COST REDUCTION THROUGH OPTIMIZATION OF HOUSING ELEMENTS

Critical Analysis for North West Plain Regions

A DISSERTATION

Submitted in partial fulfilment of the
requirement for the award of the degree
of
MASTER OF ARCHITECTURE

By

GAJENDER MEHTA

DEPARTMENT OF ARCHITECTURE & PLANNING
UNIVERSITY OF ROORKEE
ROORKEE (INDIA)

May, 1990

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled, "COST REDUCTION THROUGH OPTIMIZATION OF HOUSING ELEMENTS, CRITICAL ANALYSIS FOR NORTH WEST PLAIN REGIONS" in partial fulfilment of the requirement for the award of the Degree of M.Arch, submitted in the Department of Architecture of the University is an authentic record of my own work carried out during a period from Sept. 1989 to May 1990 under the supervision of Prof.Vishwa Mitter.

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

(GAJENDER MEHTA)

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

(Vishwa Mitter)
Professor
Department of Architecture
University of Roorkee
Roorkee - 247 667
India.

ACKNOWLEDGEMENTS

First of all, I wish to express my deepest gratitude to Prof. Vishwa Mitter for his consistent guidance in preparation of this dissertation, without which it could not have been possible to go into depth of the subject.

My sincere thanks also goes to Prof. K.C.Kambo, Head of the Department of Architecture and Planning for the encouragement, which has been of great help to me.

Further, I am indebted to Prof. Najamuddin, Prof. A.J. Contractor, Thesis Co-ordinator and other faculty members, for the help extended to me, from time to time, during my stay at the Department.

The help and co-operation extended by the Architects of Development authorities Housing Board and Scientist of C.B.R.I. for permitting liberal use of their drawings and data, is gratefully acknowledged.

It is not possible to acknowledge individually the assistance rendered by my colleagues and friends during the course of studies but nevertheless I thank them all for their active co-operation and timely help.

To my wife, I have to thank especially for her constant encouragement, inspiration in this regard.

GAJENDER MEHTA

CONTENTS

*****

LIST OF PLATES

CHAPTER-1

INTRODUCTION

Food, shelter and clothes are the three basic needs of a man. Where food is essential for the existence, shelter is equally important to live in. In fact whether it is slum dweller or a man from high income group, shelter is required in one form or other.

In fact two types of housing problems exist in our country today. First one is the shortage of houses which is being handled at every level with the help of government agencies and second one is the provision of houses within the affordable limit.

Affordable limit of people is very less in India being a poor country. Hence this factor must be kept into mind while suggesting anything in this direction. Truelly speaking right from economically weaker section to M.I.G. category, the people are just struggling to get the houses within their budget.

Despite of involvement of many agencies such as development authorities, housing boards and research organisations on this aspect, these two colossal problems are still unsolved. Housing finance is being allocated in the budget every year in our country, but the same state of affair remains. There is not even a single place, where one does not find this problem. Government has invested so much amount in establishing the housing boards and development authorities with the sole aim to do something on this aspect, then why are they not providing themselves to the satisfaction of the common man ? Thus likewise there are many quarries which need attention and demand answer.

Even in a private sector, one does not find different picture. People there are just confused and simply guided by the contractors and masons. The basic reason for such a confused state of affair is the lack of economical planning guidelines, and lack of knowledge related to the analytical study on various cost reduction elements for arriving at the optimum solutions.

My thesis is just aimed at answering them and then suggesting the guidelines for optimum solutions of cost reduction parameters so that the same may be useful to every body wishing to have an affordable house.

Its aim is also to ignite the architects, engineers and above all a common man about the need of the optimization means for reducing the cost of the building.

1.1 IDENTIFICATION OF THE PROBLEM

1.1.1 Urban Housing Situation in India :

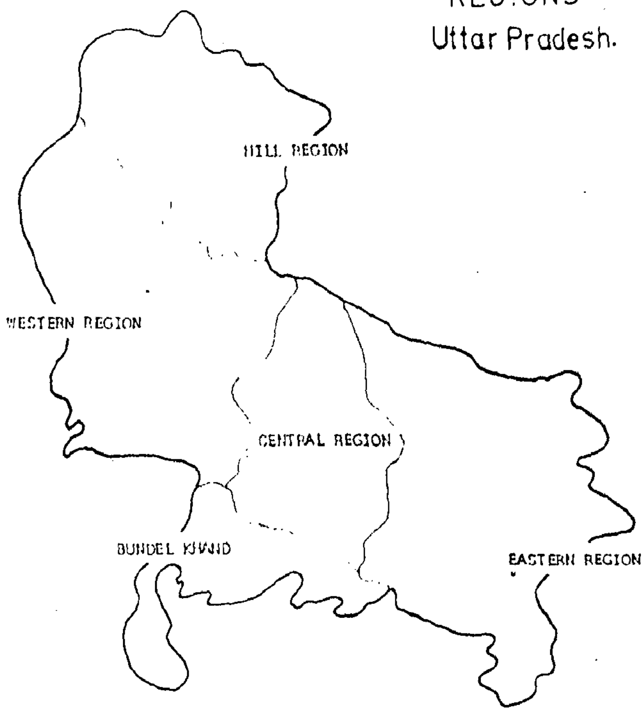
India is a vast country with the population of about 80 crores. Out of this population, about 73 % live in villages and 27 % in urban areas. In this dissertation I will not speak anything about the rural situations where problem is some what of different nature but in urban context, it can be considered as very complexed one beyond any doubt. To understand more clearly it is necessary to analyse this aspect at city, town and subtown levels. Whereas in cities and metro-cities, the cost of land and its availability, population, pollution, cost of material and labour due to continuous growth of industries have greater impact on the cost of the building, the towns and subtowns bear altogether different picture. Some of these can be cited as illiteracy, non availability of good material, non availability of skilled labour, transportation problems, lack of scientific and technical knowledge and so on. India is facing two types of problems today, first one being shortage of housing and second one is the affordable cost of housing which can be clearly observed from the table so it can be said without any doubt that rising cost of the building is one of the main reasons for the first one problem. Rise in cost of building is due to no. many factors. The most important ones are the cost of land, cost of land development and services, cost of labour and material and cost of overheads. So there is a need to analyse the problem more minutely keeping the above factors into mind. So if suitable cost reduction measures are adopted, 70 % of the shortage of the housing problem can be resolved without much difficulties.

1.1.2 Urban Housing Situation in North West Regions Especially Western U.P.

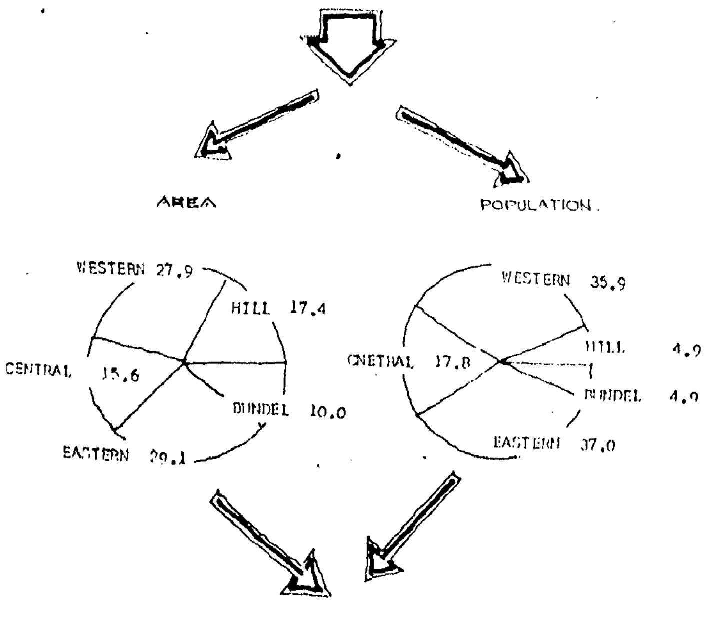
North west region is one of the thickly populated area in whole of the country. It is very much clear from the fact that population of U.P. alone is 88.3 million accounting for

STUDY

REGIONS
Uttar Pradesh.

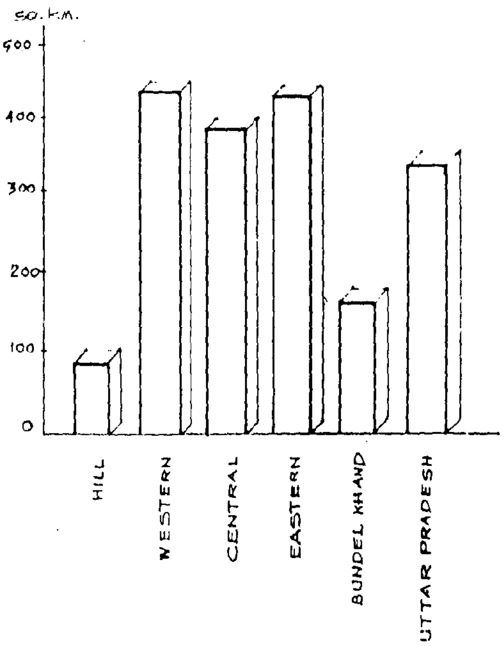


DISTRIBUTION



U·P REGION

DENSITY OF POPULATION.



16.1 % of the total population in the country. It has an area of 294,413 sq.km which is 9 % of total area of country. It has density of 300 person per sq.kilometre as per 1971 census report. Whole of the U.P. is divided into five regions i.e. hill, western, central, eastern and Bundelkhand as is illustrated in the table also which clearly shows that western region is more thickly populated than any other regions. As per 1971 census, percentage of literacy in U.P. is only 21.7 % as against in all India average of 29.0 %.

The percentage of people below poverty line in urban area is 45.94 %. So looking at these statistics, it can be observed that tackling of housing problems in this region will be different than other part of the country as housing is directly related to the level and percentage of literacy, availability of the good material and skilled labour, use of scientific and technical knowledge etc. In this region housing is being promoted by mainly two public sector agencies i.e. development authorities and housing boards but due to lack of insufficient knowledge and compiled data, they are not able to provide accommodation in time and in affordable limit though these agencies are well equipped with all kind of technical staff. In private sectors, housing problem is more complexed as due to illiteracy and lack of proper knowledge, people are just confused and can not build their houses within the affordable limit. Though it is very difficult to get the actual statistics regarding the percentage of houses being constructed through public and private sectors independantly but it is a fact that people generally in towns and subtowns where land is no problem, prefer for private construction inspite of the fact that individual housing proves costly due to so many factors. So housing budget is a main tool for a common man rather for every body which he tries to adhere, and which should be kept into mind by the architect engineers and planners while suggesting the housing solutions.

1.1.3 Composition of North West Region (Plain)

North west region comprises of north west plain area of U.P., Punjab, Haryana, Himachal Pradesh and Jammu as shown in map enclosed.

Geographical Aspects

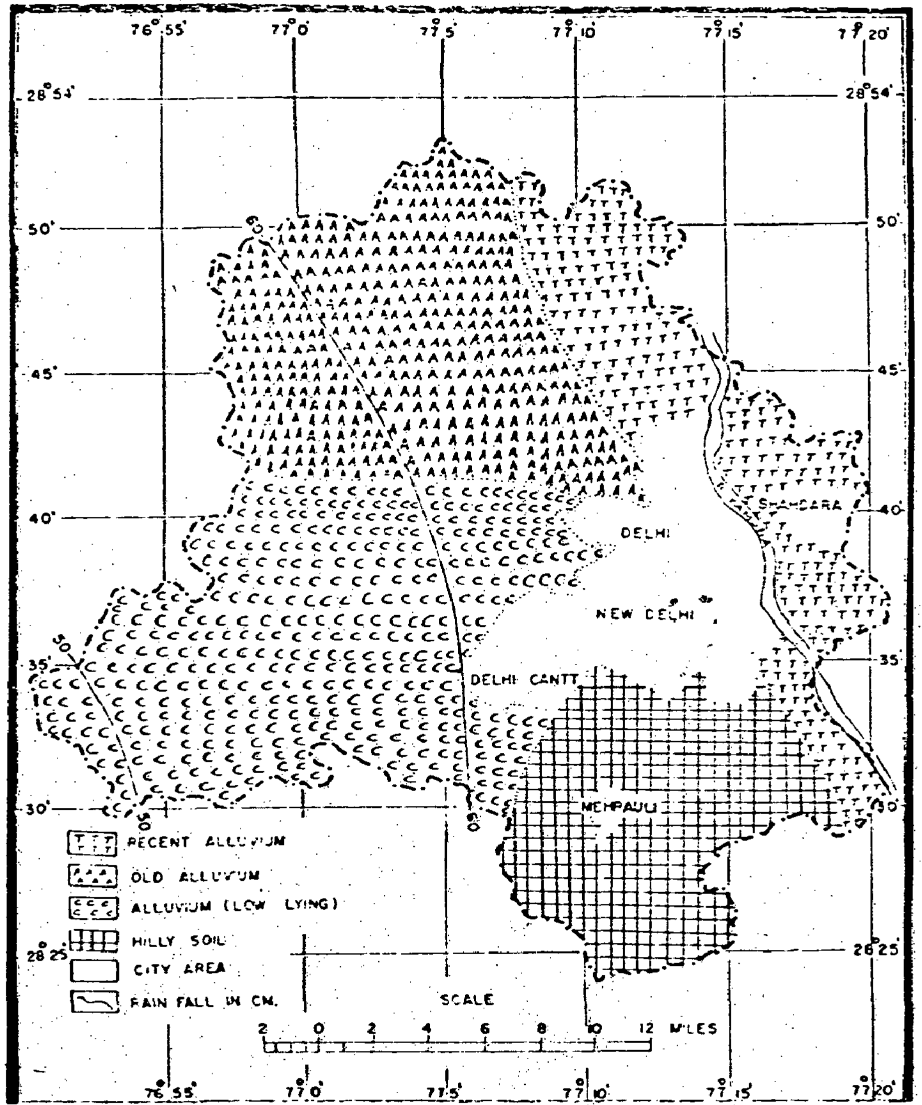
The entire region is surrounded by rivers namely Ravi, Beas, Satulaj, Ganga and Yamuna. So soil is very fertile of this region. The general characteristics of the soil of this region is alluvial clay. Fig M_1, M_2, M_3, M_4 clearly indicate that entire region is dominated by alluvial clay soil. So behaviour of the natural soil remains almost the same.

