 0.30 and 0.70.windows with higher VT to maximize daylight and view.

DAYLIGHT FACTOR	
Stack Room	0.9-1.9
Reading Room	1.9-3.75
Counter Room	2.5-3.75
Catalogue Room	1.9-2.5

Table 4 Daylight Factor

The daylight factor (refer Table 4) is important criteria of library design:

Df= inside illuminance/outside illuminance x100

I df= 1% of outdoor illuminance

The recommended design sky illuminance for different climatic zones (refer Table 5) is

CLIMATIC ZONES	ILLUMINANCE
Cold Climate	6800 lux
Composite Climate	8000 lux
Warm-Humid Climate	9000 lux
Temperate Climate	9000 lux
Hot-Dry Climate	10500 lux

Table 5 Illuminance for different climatic zones

Some Technologies:

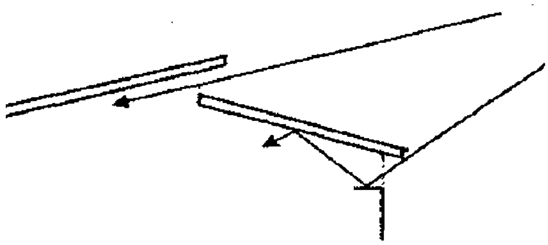


Figure 5.34 Light Shelve

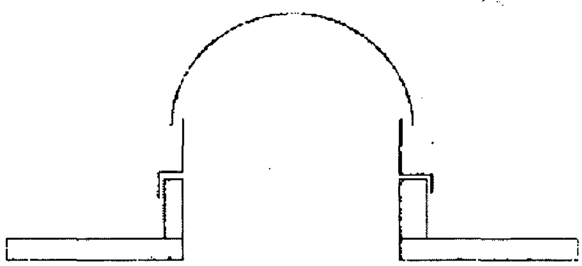


Figure 5.35 Light Pipe

Light shelve: A light shelf is an architectural element that allows daylight to penetrate deep into a building. This horizontal light-reflecting overhang is placed above eye-level and has a high-reflectance upper surface. This surface is then used to reflect daylight onto the ceiling and deeper into a space (refer Figure 5.34).

Light pipe: Light tubes or light pipes are used for transporting or distributing natural or artificial light (refer Figure 5.35).

5.3.3.3 Acoustics:

- **Sound insulation construction:** There are some conditions in a library where more sound isolation will be required, which can be accomplished by adding insulation within the wall cavity, providing a second layer of gypsum board on each side of the partition, or possibly using staggered stud construction. These program areas include conference rooms and offices requiring confidential speech privacy, where STC ratings in the range of STC (Sound Transmission Class) 45-50 are recommended. To control noise transfer from rooms having amplified sound systems such as meeting rooms into other library spaces, the surrounding walls should have a minimum rating of stc 55-60.this is commonly done by using two panels separated by an air cavity, and is known as a dual panel partition. Doubling the air space width increases the tl by about 5 db. Usually, the dual panel approach is more effective and lower cost than increasing wall mass.

Space Type	NC Rating
Open Public Areas (Circulation, Reference)	35-40
Computer Work Areas	40
Private Offices	30-35
Open Staff Work Areas	35-40
Copy Rooms	40
Teleconference Rooms	max 25
Reading Rooms	25-30
Classrooms, Training Rooms	25-30

Table 6 NC Rating for Library

Noise Criteria (NC) Curves: NC is typically used to rate the relative loudness of ventilation systems (refer Table 6),.

- **Sound absorbing materials:** The absorptivity of a given material is frequency-dependent and is affected by size, shape, location and the mounting method used. Porous insulative materials such as mineral wool or glass wool are effective sound absorbers compared with good conductors such as metals. Micro perforated plates, however, supply "hard" absorptive surfaces. Porous absorbers, typically open cell rubber foams or melamine sponges, absorb noise by friction within the cell structure.

- 5.3.3.4 **Indoor Environmental Quality:**

An indoor environment that is not only safe, but healthy and inspiring for occupants will take several environmental factors into consideration: fresh air, light, views or connection to the outdoors, thermal comfort, and the ability of the occupant to control their environment (refer Figure 5.36). As a building type, libraries have no intrinsic limitation to achieving any of the above goals.

- If materials have been selected for the interiors that off gas dangerous chemicals, then the movement of air may not be enough.
- Isolation of any sources of chemicals is important, which could be hazardous to occupants. This includes separating copiers into spaces that can be properly ventilated so that the ozone from the copiers does not affect the entire library.
- By providing CO^2 sensors in all occupied spaces, the mechanical system can "know" when there are more people needing more fresh air in a space and respond by increasing the rate of outside air into the ventilation.
- One way of quantitatively ensuring the health of indoor air is by the frequency of effective turnover of interior air by replacement with outside air., library are required to have 3 outdoor air changes per hour.

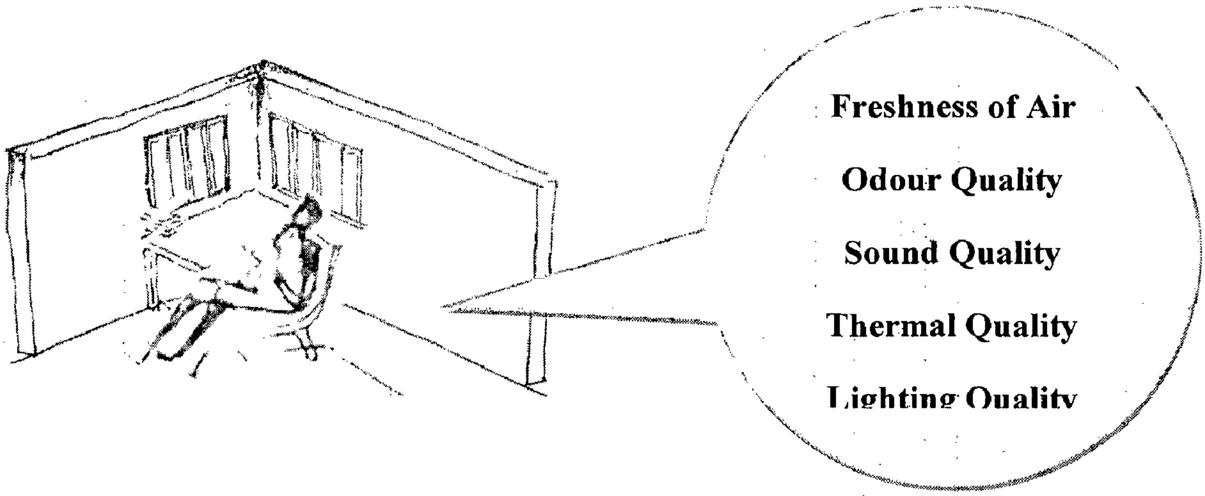


Figure 5.36 Indoor Environmental Qualities

5.4. FUTURISTIC APPROACH

5.4.1 Enabling Digital Environment:

5.4.1.1 Hybrid digital library:

Hybrid digital library is the solution for modern library digitization process. Hybrid libraries are mixes of traditional print material such as books and magazines, as well as electronic based material such as downloadable audio books, electronic journals, e-books, etc.

Needs to be fulfilled by HDL:

- Enable faster service
- multi-user and all-time access
- Ease the library management process and save resources (e.g. manpower, time)
- Maximize the use of information and documents
- Reduce the physical space requirement for bookshelves (refer figure 5.37)

Physical Spaces required:

- Ipad
- Desktop and Laptop computers
- Proper workstations
- server room
- IT sector room
- Conference room
- CD-ROM collection storage area
- Area for Scanner
- Area for camera, printer, plotter

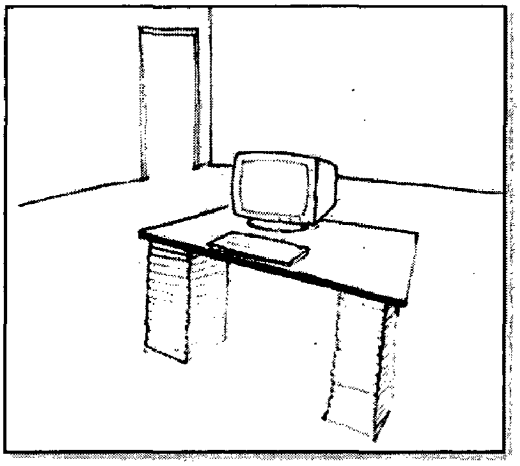


Figure 5.37. Information technology, Reduce the physical space requirement

Services & Servers:

- Servers: To make resources available for internet access, a high-end server is recommended.
- *Centralized Information Search Service:* All kinds of information such as bibliographic data, thesis and dissertations, conference papers, preprints, courses,

pictures, audio and video material, scholarly web pages, etc can be linked to related full-text, abstracts, holdings, etc.

- *Delegated Discovery and Retrieval Service:* Users can send requests for information to professional librarians, who can help find and deliver the requested material.
- *Social and Communication Service:* This service includes communities, blogs, personal information space, reviews and tags, and other Web 2.0 services, etc.

5.4.1.2. Digital information Storage:

Digitization involves a huge storage space and photographs and other high-end resources involve even further storage problems. Photographs are frequently required for printing, so high-resolution TIFF files are stored and preserved on CD-ROMs. The database for photographs also provides a key number for a given CD-ROM in which a particular high-resolution image is stored, and JPEG files are made available for access.

5.4.1.3. Digital technology preservation:

With any new advanced technology related to digital information storage, the main question to be answered is its durability. Digital storage media like disc or tapes deteriorate over time. The main question related to digital preservation is what and how much should be preserved. To make the preservation of digital media cost effective, standardization of different media format is required. In technology preservation, both hardware and software related to digital information are preserved. This may not be cost effective because changes to hardware and different versions of software need to be either maintained or constantly upgraded.

5.4.1.4. Accessibility problem and solutions:

For simple flat files there is no problem of retrieval. However, large files of more than a few hundred resources or records would create problems for users as well as for the content manager. For better management of huge resources a database is the perfect solution. Further, for digital library purposes, special software is better suited. Various commercial digital library software packages are available off-the-shelf. Library organization should go for easy to handle free/open source software(s) with powerful indexing, search and retrieval capabilities, comparable to any commercially available software. Such software can search for metadata with linkages to various types of information and knowledge in simple textual database, news clippings, multimedia, etc. Digital Library Software: GENISIS, LibSys , Lotus DOMINO. These are the solutions of accessibility problems.

5.4.1.5 Server room:

A server room is a room that houses mainly computer servers. In information technology circles, the term is generally used for smaller arrangements of servers; larger groups of servers are housed in data centres. Server rooms usually contain headless computers connected remotely via KVM switch, VNC, or remote desktop.

Physical characteristics of server room:

- A server room needs to be isolated from environmental elements like heat and moisture
- It needs to be in a secure location where others cannot access the computer.
- Server room requirements are determined by the amount of rack space needed for routers, switches and computers.
- Server room needs space for high A/C requirements and low humidity Constant A/C cooling needs to be incorporated in the server room planning.
- This includes multiple vents and units that remove moisture. Hot, humid rooms can lead to hardware failure and data loss.
- Tiled flooring is useful for the best reduction of heat.. Servers laid on carpet become hot due to poor ventilation and heat. Tile also stays cooler even during hotter months.
- Security systems inside the server room and on the doors are required.
- Backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and security devices are required.

5.4.1.6 Spatial quality:

Temperature: A temperature range of 16–24 °C (61–75 °F) and humidity range of 40–55% with a maximum dew point of 15°C as optimal for data centre conditions. The temperature in a data centre will naturally rise because the electrical power used heats the air.