Social Aspects

One finds interaction in many things in this region such as living style, habits, agriculture, marital relationship, type of houses, material and techniques. Thus one does

SOIL COMPOSITION

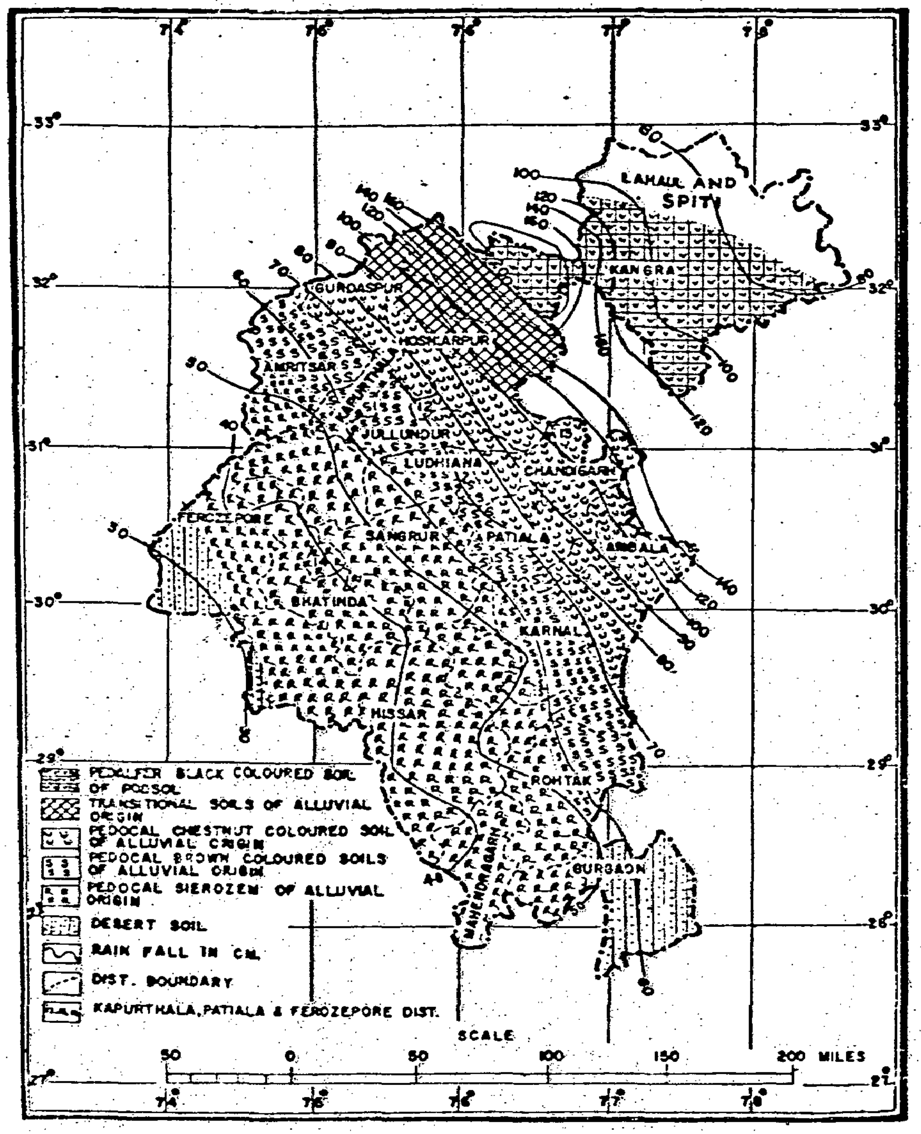
UTTER PRADESH



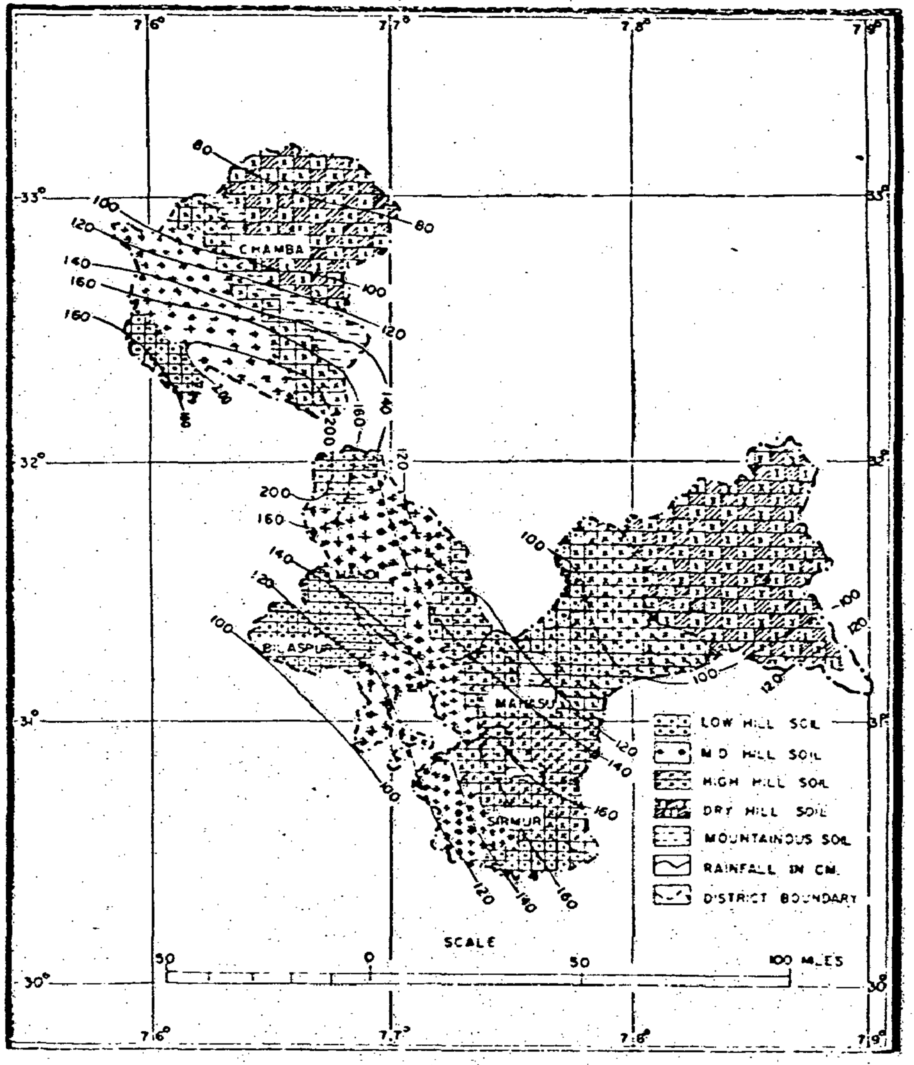
DELHI

P/2

SOIL COMPOSITION



PUNJAB - HARYANA



HIMACHAL PRADESH

not find much difference in house construction activities of this region. Almost in entire region, typical type of houses, material and techniques being adopted by the people can be found.

Climate

This entire region comes under hot dry humid zone. Study of data about the climate of some of the places in this region imparts following information :

1. Height from sea level varies from 218 to 682 m.
2. Temperature ranges between 35^{o} C and 40^{o} C.
3. % humidity lies between average 40 and 80 .

1.1.4 Government Policies

If we look at the previous five year plans and the policies being adopted in regards to housing, it can easily be observed that government main aim is to provide the maximum number of shelters irrespective of their quality. First preference in this regard is economically weaker sections, for whom 70 % of the housing budget is absorbed. Despite of this, all types of subsidy is also given to this category. But inspite of this, percentage of shortage of houses increases every year with a lot of backlog. This has affected other categories of people also such as L.I.G. and M.I.G. for whom provision of housing within the affordable budget is equally important. So maximum time of the policy makers in government agencies is devoted only into the problems of shortage of houses and it appears that they are not able to think beyond this inspite of many international conferences and seminars being held time to time in this context. Government had established the development authorities and Housing Boards to help the common man in this aspect, but inspite of their best efforts, these boards and authorities are not able to put any remarkable dent due to many problems such as finance and availability of knowledge on cost reduction parameters.

Upto fifth five year plan, there was nothing significant in the outlay to promote the housing programme. It was only sixth five year plan which diverted the attention of planners on this aspect though late. With the result, a lot of housing development activity started during the year. It was during this period that activities of Delhi development authority U.P. development authorities and U.P. housing boards came into lime light.

A lot of money was spent in establishment of these public sector agencies, resulting in increase of development cost, thus overall cost of the buildings.

It was only sixth five year plan where we can observe some beginning in the development in housing. Examples are such as housing done by development authorities and Housing Boards. But now in seventh plan we again find some radical change in housing. The development authorities have been asked not to construct the houses but rather to give more emphysis to land acquisition and its development. Perhaps

Table-I

Places	Latitude N	Longitude E	Height above mean sea level in metre
Jammu	$32^{o}44'$	$74^{o}55'$	366
Ludhiana	$30^{o}56'$	$75^{o}52'$	247
Ambala	$30^{o}23'$	$76^{o}46'$	272
Delhi	$28^{o}53'$	$77^{o}12'$	218
Roorkee	$29^{o}51'$	$77^{o}53'$	274
Dehradun	$30^{o}19'$	$78^{o}02'$	682

Source : Climatological and solar data, for India, CBRI, Roorkee.

Table-II

Places	Temperature mean monthly max. temp.				Relative humidity %		Annual rainfall in mm	Wind direction			
	Jan	May	Aug	Nov.	Min.	Max.		Jan	May	Aug.	Nov.
Jammu	18.4	37.7	33.2	25.5	37	82	1069.3	N/NE	N/NE	N/C	N/NE
Ludhiana	19.4	40.1	34.9	27.4	41	82	691.1	C/NW	C/SE	C/SE	C/NW
Ambala	20.6	39.9	34.0	27.8	34	82	837.4	C/NW	SE/C	C/SE	C/E
Delhi	21.4	40.0	33.9	28.4	39	80	666.5	W/C	W/SE	W/SE	W/C
Roorkee	20.2	29.0	32.1	26.4	42	86	1049.5	C/NW	C/SE	C/SE	C/NW
Dehradun	18.9	35.5	29.1	24.1	47	88	2160.0	C/E	C/W	C/SE	C/W

Source : Climatological and solar data for India, CBRI, Roorkee.

Perhaps this has been done after analysing the performance of the public sector agencies.

1.1.5 Concept of Low Cost Housing and Need for Cost Reduction Measures

There are many concepts on low cost housing. According to one, housing which the low income groups can afford, which does not cost more than 2.5 times their present house hold income to build or buy. Yet another concept on low cost housing can be termed as the agglomoration of these dwelling units where in the space available, the expected life span and the available services are either just at the minimum level or marginally below them and which would cater to the needs of the economically weaker sections of the society who are neither able to afford to own a house of their own nor in a position to bear the economic rent, thus involving the element of subsidy.

But in fact it can not be the universal concept of low cost housing. Every body needs low cost house whether it is E.W.S., L.I.G. or M.I.G. So low cost housing in a real sense is one which is conceived through various cost reduction measures affecting the cost of the building without sacrificing the basic needs i.e. function and comfort. If we suggest a $4\frac{1}{2}$'' wall construction to an E.W.S. and 9'' to M.I.G., it can not be termed as cost reduction measure and thus there is a need for such a low cost house which should be suitable fof every category of people. Thus it can be stated without any doubt that only cost reduction measures can help a common man to adjust his budget accordingly well in advance.