Humidity: Air conditioning systems help control humidity by cooling the return space air below the dew point. Too much humidity and water may begin to condense on internal components. In case of a dry atmosphere, ancillary humidification systems may add water vapor if the humidity is too low, which can result in static electricity discharge problems which may damage components.

Greenhouse gas emissions: Given a business as usual scenario greenhouse gas emissions from server room are projected to more than double from 2007 levels by 2020. This should be taken care of by environment responsive strategies.

5.4.1.7. Fire protection:

Fire protection systems, including passive and active design elements, as well as implementation of fire prevention programs in operations, are required. A fire sprinkler system is often provided to control a full scale fire if it develops. Passive fire protection elements include the installation of fire walls around the data centre, so a fire can be restricted to a portion of the facility for a limited time in the event of the failure of the active fire protection systems, or if they are not installed.

Fire Detectors Systems

- Smoke detectors
- Flame detectors
- Carbon Monoxide Detector
- Ionization Smoke Detector
- Heat Detectors
- Gas Leakage Detectors

5.4.1.8. Structural system:

i. **Stringerless Raised Floors** - One non-earthquake type of raised floor generally consists of an array of pedestals that provide the necessary height for routing cables and also serve to support each corner of the floor panels. With this type of floor, there may or may not be provisioning to mechanically fasten the floor panels to the pedestals. This stringerless type of system (having no mechanical attachments between the pedestal heads) provides maximum accessibility to the space under the floor. However, stringerless floors are significantly weaker than stringered raised floors in supporting lateral loads and are not recommended (refer Figure 5.38).

ii. **Stringered Raised Floors** - This type of raised floor generally consists of a vertical array of steel pedestal assemblies (each assembly is made up of a steel base plate, tubular upright, and a head) uniformly spaced on two-foot centres and mechanically fastened to the concrete floor. The steel pedestal head has a stud that is inserted into the pedestal upright and the overall height is adjustable with a leveling nut on the welded stud of the pedestal head (refer Figure 5.39).

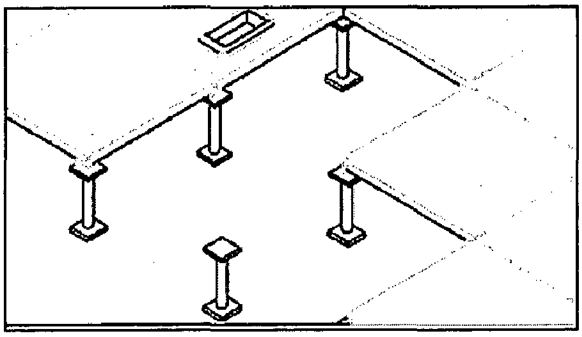


Figure 5.38 Stringerless Raised Floors

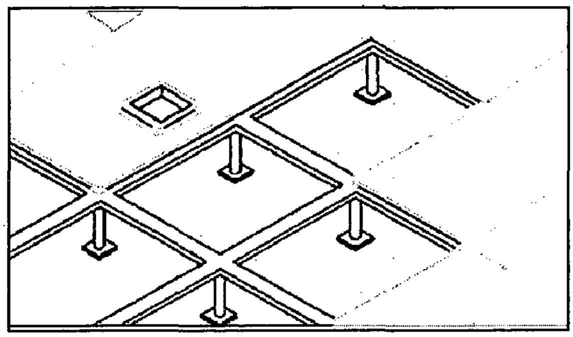


Figure 5.39 Stringered Raised Floors

iii. **Disaster mitigating structure:** Disaster is a function of hazard (event), vulnerability and capabilities of the people. In order to reduce the impact of future disasters, there is a need to put in place very comprehensive guidelines for reduction of vulnerability to natural and manmade disasters. The Code will apply to disaster management administration for all possible hazards that the State is prone to. The objective of the Code is to minimize the loss of lives and social, private and community assets because of natural and manmade disasters like earthquake, flood, cyclone, tsunamis etc. The library building structure should have disaster mitigating property.

5.4.2 Active Strategies & Advanced Building Services:

Advanced building services is basically use of technology and process to create a building that is safer and more productive for its occupants and more operationally efficient for its owners.

5.4.2.1 Access Control System:

Access control is the ability to permit or deny the use of a particular resource by a particular entity. Physical access of a person may be allowed depending on payment, authorization, etc. Also there may be one-way traffic of people. Typically the access point is a door. An electronic access control door can contain several elements. At its most basic there is an electric lock.

Biometrics is a method of associating unique characteristics of an individual with a database entry. The biometric system recognizes the individual when the data acquired from an individual person reasonably approximates the information in their database entry. Biometric verification is frequently used in everyday security, for granting (or denying) access to valuable materials, currency or information. There exists a large host of options for biometric identification and verification. A short list of techniques may include, fingerprint, facial, hand geometry, iris, retina, token and knowledge based identification. Each of these methods has limitations in accuracy in identification. Biometrics are used to identify the identity of an input sample when compared to a template, used in cases to identify specific people by certain characteristics.

- Possession-Based: using one specific "token" such as a security tag or a card
- Knowledge-Based: the use of a code or password.

Common human biometric characteristics:

- Physiological: related to the shape of the body. The oldest traits that have been used for more than 100 years are fingerprints. Other examples are face recognition, hand geometry and iris recognition.
- Behavioural: Related to the behaviour of a person. The first characteristic to be used, still widely used today, is the signature. More modern approaches are the study of keystroke dynamics and of voice.

5.4.2.2 Fire Fighting Controls:

The fire safety system (refer Figure 5.40), includes smoke sensors, fire alarms and fire sprinklers. Ceiling mounted smoke sensors at a spacing of about 3m, initiates the alarm on sensing the smoke and conveys the information to BMS. The automatic fire sprinkler system then sprays out water on melting up of its fuse link at a temperature of 55degree c.The required water pressure can be kept available through BMS monitoring on detecting fire.

- A fire alarm control system detects reports and acts on hazardous fires in buildings. This protective system is bound by many different rules and safety regulations.
- Smoke and fire control designs should adhere to the highest level of life safety possible. Smoke detectors are typically housed in a disk-shaped plastic enclosure about 150 millimetres (6 in) in diameter and 25 millimetres (1 in) thick, but the shape can vary by manufacturer or product line.

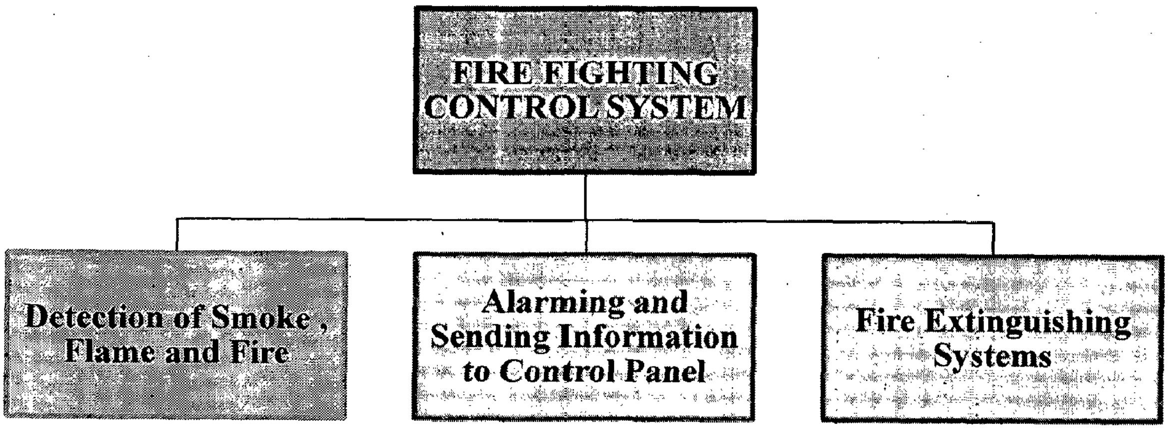


Figure 5.40 Fire Fighting Control System

Design guidelines for smoke and fire control systems:

- Provision of fire dampers in all wall penetrations for fire walls rated two hours Provision of smoke dampers in all wall penetrations through smoke barriers
- Smoke control systems usually are designed to evacuate a floor area at a rate of six air changes per hour, or 1 cfm/sqft, whichever is greater.
- Stairwell pressurization, to create smoke-free exit passageways, requires multiple supply air outlets throughout the full height of the stairwell.

- In special design cases, like a building atrium, smoke and fire safety guidelines will include fire exhaust as well as makeup air supply.
- Most importantly, on detection of fire or smoke, all air systems are to shut down. The impact of smoke and fire management codes on mechanical and electrical building systems should provide.

Fire Detectors:

- Detectors help in the functioning of fire alarms.
- All detectors consist of two basic parts: a sensor to sense the smoke and a very loud electronic horn to wake people up.

Fire Sprinkler System:

A fire sprinkler system is an active fire protection measure, consisting of a water supply system, providing adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected. A fire sprinkler is the part of a fire sprinkler system that discharges water when the effects of a fire have been detected, such as when a predetermined temperature has been reached.

Fire extinguishers:

Fire needs fuel, oxygen and heat in order to burn. Fire extinguishers remove one of these elements by applying an agent that either cools the burning fuel, or removes or displaces the surrounding oxygen (refer table 7).

Class A fire extinguishers	Ordinary combustible materials such as paper, wood, cardboard, and most plastics.
Class B fire extinguishers	Combustible liquids such as gasoline, kerosene, grease and oil.
Class C fire extinguishers	Electrical equipment, such as appliances, wiring, circuit breakers and outlets. No use of water to extinguish class C fires.
Class D fire extinguishers	Fires that involve combustible metals, such as magnesium, titanium, potassium.

Table 7 Fire Extinguishers

5.4.2.3. Lighting:

Dividing, the lighting scheme into 'General Lighting' and 'Task Lighting' results in energy savings. Lowering the height of Electrical fixtures from 3 mt., to 2.5 mt , the illumination level in between the racks has nearly increased by 1.7 times.

- Automatic switching On and Off of lighting by using sensors. Segregating the controls is conducive to energy saving.
- Light surrounding décor: The décor plays an important part in illumination design. Light décor will require less lighting and thus, can contribute for energy saving.
- Use of energy efficient lamps (HPMV, HPSV, CFL,Slimline tubes TL5 tubes etc. etc). The compact flursocent lamps instead of incandescent lamps, in general area, will result in substantial energy conservations. Slimline tubes (36watt), and Asian E+ tube fittings with T5 lamp, can result into substantial savings.
- Use of dimmers to reduce the intensity of artificial light
- High efficiency luminors & High frequency chokes

The interior lighting power density (LPD) should not exceed the recommended LPD

Library Space Function	LPD (W/sqm)
card file and cataloguing	11.8
stacks	18.3
reading area	12.9

Table 8 Library Building LPD

Lighting Occupancy sensors:

- Building area greater than 500 sqm, automatic control device for interior lighting
- All enclosed areas less than 30 sqm, meeting room, conference room, storage shall equipped with occupancy sensors.
- Other spaces shall have either a programmable timer for less than 2500 sqm or occupancy sensors.
- Other space shall have a manual swtch or occupancy sensor for areas less than 250 sqm for a floor area <1000 sqm.
- Luminaries in a day lit area >25 sqm shall be equipped with either a manual or automatic control device.

5.4.2.4. Heating Ventilation and Air Conditioning:

There are two types of requirements for air conditioning. Entire system of pipes chillers need to be filled up with water at the beginning. Demand is calculated on the basis of percentage losses of the circulation rate in the system during 24 hours.