1.1.6 <u>Concept of Optimization and Its Significance</u> :

Frankly speaking, there is total confusion in all sections where as cost part is concerned. There is not a single department which is able to provide the house within an affordable limit. Now there is a utter need for the comprehensive approach and it has become necessary to analyse each and every element in housing. But it needs to be tackled from the base itself i.e. dwelling unit.

In fact when we talk about the optimization of any element or parameter, the optimum use of that element is required to be studied and it is possible when one observes different proposals, analyse and arrive at the economical values without sacrificing the basic qualities and functions. Before I say anything else, let me define the optimization and its need. According to me, optimization is nothing but a selection of such parameters out of parameters which are functional, economical in nature and satisfy the basic values of living. For illustration let us take the case of a bed room. We suggest the area of 14 m^2 for a bed room. With 14 sq.m area size of the room may be 2.4x5.8, 2.7x5.18, 3.0x4.66, 3.3x4.24. With these different sizes for same area, critical space analysis is done for other elements, such as cupboard, door and window location type of furniture to be used to judge its best utility. After completing this analysis suitable size is finalised satisfying all basic functions. This final value can be called nothing but the optimum value for size of a bed room.

Likewise optimum values for all components can be calculated. The basic difference between components and housing elements is that component is a broader term whereas element is a term at microlevel.

Optimum value varies from place to place and situation to situation. So the Optimization procedure helps a person in selecting the values according to his requirements.

So it can be said that the concept of optimization is nothing but the critical analysis of a problem to arrive at the suitable solutions.

Significance :

Soaring prices of building material, its wasteful use by the builders due to faulty designing, increasing shortage of housing, less affordability limit of the owners and above all substantial national loss due to material has increased the significance of optimization more not only in India but throughout the world to day.

1.1.7 Identification of Housing Elements :

All housing elements can be put under following broad categories :

1. Land
2. Structural Elements
3. Architectural Elements
4. Services
5. Management Aspect

Land :

In all urban centres land is very important housing element. Cost of land very much depends upon the main three aspects :

1. Location
2. Type
3. Topography

and these are the elements which can further multiply the cost.

Structural Elements

1. Type of structure
2. Foundation
3. Plinth level
4. Damp proof course
5. Walling
6. Plastering
7. Door and window lintels and sun projections
8. Flooring
9. Roofing

Architectural Elements

1. Building form

2. Door and window design

3. Wall projections

4. Internal and external finishing on the walls

5. Parapet wall/M.S.railing

6. Roof projections

7. Cupboards, showcases, design

8. Painting on wood work and iron work

9. Compound wall

10. Planning/Design elements

    a - Space requirement
    b - Circulation area
    c - Combination of dwelling units
    d - Layout plan

11. Grill and gate design

Services

Services are of two kinds :

1. Sanitary and water supply

2. Electrical

Sanitary and Water Supply Services

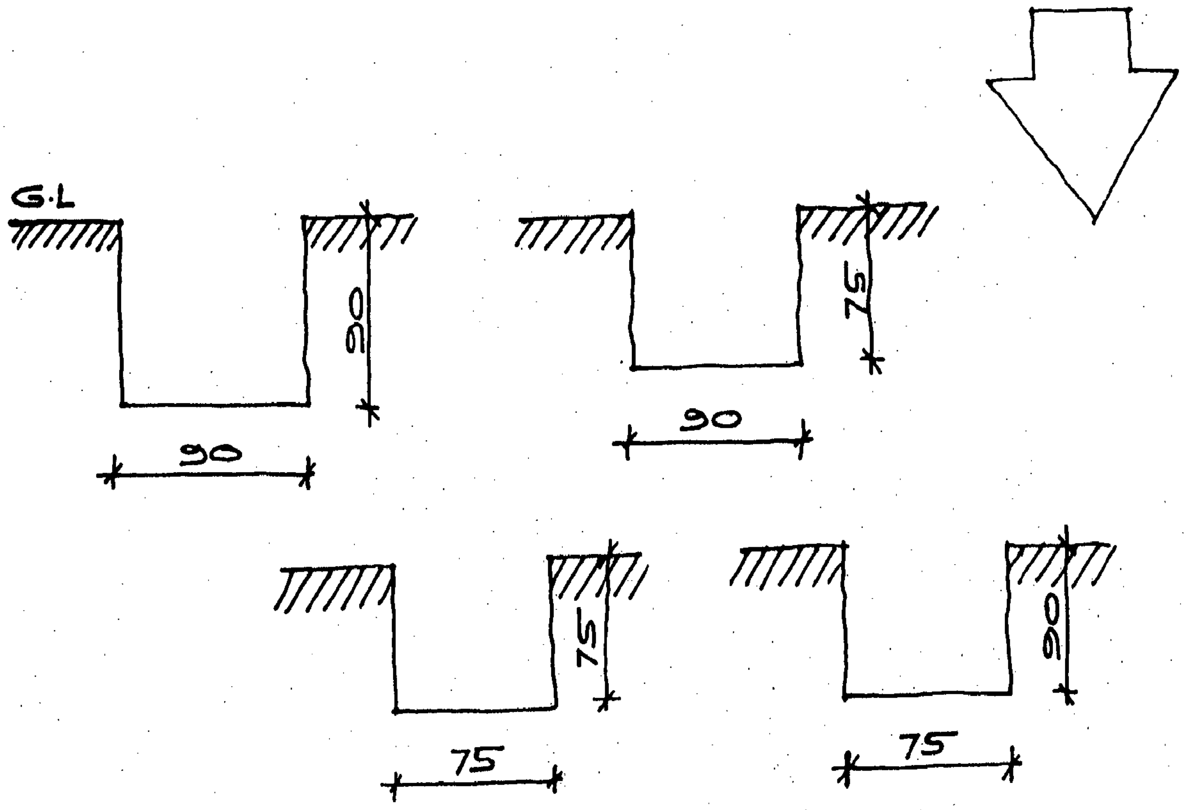
These services are further divided into two categories:

- Internal services

- External services

Internal services are largely related to the internal layout of the fittings and while the external services depend upon the overall layout of the buildings.

FOUNDATION

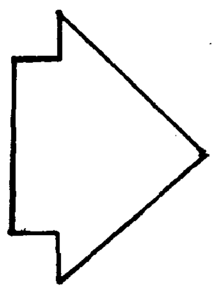


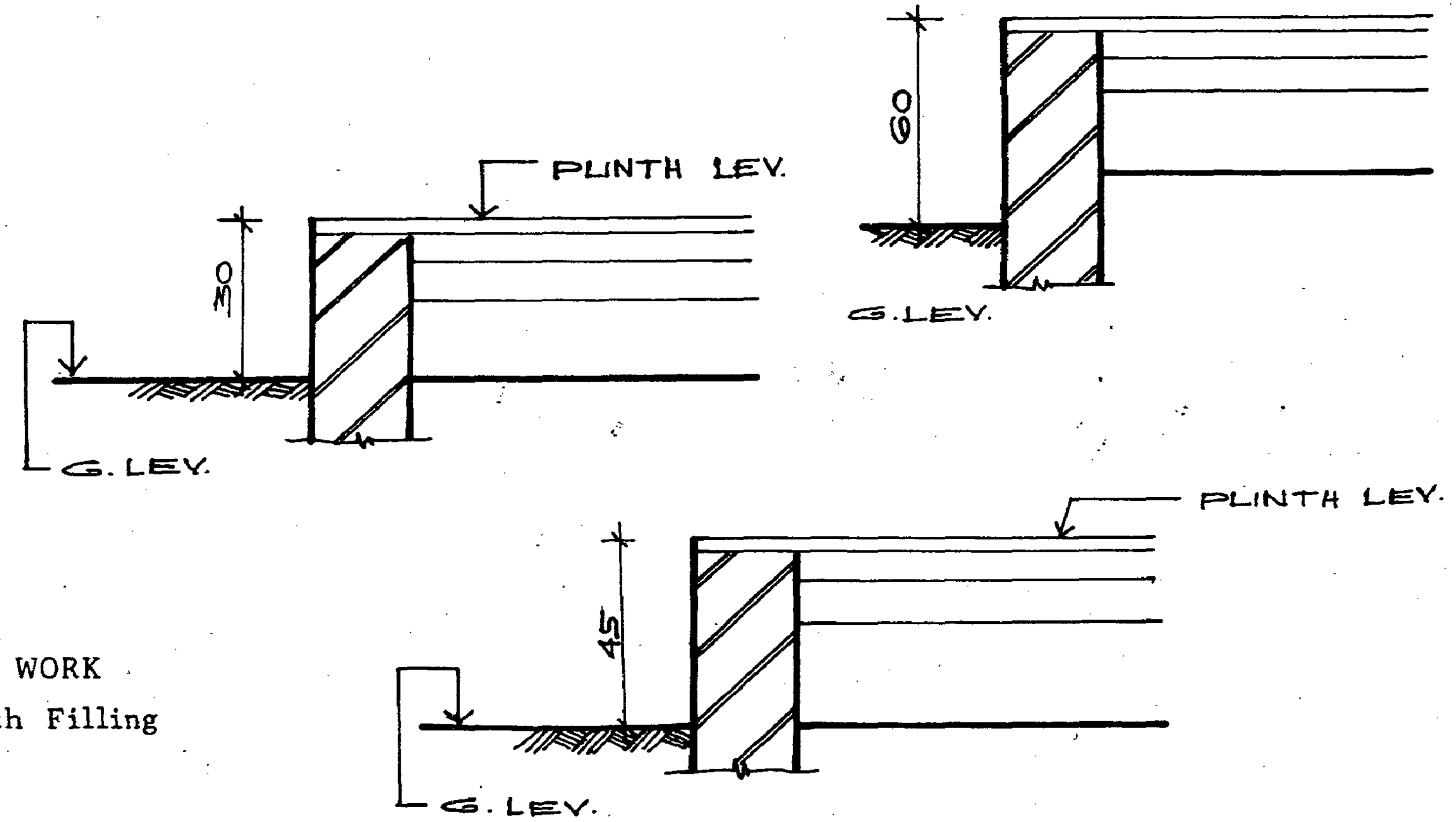
* Have different cost

* Foundation depends upon soil bearing capacity of soil and soil braring capacity varries from place to place.

  In private sector housing, in about 90% case, standard foundation designes are followed, thus affecting the cost. Survey reveals that foundation sizes generally used in private housing are 90 x 90, 75 x 75, 75 x 90, 90 x 75.

PLINTH HEIGHT

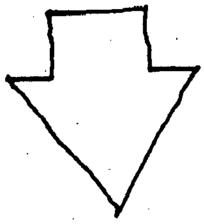


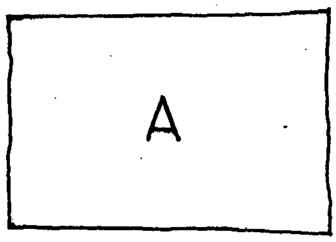


* Increases BK. WORK
* Increases Earth Filling

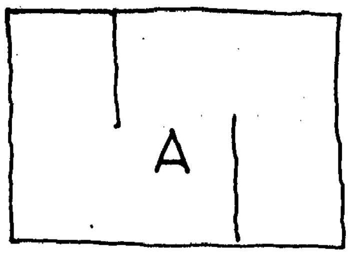
* Gives different cost
* Has substantial impact on cost.