- Chilled water
- Hot water in a closed circuit system

Fresh air economy cycle:

The fresh air economy cycle system incorporates motorised dampers {valves} to allow isolation of the air streams as appropriate. The term fresh air economy cycle describes the use of total outside air to provide free cooling for a building when the ambient air is at an appropriate temperature. For melbourne ambient temperatures below 23 C can be used to reduce the energy cause associated with mechanical cooling.

- It is possible to reduce cooling requirements even when the ambient air is not cool enough to provide full cooling.
- In this case, the refrigerated cooling system can operate in conjunction with the outside air and reduce the mechanical cooling requirements for the building.
- When ambient air temperature is lower than space temperature and the air conditioned spaces requires cooling, the ventilation air dampers and the relief air dampers will be opened and the return air damper will be closed.
- When the ambient air temperature reaches the same value as the internal space temperature, the motorised dampers are repositioned so that the ventilation air damper closes to minimum position, the relief air damper closes to its minimum position, and the return air damper opens.

Benefits: The benefit of the system is that not only are energy cost and green house gas emission reduced, but for much of the year the building will be provided with a higher level of fresh ventilation air due to the opening of the outside air dampers.

Typical application: The fresh air economy cycle system can be applied to all ducted air conditioning system but cannot be installed on small packaged unitary systems.

Two types of HVAC systems, one is centralized and one is distributed.1 deg c decrease in temperature increase cooling load by 3.5%.Centralized air conditioning unit is normally

Building Cooling Demand	TR
Small Buildings	<150 TR
Medium Buildings	>150 &<300 TR
Large Buildings	>300 RT

Table 9 Building Cooling Demand

used. Air handling units are provided at all floors to supply the conditioned air into various spaces marked for it, with controlled temperature through BMS. Here the role of BMS is to adjust the temperature of inflow air, so as to activate the desired environment within a short period of a time. Pre-cooling of fresh air, reduction of cooling demand is 16%.

Cooling Demand	Equipment Selection	Capacity	COP
cooling demand <150 TR	Ductable AC	upto 16.5 TR	1.95
	Air cooled chiller	up to 150 TR	2.90
cooling demand >150 TR & <300 TR	Centrifugal chillers		5.8
	Screw chillers		5.4
Cooling demand< 300 TR	Air cooled chiller	>150 TR & <300 TR	3.05
	Centrifugal chillers		6.3
	Screw chillers		5.75

Table 10 Building Cooling Demand and COP

Centralized unitary system, can cater to different indoor unites, refrigerant flow changes according the building load.

Centralized System	COP
Air Cooled Chiller	3.5
Water Cooled Chiller	5

Table 11 Chiller and COP

EER: Cooling Output/Input Power

TR: Building cooling demand

Coefficient of Performance (COP): COP is measure of efficiency in the heating mode that represents the ratio of total heating capacity (Btu) to electrical input (refer Table 10, 11).

5.4.2.5. Plumbing System:

The plumbing, water supply and water treatment plant ,sewerage treatment are all monitored and controlled through BMS .especially the quantity of water to be pumped ,the pressure to be maintained (at various outlets including fire sprinklers),the PH of water , the quality of water ,the quality of treated water to be reused etc.

Efficient usage of water: Application of water only when and where it is needed. Rain Sensor, Weather Track Controller, Soil Moisture Sensor are useful.

Water supply and sewerage treatment control:

A BMS controlled pumping system can be provided for supplying water to various domestic purpose and also a sewerage treatment plant for the purpose of reducing the load over public treatment plant. The treated water can be reused for flushing toilets thereby reducing the monthly bills over water consumption.

Water Efficient Fixture:

- **Water efficient toilets:** Conventional toilets use 13.5 litres of water per flush. Low flush toilets are available with flow rate of 6.0 litres and 3.0 litres of water per flush. Dual flush adapters can be used for standard flushing for solid waste and a modified smaller flush for liquid waste. Flush valves with 20–25 mm inlets can be used for restricting the water flow.
- **Water-efficient urinals:** The conventional urinals use water at a rate of 7.5–11 litres per flush. Use of electronic flushing system or magic eye sensor can further reduce the flow of water to 0.4 litres per flush. Waterless urinals use no water.
- **Auto control valves:** Installation of magic eye solenoid valve (self-operating valves) can result in water savings. The sensor taps has automatic on and off flow control. It is not only convenient and hygienic but also an excellent water saving device that can work under normal water pressure.
- **Pressure Reducing Devices:** Aerators and pressure inhibitors for constant flow. Use of aerators can result in flow rates as low as 2 liters per minute,

which is adequate for washing hands. Flow regulators are installed when aerators cannot be installed.

- **Composting/ Ecosan Toilets:** Composting Toilets are based on the bio-logical process of converting solids of human waste in to enriched manure. A composting toilet consists of two underground pits. The first pit will be filled with waste over one to two years. Source: During this time, bacteria digest the sludge. After two digestion CSE years of digestion, the contents are odourless and safe to handle, and can be used as soil fertilizer. The second pit is used when the first is full.
- **Low-Flow Fixtures:** Reduce the total water consumption in the building (by 25% or more) by using low-flow fixtures (refer Table 12).

Plumbing Fixtures	Maximum Flow Rate
Water closets	6 lpf
Urinals	4 lpf
Lavatory faucets (pvt)	8 lpm
Sink faucet	8 lpm
Bidet, hand-held spray	8 lpm

Table 12 Plumbing Fixtures and flow rate

Waste Water Treatment Technologies

- Aerobic treatment system
- Anaerobic treatment system
- Constructed wetland system (Root zone system) : DEWATS system

Water recycle and reuse (including rainwater)

Objective is to utilize the treated waste water and rainwater for various applications including groundwater recharge (where potable municipal water is normally used);

- To reduce the load on municipal supplies
- To reduce load on city sewerage system and
- To improve the groundwater level

Reuse applications

- Landscaping/irrigation

- External washing
- WC flushing
- Cooling towers
- Water recharge

5.4.2.6. Power Monitoring:

An electrical room will be provided which incorporates the ups,transformer etc, which are controlled through BMS. In case of power failure the system will detect it and would be able to re-established power connection from backup generators.