INTERNAL WALLS

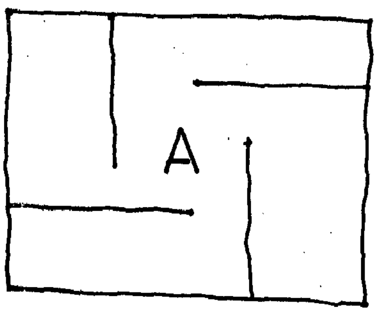




Alt-I,



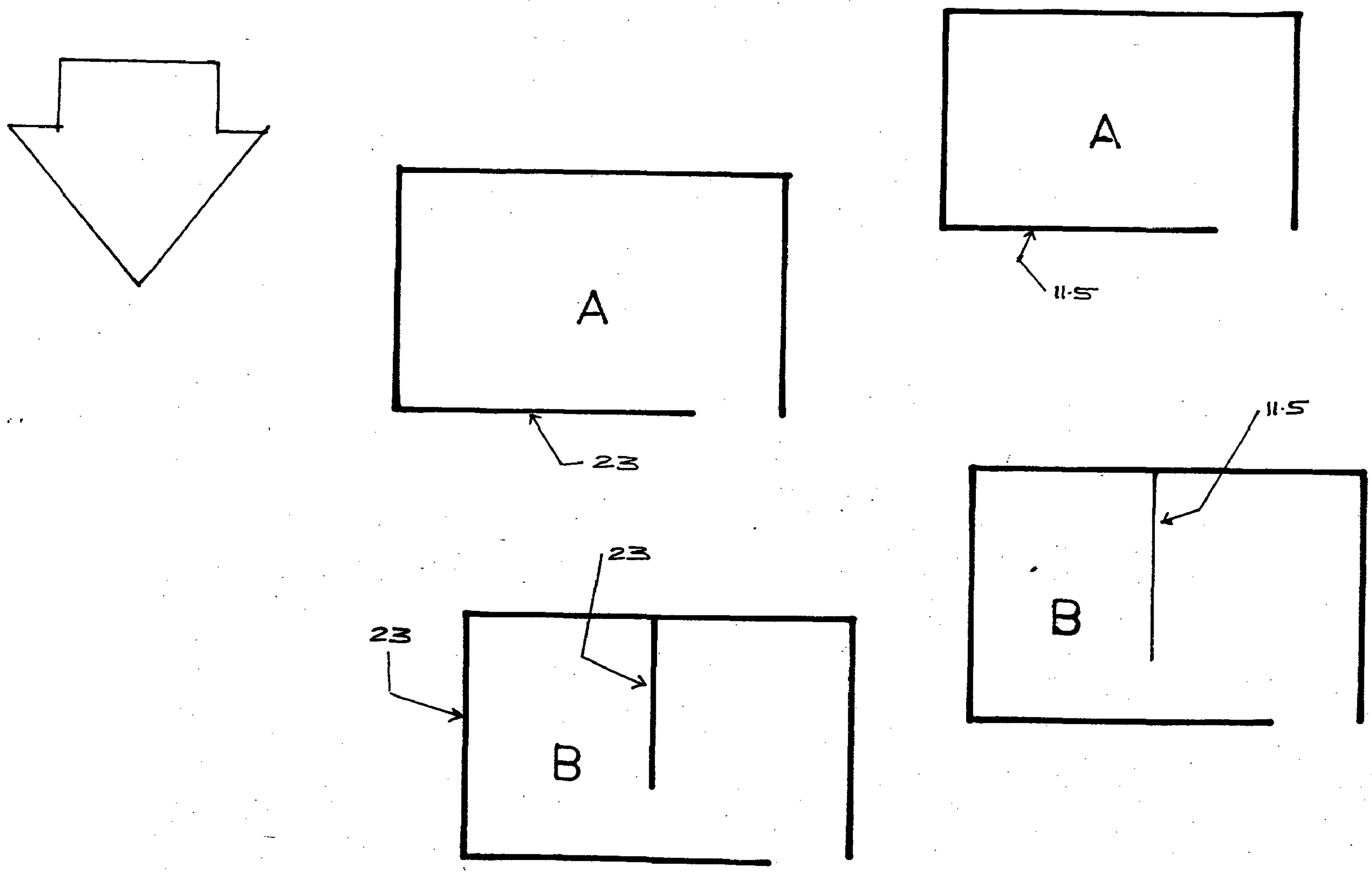
Alt-II,



Alt-III,

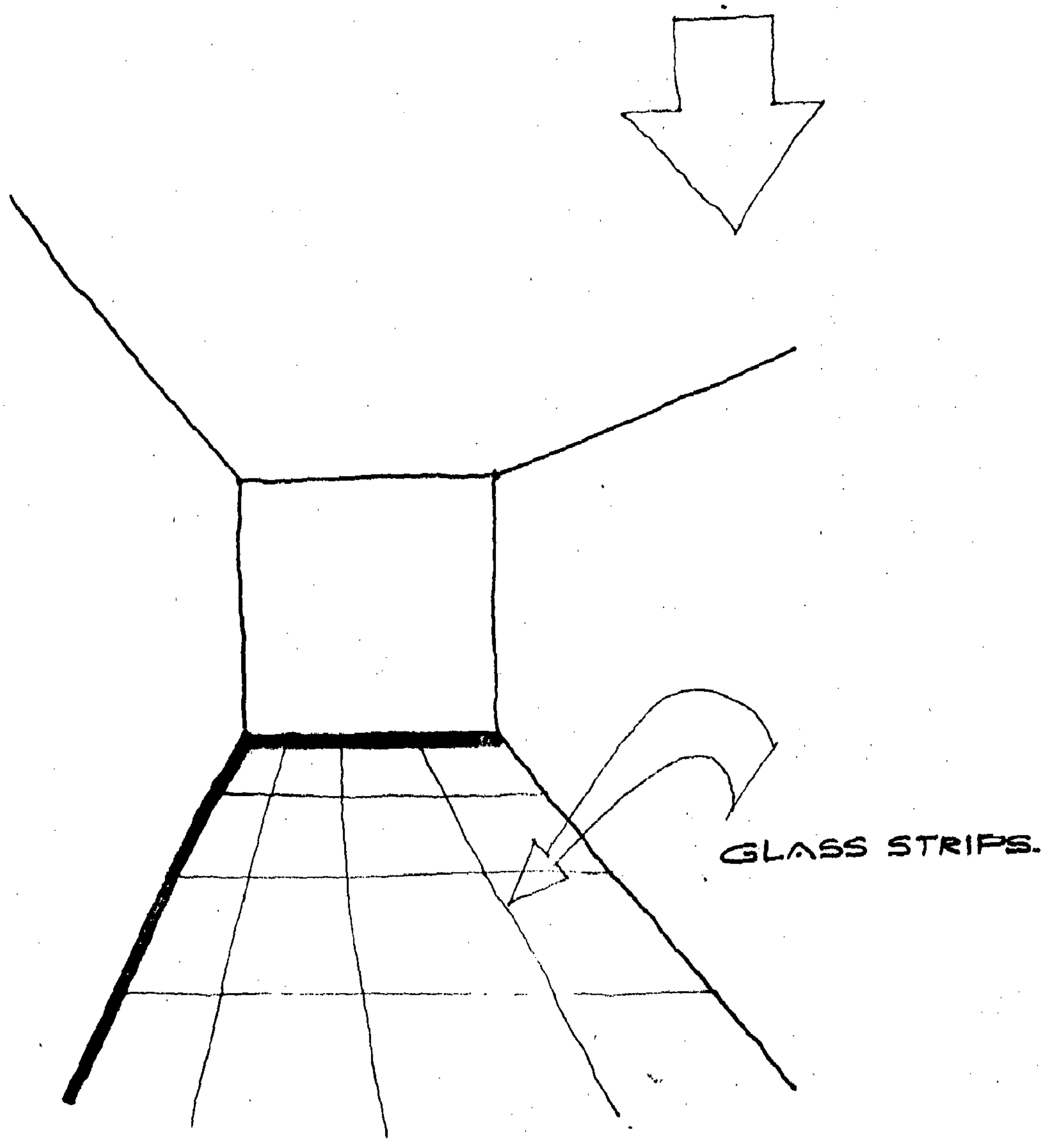
Houses having the same plinth area but with varried internal walling elements shall have different cost.

THICKNESS OF WALL



represent different cost

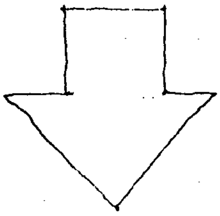
FLOORING

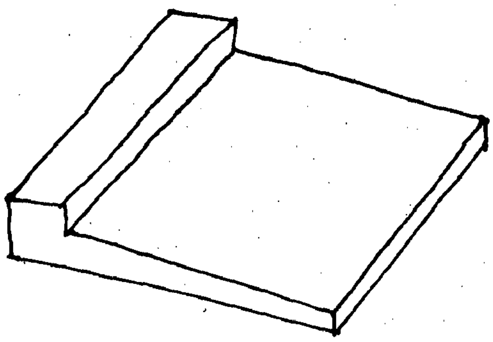


Size of glass strips, pattern of floor, grade of mosaic chips have substantial impact on cost of floors.

DOOR/WINDOW LINTEL

SUN PROJ.



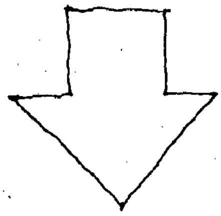


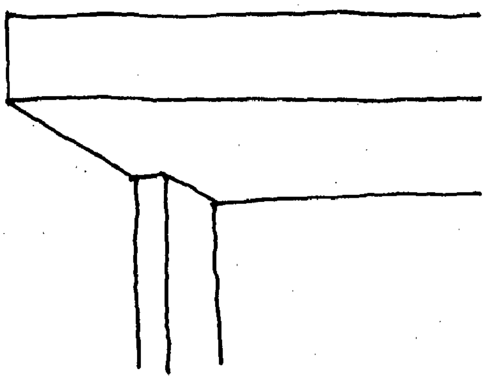
* depends upon the no. of openings

* depends upon the width of opening

* Depends upon the size of sun projection.

ROOFING

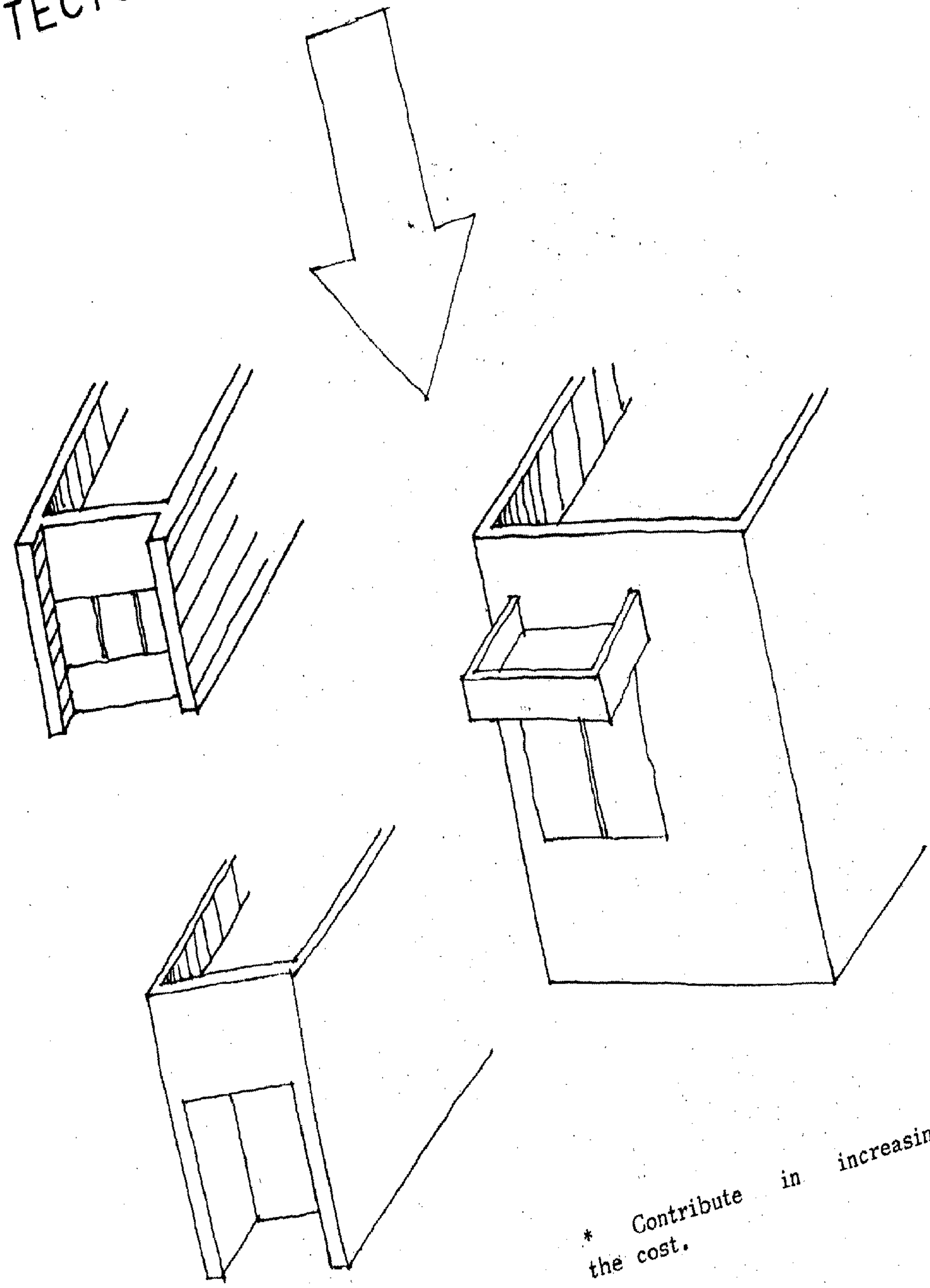




Cost of roofing depends upon type of roofing R.C.C., R.B. or R.B.C., Span, life load, canti lever or wall supported and so on.

Canti levers in roof are more more costly than simply supported.

ARCHITECTURAL FEATURES

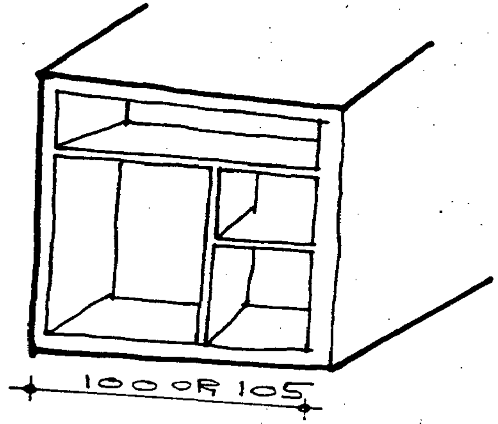


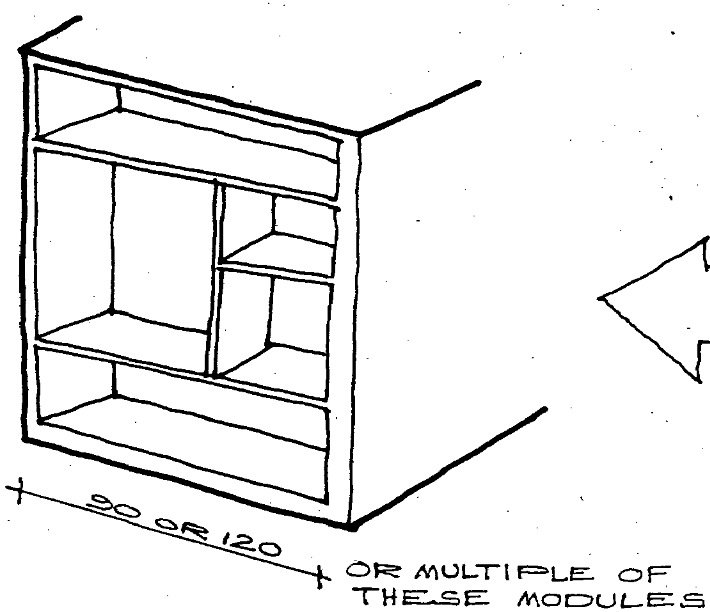
* Contribute in increasing the cost.

CUPBOARD SIZES.

With of the plyboards should be
the governing tool.
there are only two withs available
ie. 90 cm and 120 cm. sn
So the sizes of cupboards should be
according to that.

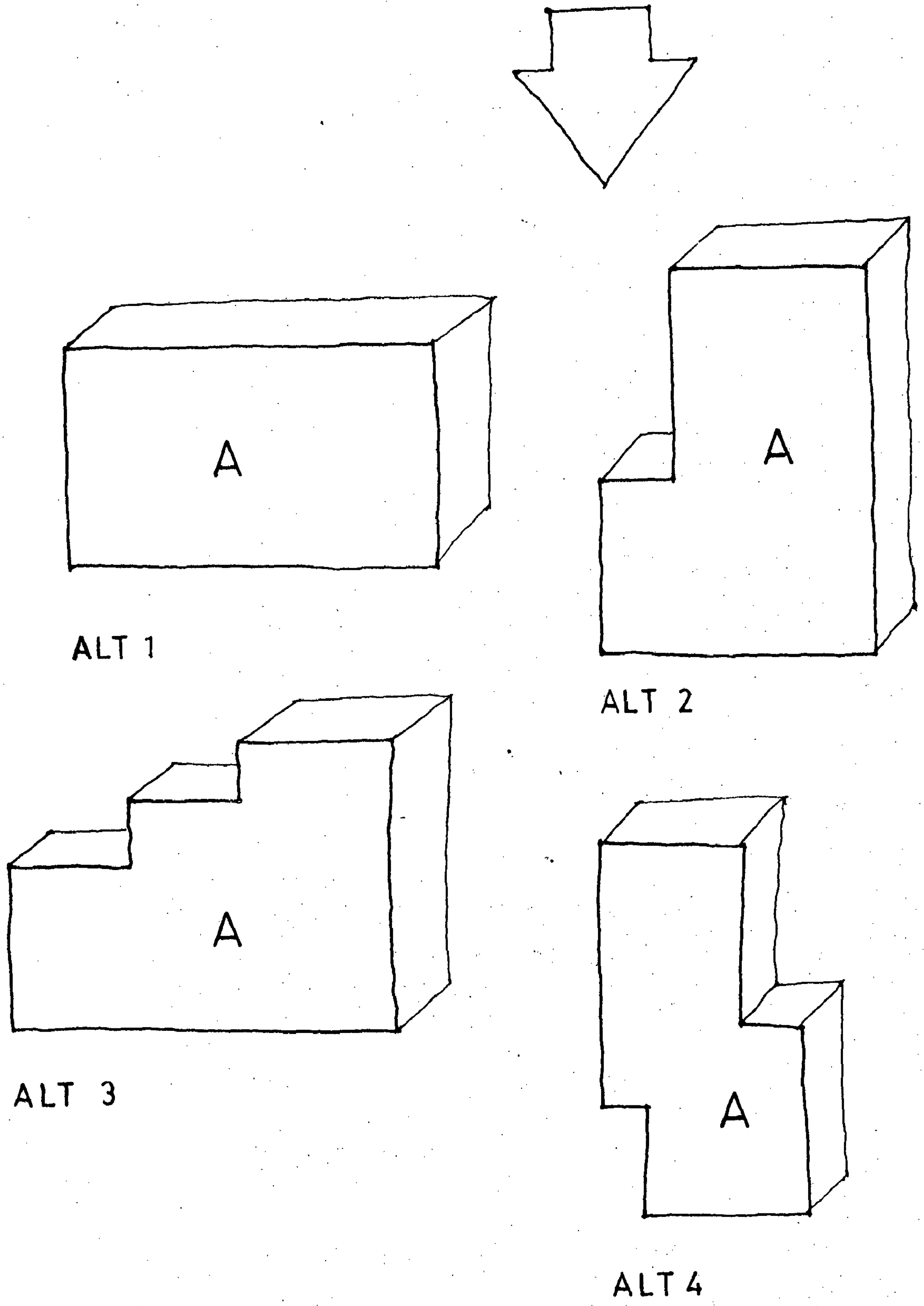
Odd sizes increases cost





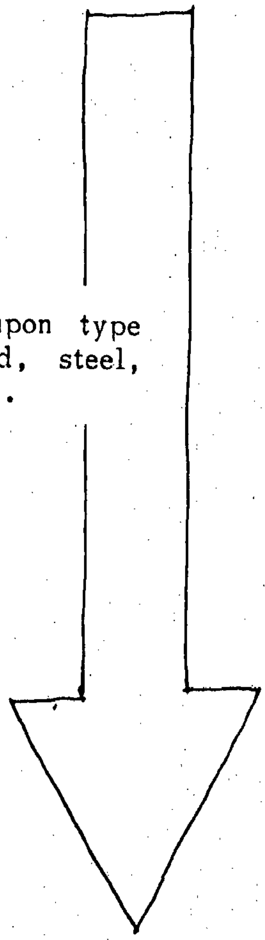
This will reduce the cost
this will reduce the wastage
of ply board , sunmica to a
Great extent.

PLAN FORM



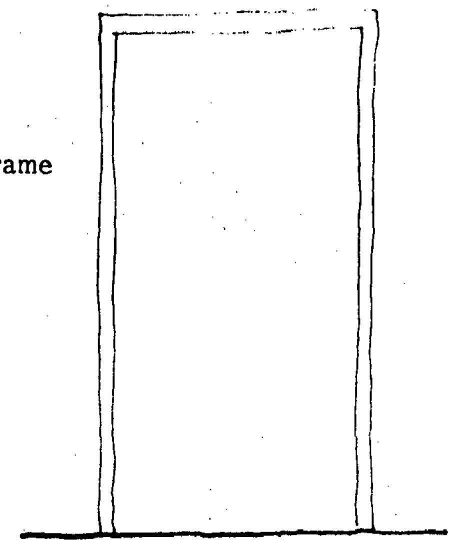
All house plans though having the same plinth area shall have different cost depending upon the plan form.

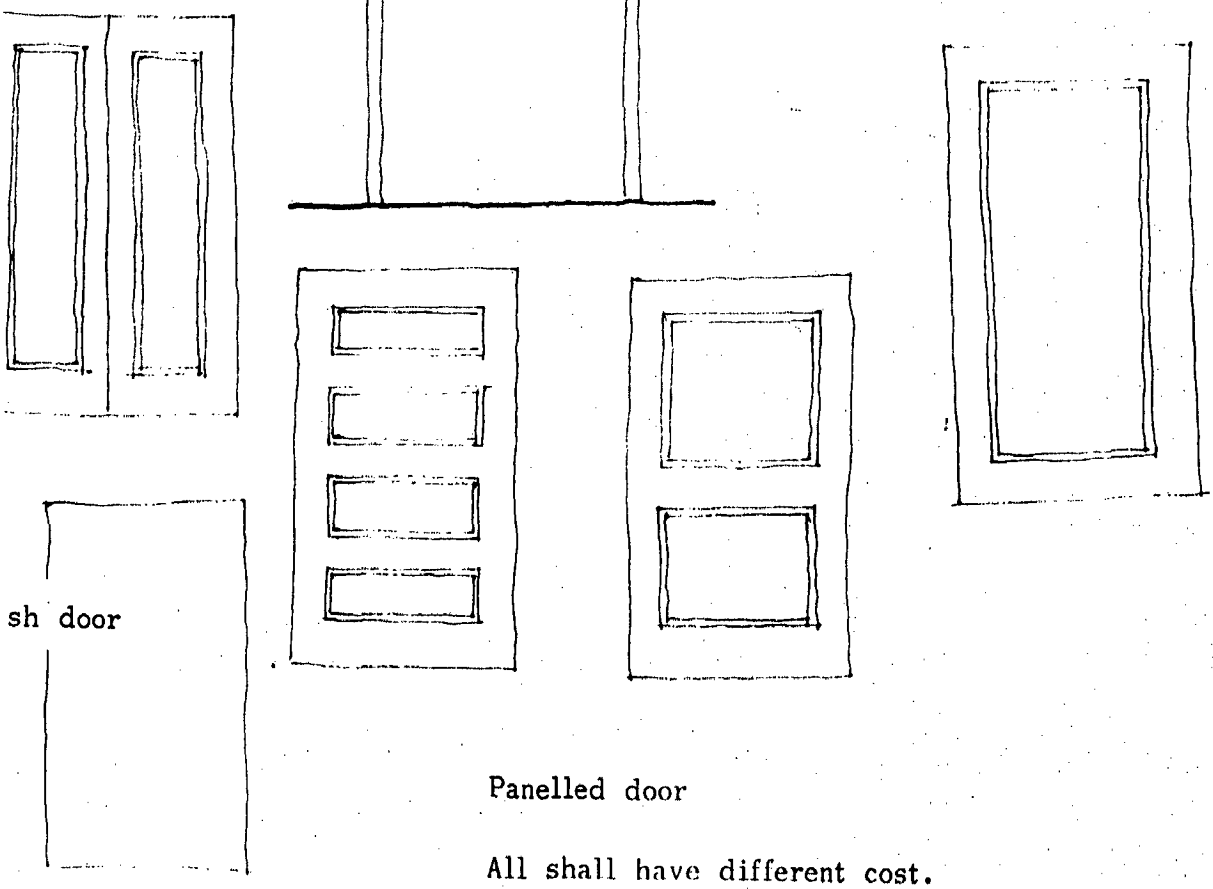
DOOR FRAME / SHUTTER



* Cost of frames depends upon type of material such as wood, steel, concrete and size of section.

Door Frame

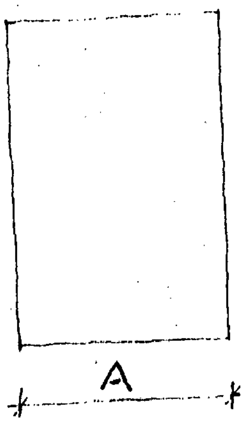


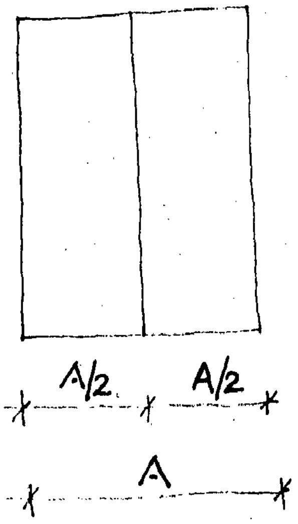


Panelled door

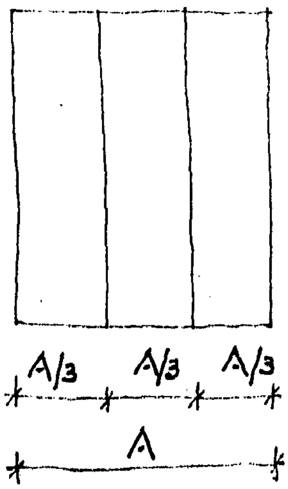
All shall have different cost.