5.4.2.7. Mechanical and Electrical Systems Noise Control:

When designing a building, it is important to control the noise and vibration of its mechanical and electrical equipment. Without adequate consideration during design, the very equipment that provides thermal comfort and electrical power can generate annoying noise and vibration. Proven techniques are available for mitigating noise and vibration from this equipment.

The recommended acoustical design sequence for a building project is:

- Selection noise criteria for each space in the building
- Organization of spaces to avoid adverse adjacencies of noisy equipment with quiet spaces
- Provision of adequate noise and vibration control for equipment

Noise Control for Library Building Equipment

Large fans used as part of the air conditioning system in a building are sources of a significant amount of unwanted noise. The quietest type of fan that will satisfy the operating requirement should be selected whenever possible to reduce the need for mitigation measures.

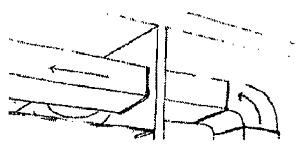


Figure 5.41 Duct borne noise and breakout noise

A down discharge fan on the rooftop should be located only near spaces that allow a noise goal of NC 45 or higher, since noise is inevitably transmitted to the space below. For such a location, a side discharge fan with long lengths of rectangular ducts on the roof should be used so that as much noise as possible is dissipated before entering the space below (refer figure 5.41).

Absorption of fan-generated noise and mitigation of air turbulence are the strategies for reducing unwanted mechanical noise in a building. To reduce fan-generated noise, provide long duct lengths between fans and the nearest air register serving a room and treat the duct internally with duct liner. Fifteen feet of lined duct inserted after the fan can reduce fan noise by 10 dB.

5.4.2.8. Video Monitoring:

Video monitoring (refer Figure 5.42) shall be implemented with Digital Video Recording (DVR) or a fully IP based Network Video Recording (NVR) system. The video monitoring system shall be integrated to BOS server so that the system shall start recording video stream upon triggering from intruder alarm system, access control,

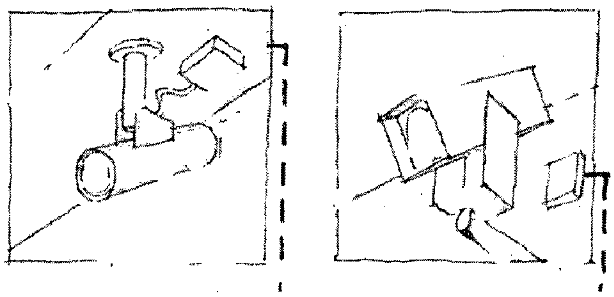


Figure 5.42 Video Monitoring

CCTV or any other system integrated to BMS. The video monitoring system shall support both analog and IP cameras. The system shall preferably run on Linux operating system. Usage can be done both via video monitoring system's own User Interface client and the integrated user interface of the BOS. In addition to the software based user interface, it shall be possible to additionally expand the operator workstation with hardware based keypad and joystick interfaced with the system.

5.4.2.9. Elevator & stairway control:

The BMS monitors all elevators in the building to have a faster access to the various floors. In case of fire, all elevators will be brought down to the ground floor. It is also possible to control the access to users; only to those floors they have valid access to, through the access control system installed in it. Every emergency stairway will be provided with pressurization fans, which will blow air into the stairwell, thus making it free from smoke or fire in such situations. This is automatically controlled by the BMS. The locks in exit-ways will be opened on detecting such hazards.

5.5. SUMMARY:

The design objectives for tomorrows' library project are to understand trends in learning processes in a way that will enable the future spaces and services to facilitate efficient, productive research and inspire users by providing a sense of participation. The proposal of guidelines for modern library building has been discussed in this chapter. The design guidelines deals with main four issues like physical planning process of library designing, environment responsive passive planning strategies , active strategies & advanced building services and digitization process. Economic viability of proposed strategies is not the part of these proposed guidelines for the time constraint. The final chapter deals with conclusions and recommendations of this dissertation. The future research and implications also have been discussed in this chapter.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.2 Recommendations

6.3 Future Research and Implications

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS:

The Libraries of modern era should expand services beyond traditional conceptions of the library and thus serve as a centre of intellectual life. There should be modern tools and services offered by the Libraries, as well as of its role in the intellectual production of the University and the city. Stacks browsing, traditional discovery process in research is one of the most beloved activities in library. The introduction of electronic resources has made the same experience less thrilling but even more crucial. Paradigms are shifting due to changing perceptions and preferences of new generations. Important evolving concepts like collaborative and interactive learning environment, use of digital technology as catalyst for change and environment-responsive open-book building command appreciation. Planning for libraries today should be premised on 24-hour access, with critical services and technology provided and located when and where they are needed. In the pre-digital age, people used to measure importance of a library primarily by number of books on its shelves and quantity of journals to which it subscribed. In the digital age, speed of access and quantity of online information stored on a particular site is the benchmark. Young generations are dependent on and also importantly comfortable with digital tools provided by the library for convenience and to easily connect with others. Desktop computers, laptops and I-Pads are used as platforms for audio-visual media. Mix of appropriate passive and active strategies, for optimum use of natural resource can create users' comfort. Library means a secure, comfortable and quiet built-environment offering opportunities to learn, search, inquire and recreate with the prospect for choice and intellect. Library should be an intellectual social space which is collaborative, digitized, user- friendly, contemplative, flexible, environment responsive, fitted with state-of-the art services, and finally aesthetically creating a landmark impression. The appropriate emphasis on sustainable concept shall be mandatorily followed for buildings of 21st century.