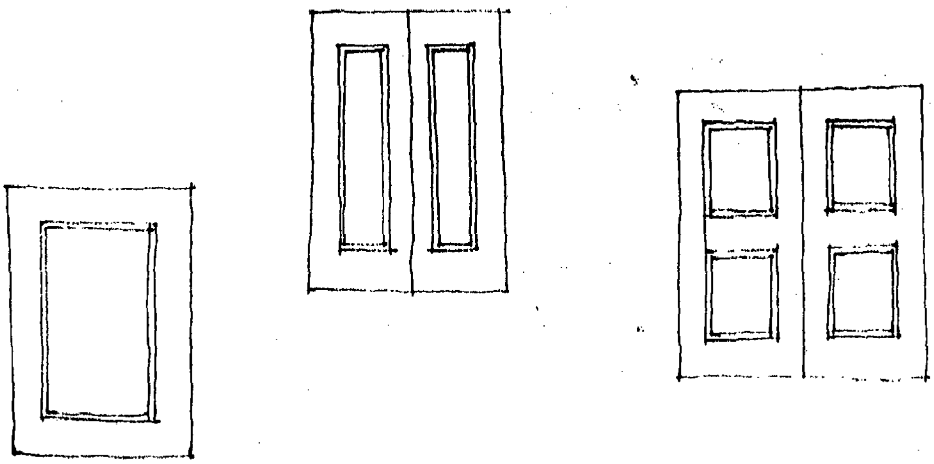
WINDOW FRAME/SHUTTER





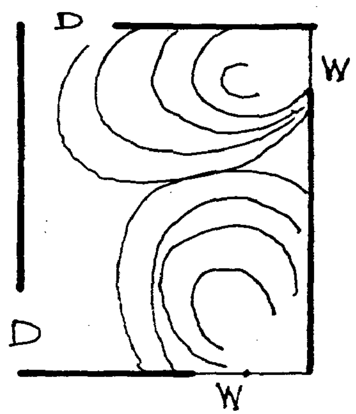
* Gives different cost

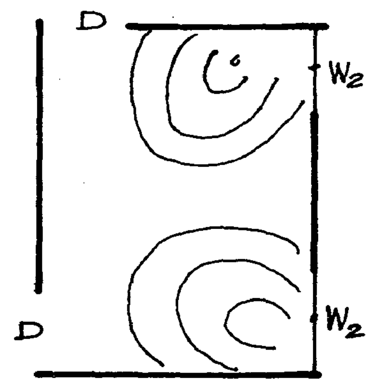


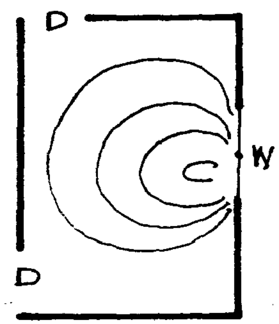


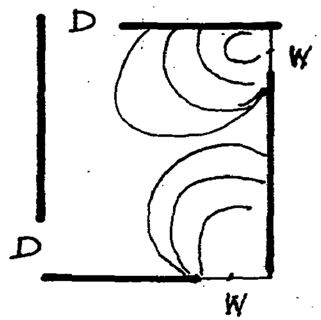
* Has substantial impact on cost.

LOCATIONAL ASPECTS OF WINDOWS



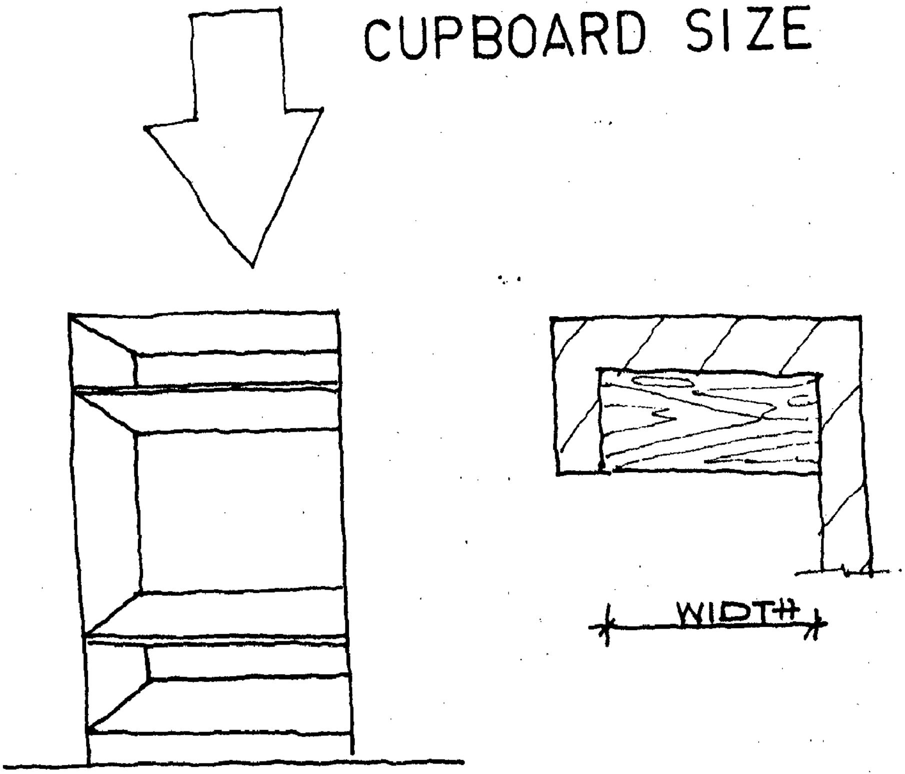






Different location of windows greatly help in determining the size of windows. Thus helps in reducing the cost.

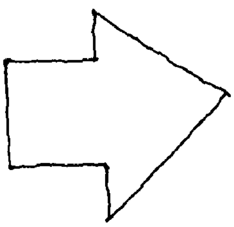
CUPBOARD SIZE



* Each room has at least one cupboard.

Its size and no. has great impact on cost.

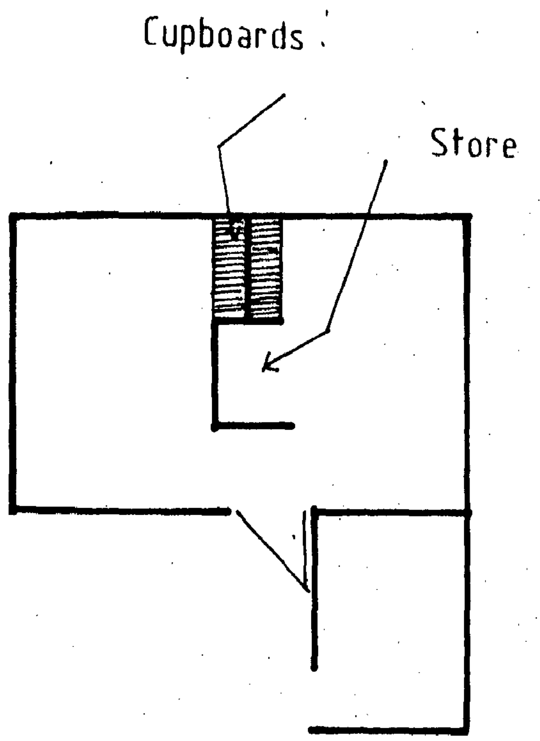
EXTERNAL FINISH OF WALLS

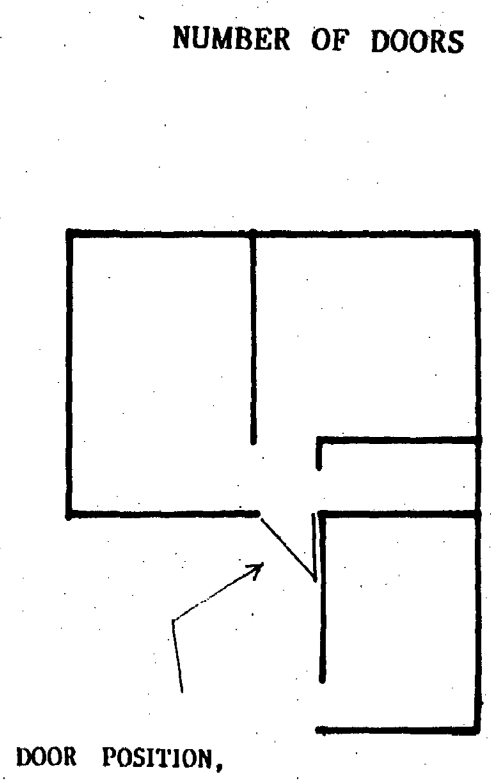


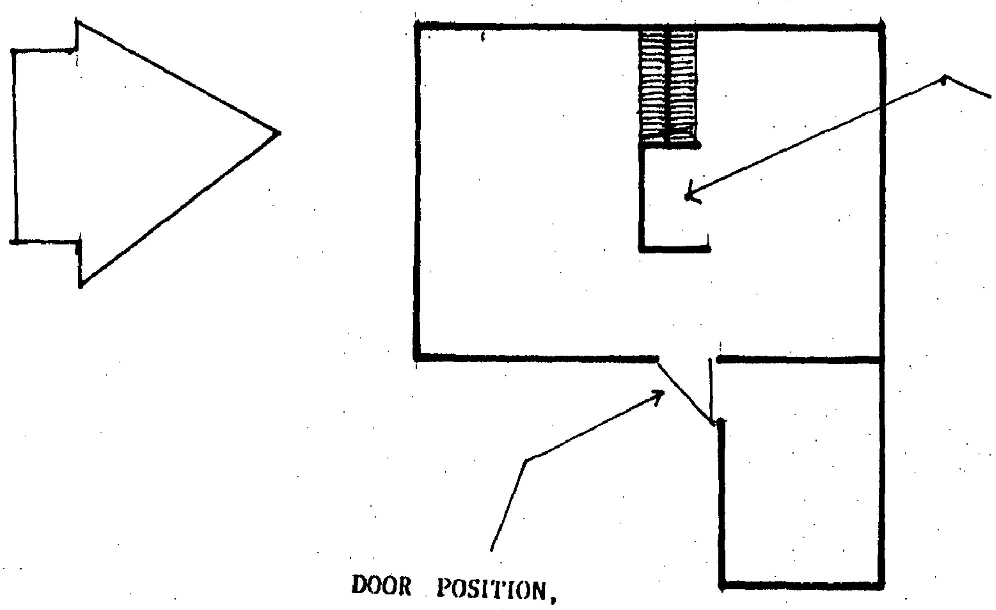
Type of external finish whether

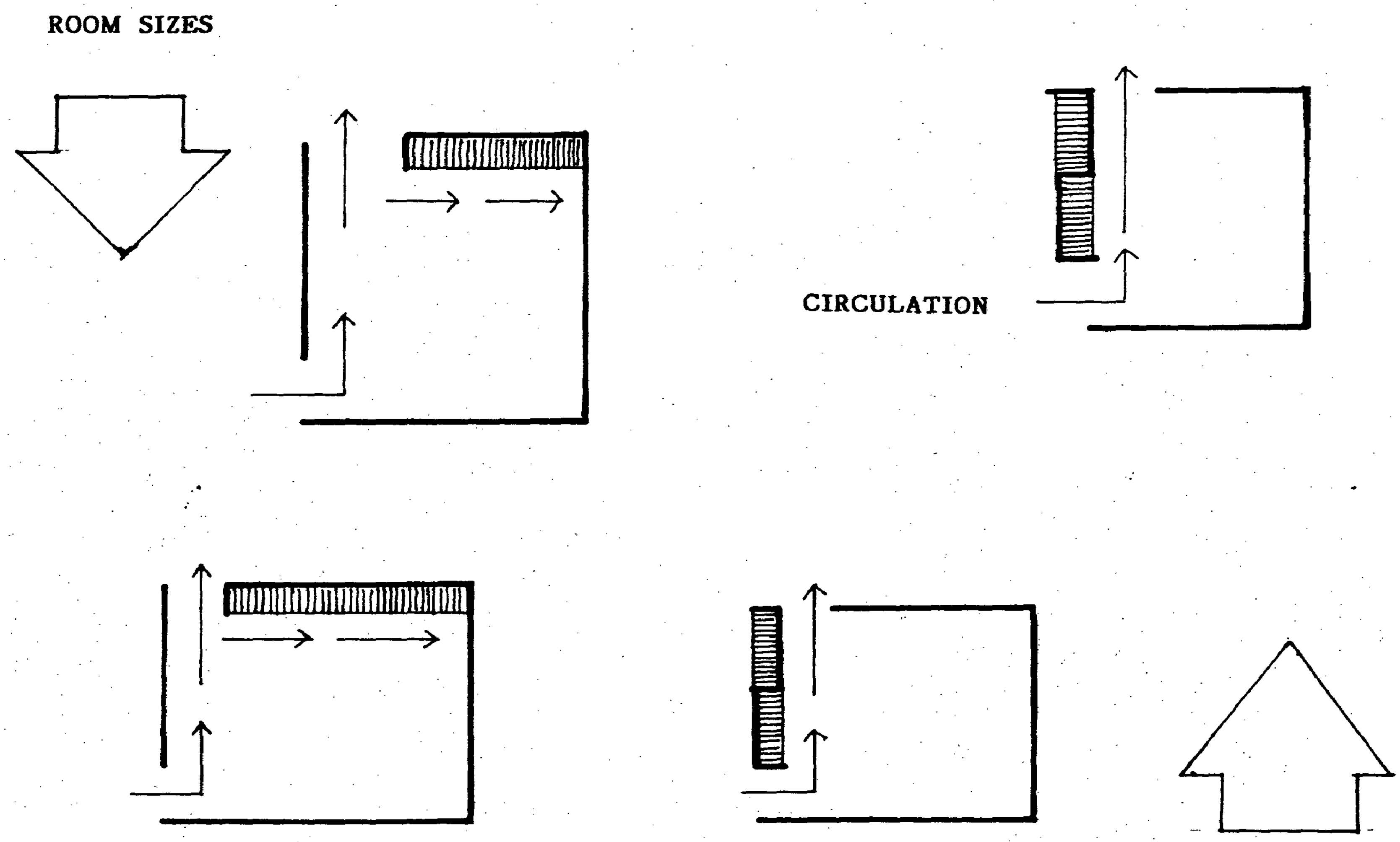
Rough cost, plain or with grooves.