Obsolescence crisis of traditional libraries:

Physical libraries are in crisis due to changes in culture of teaching and learning. Providing access to information is prime function of any library traditionally; only change is that the print media is not the most sought after source to get information for younger generation. Changing patterns of student learning is the main reason of crisis in traditional library. The expectation of students will swell as availability of technology and resources provides new and friendly options of library services, materials and forms of organization as well. Beyond general changes to the spatial design of the library in the regime of paradigm shift, there is a need for change in the traditionally understood role of the same. The role of the library is to create an environment that inspires creativity in learners and to reinforce their sense of participation. Users need sources of inspiration. Prediction is that may be internet become the future library; some also opined that physical library is in a way of obsolescence. The Internet has tended to isolate people from real world; but library as a physical place, should fulfil the expectations of students, teachers and society. Connecting to both real and virtual world in right proportion would be the serious duty of today's libraries to dispense.

Paradigm shift of library designing:

- ***Collaborative and Interactive Learning:*** The library has moved ahead of the existing model that optimizes individual learning environment to one that allows group-study or work.
- ***Digital Technology as Catalyst:*** Young generations are dependent on and also importantly comfortable with digital tools provided by the library for convenience and to easily connect with others.
- ***Environment Responsive Building:*** Credibility of the design increases when the building itself becomes a text to express environmental responsiveness.

Future-proof library designing criteria:

- ***Learning space:*** Today's library offers inviting quiet learning spaces for individual and group study, project work, laboratories for multimedia production, and service spaces.
- ***Connectivity and services:*** Library being a public space, proper connectivity between different functional spaces is a necessity.
- ***Activity oriented space***: There are five types of user activity in a modern library to attract the young generations: information seeking, learning, connectivity and services, contemplation and recreation.
- ***Zoning:*** Proper zoning is important. The designer needs to serve to these disparate requirements by establishing different zones.
- ***Built environment:*** Built environment should be comfortable and aesthetically pleasing
- ***User friendly and contemplative environment:*** Since the planning or designing stage itself, user-friendliness should get its due priority.
- ***Spatial quality:*** The quality of space is typically considered from two perspectives: comfort and flexibility. Comfort level of library users is dependent on Thermal quality, Daylighting, Indoor Environmental Quality and, Acoustics. Proper lighting is crucial to the overall success of it. Use of daylighting has traditionally been a desirable design feature. Acoustical design for library building is another important component for consideration.
- ***Advanced building services***: Building Management System is a computer-based control system which controls and monitors the building's indoor environment quality, mechanical and electrical services, and safety measures.
- ***Contemplation:*** Upon entering the library, students become part of a larger community. They want to experience psycho-social impetus in the form of sense of inspiration.
- ***Recreation:*** Some non-library activities like refreshment, informal meeting etc. are required to be incorporated where people stay beyond regular working hours.

- ***Ergonomics: Furniture layout*** based on ergonomics is one of the important considerations of library designing.
- ***Collection and storage:*** One of the principal space uses of library, even as electronic media and online access to information has changed the nature of information storage.
- ***Data preservation:*** Data preservation in the form of printed copy and digitized format are both important now.
- ***Data transparency:*** Data findability is met through thoughtful cataloguing of collections for inter-disciplinary subjects; integrated search and retrieval system should be implemented to enable faster service. To make resources available for internet access, a high-end server is recommended.
- ***HDL: Hybrid digital library*** is a solution for fulfillment of needs of modern library. Solutions of digitization problems: software like LIBSIS,GENISIS, Lotus DOMINO etc are useful.
- ***Flexibility:*** The design can accommodate a wide range of individual preferences and abilities in future.
- ***Future expansion:*** It should take care of growth problem. May be large, open spaces can offer easy re-constructability, so that they could be reconfigured to meet future needs.
- ***Disaster mitigating structure:*** In order to reduce the impact of future disasters, there is a need to put in place very comprehensive guidelines for reduction of vulnerability to natural and manmade disasters.
- ***Aesthetics:*** Any important building, especially buildings like library, which have historically responsibly carried the wand for land mark buildings, requires making strong aesthetical statements.

6.2 RECOMMENDATIONS:

The design guidelines are recommended for every types of library like academic, public or private libraries. Recommendations for future libraries are like improving spaces for study, enabling collaboration and connections across different disciplines, making the discovery process more powerful. Need for considerations of different climatic regions are highlighted. All kind of library design can be analyzed by LIB-ED, structured model, which has all parameters of modern library designing. LIB-ED is the basic analytical model, covering multi-design criteria of modern library design to address new paradigm, like environment responsive built form planning issues, enabling digital environment and advanced building services. This is followed by 3 flowcharts, namely: "The planning process", "Digital technology as catalyst" and "Environment responsive strategies". Economic viability is not the part of these proposed guidelines for the time constraint.

6.3 FUTURE RESEARCH AND IMPLICATIONS:

Maintaining the vision of the Libraries' future is important.

- Future research can be done on the field of creative thinking relating to the library design. Setting the right level of creative thinking is important in future.
- Research can be done on the field of improving the quality of space for work.
- Future research can be done on creating some mechanisms for inspiration among the library users. This will be very helpful for designing library. In creating mechanisms for inspiration through social interaction (cafes or through art (exhibits and displays), the library can play an enhanced role in connecting library users with each other and each others' work.