Has direct implication on cost.


Cupboards
Store

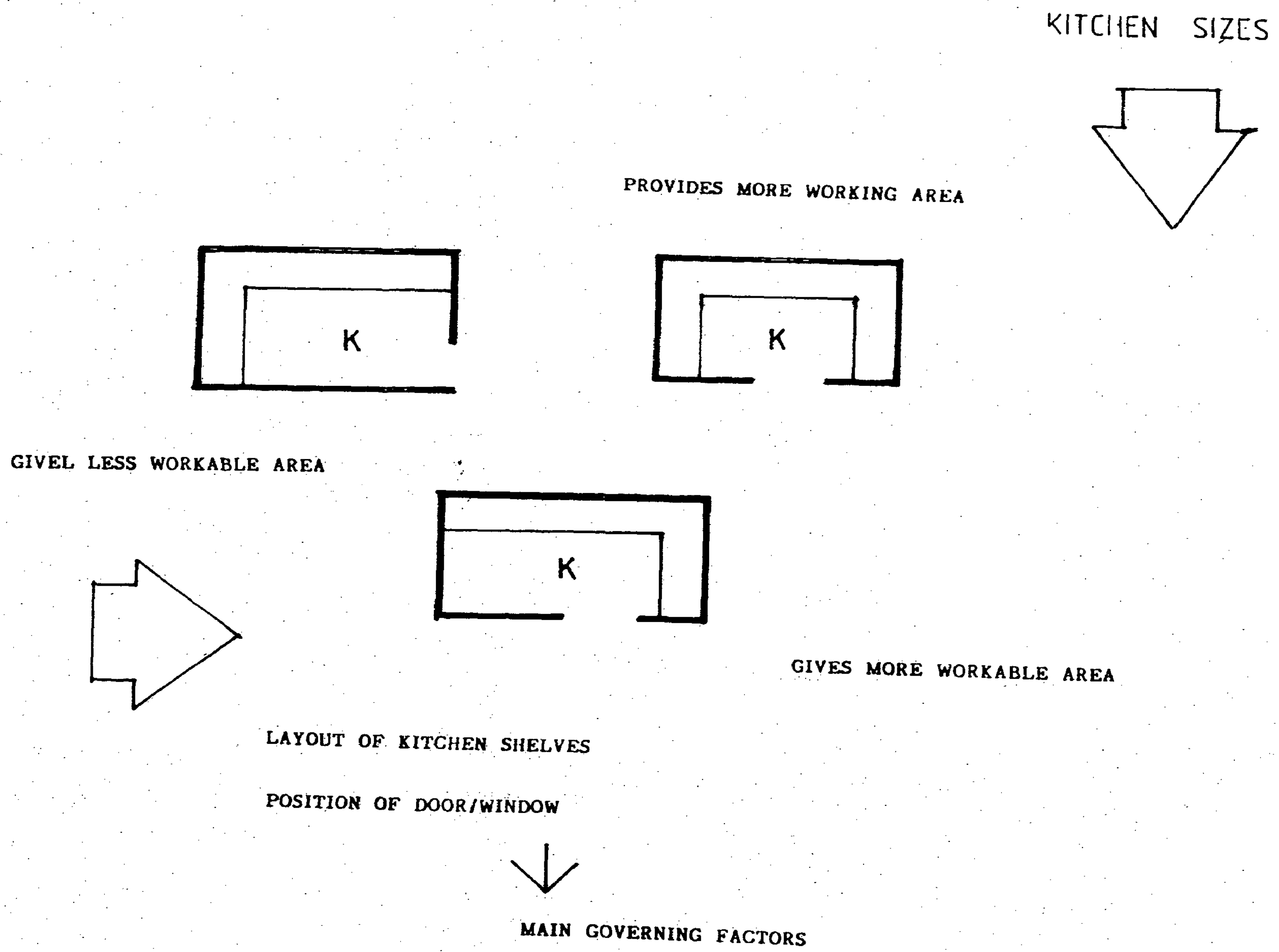

NUMBER OF DOORS
DOOR POSITION,


DOOR POSITION,

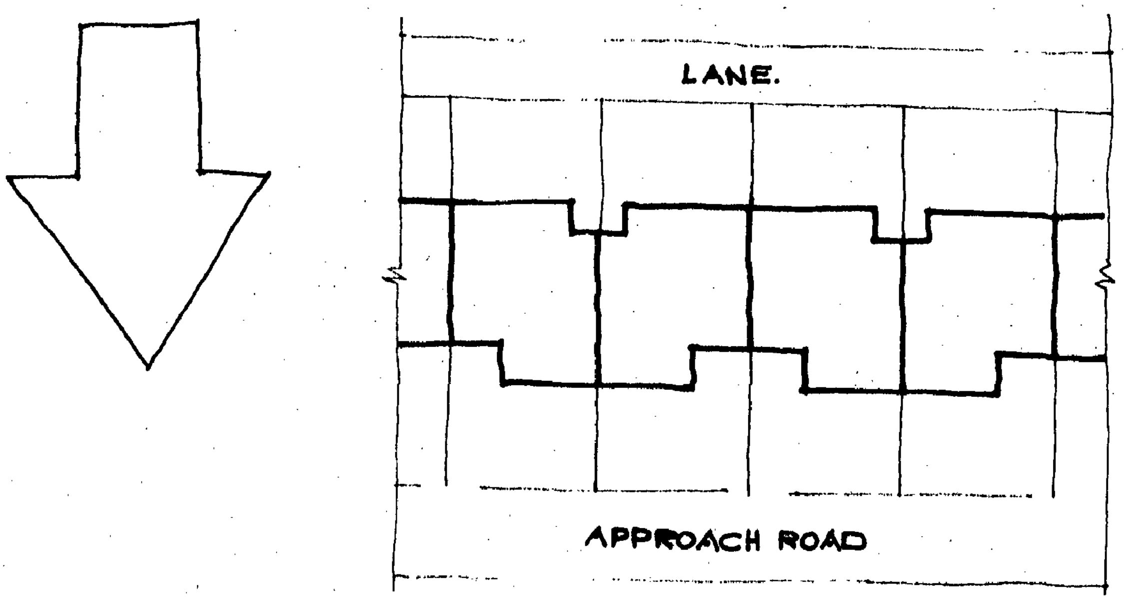


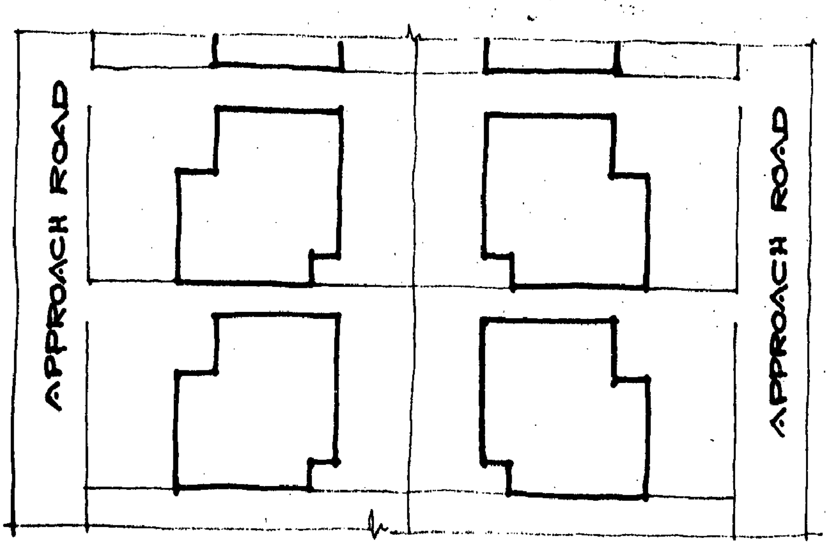
IMPACT OF DOOR/CUPBOARD LOCATION

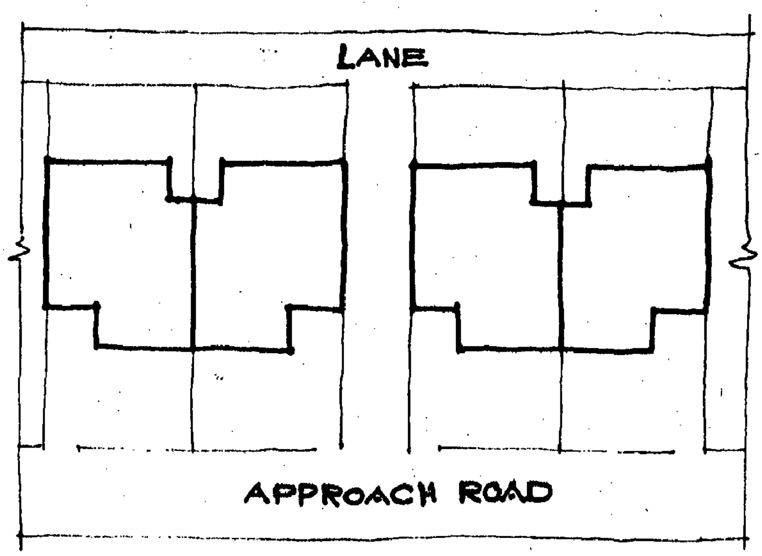
ASPECTS


KITCHEN SIZES
PROVIDES MORE WORKING AREA
K
K
GIVEL LESS WORKABLE AREA
K
GIVES MORE WORKABLE AREA
LAYOUT OF KITCHEN SHELVES
POSITION OF DOOR/WINDOW
MAIN GOVERNING FACTORS