GLOSSARY OF TERMS

REFERENCES

GLOSSARY OF TERMS

Absorption Coefficient	The fraction of the incident sound power that is absorbed by a material on a scale from 0 to 1
BMS	Building Management System is a single, cohesive building management system controlling lighting, HVAC, fire, security, energy use and other facilities.
BOS	Building Operating System.
CO^2 sensors	A carbon dioxide sensor or CO_2 sensor is an instrument for the measurement of carbon dioxide gas. The most common principles for CO_2 sensors are infrared gas sensors and chemical gas sensors. Measuring carbon dioxide is important in monitoring indoor air quality and many industrial processes.
Cooling Capacity	The cooling capacity is the quantity of heat in BTU (British Thermal Units) that an air conditioner or heat pump is able to remove from an enclosed space during a one-hour period.
COP	Coefficient of Performance is a measure of efficiency in the heating mode that represents the ratio of total heating capacity (Btu) to electrical input

Decibel (dB)	The measurement unit used in acoustics for expressing the logarithmic ratio of two sound pressures or powers.
DF	The daylight factor , illuminance/outside illuminance x100
Daylight Aperture	Shaped opening in the exterior surface of a building that is designed to admit daylight.
ECBC	The Energy Conservation Building Code (ECBC), is a document that specifies the energy performance requirements for all commercial buildings that are to be constructed in India.
Efficacy	Ratio of the amount of light energy from a source to the heat content of that energy.
EER	Energy Efficiency Ratio (EER): EER is a measure of efficiency in the cooling mode that represents the ratio of total cooling capacity (Btu/hour) to electrical energy input (Watts).
ETV	Acronym for *Electric Track Vehicle*, a type of transport system utilizing a track, used to move library collection items from the ASRS to the distribution desk or similar location within the library

Ecosan	Ecological sanitation, also known as ecosan or eco-san, is a sanitation process that uses human black water and sometimes immediately eliminates fecal pathogens from any still present wastewater (urine) at the source. The objectives are to offer economically and ecologically sustainable and culturally acceptable systems that aim to close the natural nutrient and water cycle.
Frequency	A descriptor for a periodic phenomenon. The frequency is equal to the number of times that the pressure wave repeats in a specified period of time. In the case of sound, frequency is measured in units of Hertz (Hz), which correspond to one cycle per second
Fire extinguishers	A fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.
Fire Sprinkler System	A fire sprinkler system is an active fire protection measure, consisting of a water supply system, providing adequate pressure and flowrate to a water distribution piping system, onto which fire sprinklers are connected.
GRIHA	GRIHA, an acronym for Green Rating for Integrated Habitat Assessment, is the

National Rating System of India. GRIHA has been conceived by TERI and developed jointly with the Ministry of New and Renewable Energy, Government of India. It is a green building 'design evaluation system', and is suitable for all kinds of buildings in different climatic zones of the country.

HDL — Hybrid libraries are mixes of traditional print material such as books and magazines, as well as electronic based material such as downloadable audio books, electronic journals, e-books, etc.

Illuminance — Illuminance is the total luminous flux incident on a surface, per unit area.

Laneway sunshades — The sunshade blades, solar shielding devices. These blades protect from solar penetration and glare.

LEED — Leadership in Energy & Environmental Design (LEED) is an internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies intended to improve performance in metrics such as energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and

	sensitivity to their impacts.
Light Shelf	A device located at the bottom of a clerestory that captures direct sunlight by reflecting it off the top of a plane that extends into the space.
LPD	Lighting power density, a measure of the amount of light in a given area; often used to set a limit on the brightness of external lights.
Low voc	A material that is low-voc emits low volumes of Volatile Organic Compounds, which are harmful to human health. VOCs are common in paints, primers, sealants, glues, and many other products containing chemicals.
Low-Flow Fixtures	Low-flow fixtures are plumbing fixtures that use significantly less water than conventional fixtures. They include toilets, urinals, showerheads, and faucets. Typically, a low-flow fixture will reduce water consumption by at least 20% when compared to conventional fixtures. That translates into measurable savings in both water expenses and sewage expenses, as well as a savings in the energy used to heat the water.
LON	Local Operating Network.

MoEF	Ministry of environment and forest
Noise Criteria (NC) Curves	A set of spectral curves used to obtain a single number rating describing the "noisiness" of environments for a variety of uses. NC is typically used to rate the relative loudness of ventilation systems.
Noise Reduction Coefficient (NRC)	A single number rating of the sound-absorption of a material equal to the arithmetic mean of the sound-absorption coefficients in the 250, 500, 1,000 and 2,000 Hz octave frequency bands rounded to the nearest multiple of 0.05.
Occupancy sensors	Occupancy sensors are sensing devices commonly connected to a room's lighting but also occasionally to heating or ventilation, which shut down these services when the space is unoccupied.
Passive strategies	Use natural energy (sun, wind, etc.) to conserve conventional energy for achieving thermal comfort.
Physical Library	A physical library is a collection of sources, resources, and services, and the structure in which it is housed
Reverberation	An oscillation in pressure, resulting from molecular motion, in a viscous or elastic medium such as air, water, wood, steel, etc. (2) Sound is an

	auditory sensation evoked by air molecules vibrating in a frequency range between 20 Hz and 20,000 Hz
Renewable materials	Products that are made of raw materials that replenish themselves within a ten-year cycle. An example would be bamboo, which replenishes within one growing season, and can be used to make an alternative to wood flooring or paneling.
SAV	Surface area to volume ratio, is the amount of surface area per unit volume of an object or collection of objects.
Sound Insulation	The capacity of a structure to prevent sound from being transmitted from one space to another. (2) Insulation used in a wall, floor or ceiling cavity to add damping and decrease transmitted sound. (See Sound Transmission Loss.)
Smoke detector	A smoke detector is a device that detects smoke, typically as an indicator of fire. Commercial, industrial, and mass residential devices issue a signal to a fire alarm system, while household detectors, known as smoke alarms
STC	The standard way of describing sound isolation of constructions is a metric called STC, or Sound Transmission Class. The STC rating of a wall, floor or ceiling is determined by the components

	of the construction and how they are assembled.
TR	Building cooling demand
Turbo ventilators	Turbo-vents work up the hot air from inside the building by natural convection.
U-Value	U-Value is the measure of the rate of heat loss through a material
Virtual Library	Library in which collections are stored in digital formats (as opposed to print, microform, or other media) and accessible by computers. The digital content may be stored locally, or accessed remotely via computer networks.
Venturi effect	The Venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section of pipe.
VRV	VRV system is centralized unitary system in which refrigerant low changes according the building load
WWR	The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area.

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