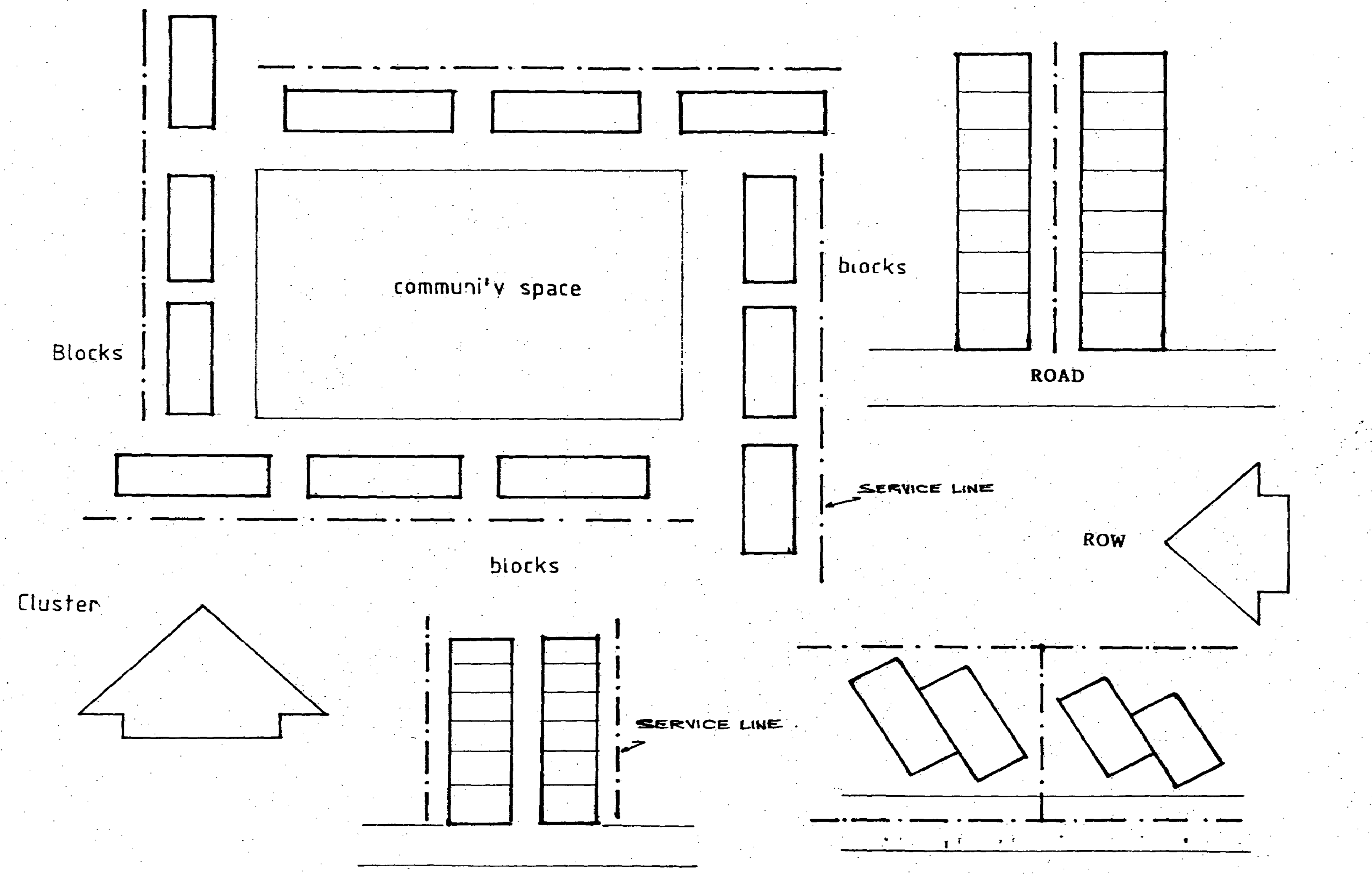
COMBINATION OF UNITS



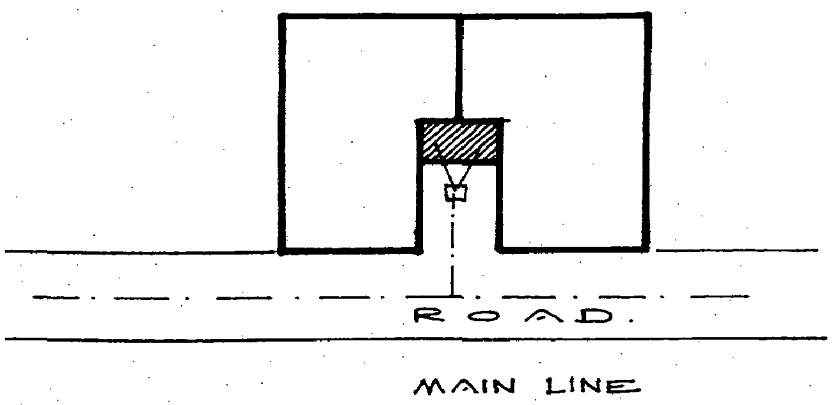


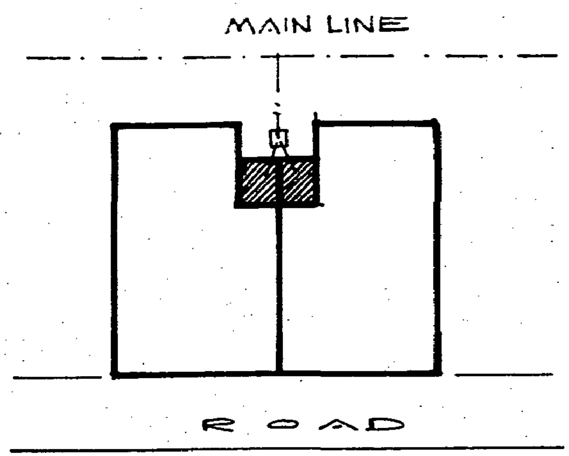


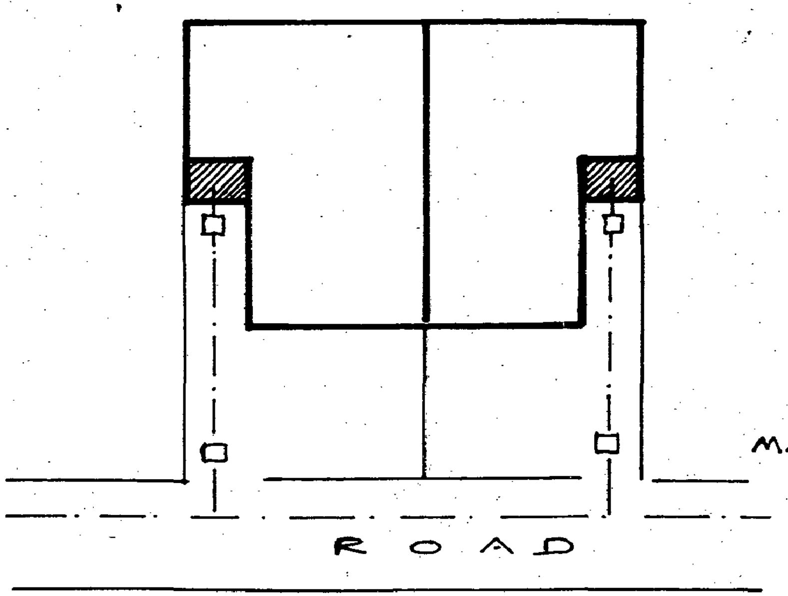
LAY OUT PATTERNS

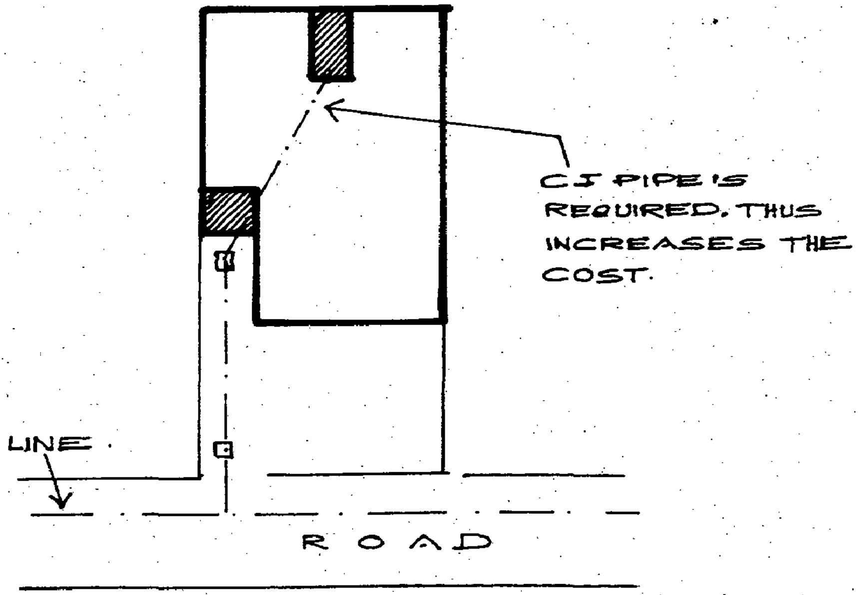


EXTERNAL SERVICES

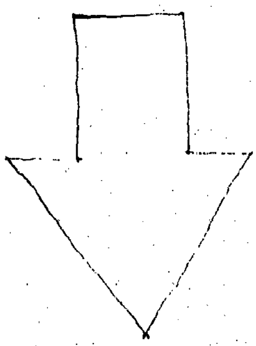


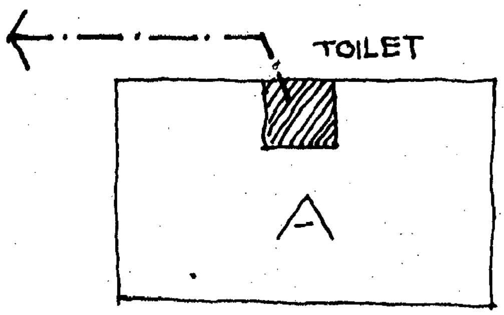




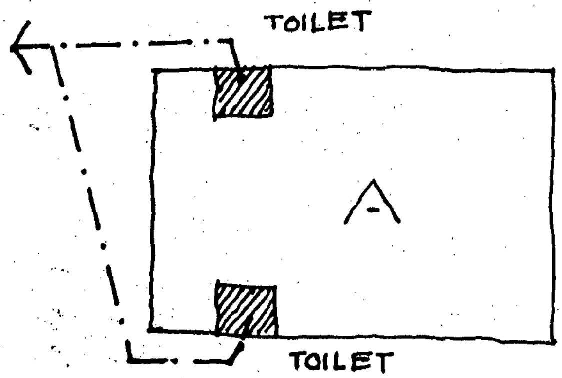


INTERNAL AND EXTERNAL SERVICES

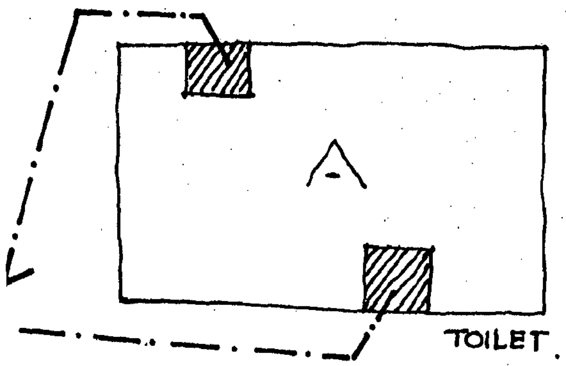




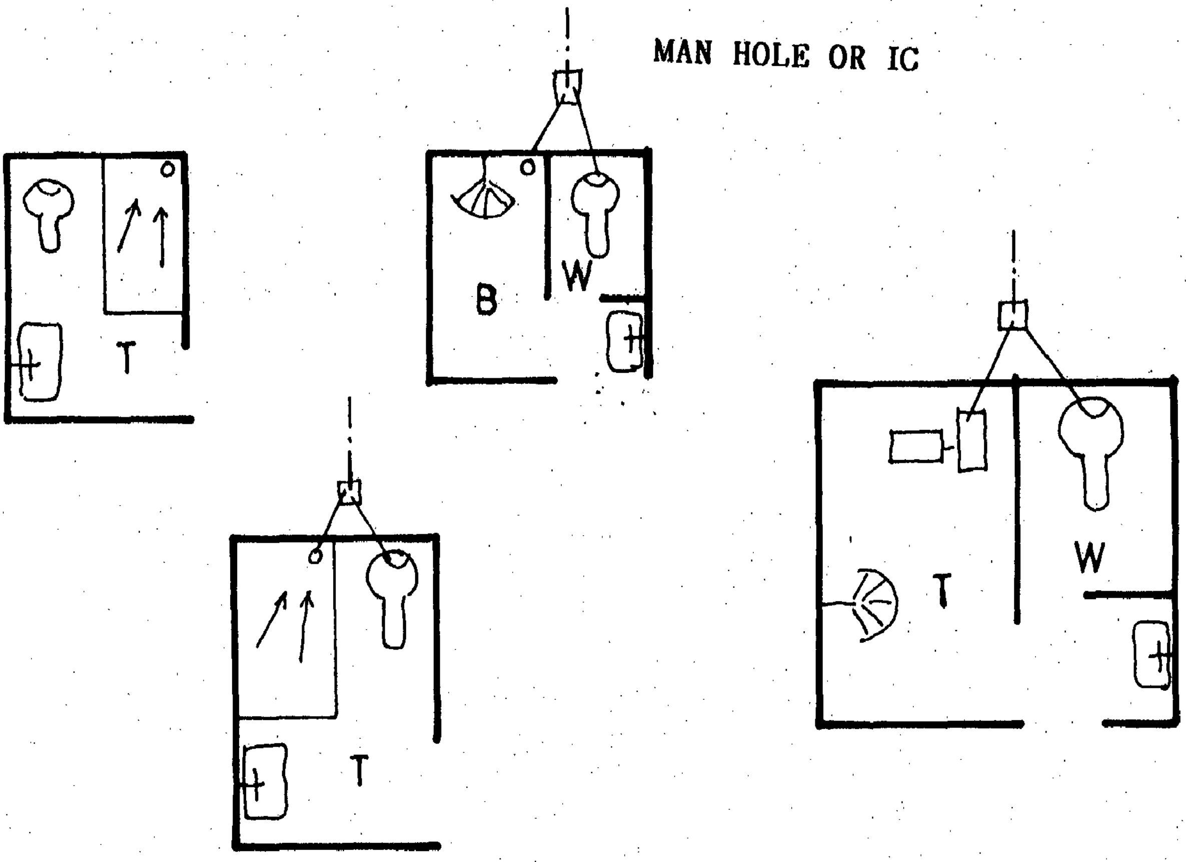
Alt-I,



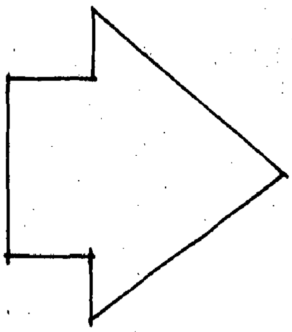
Alt-II,

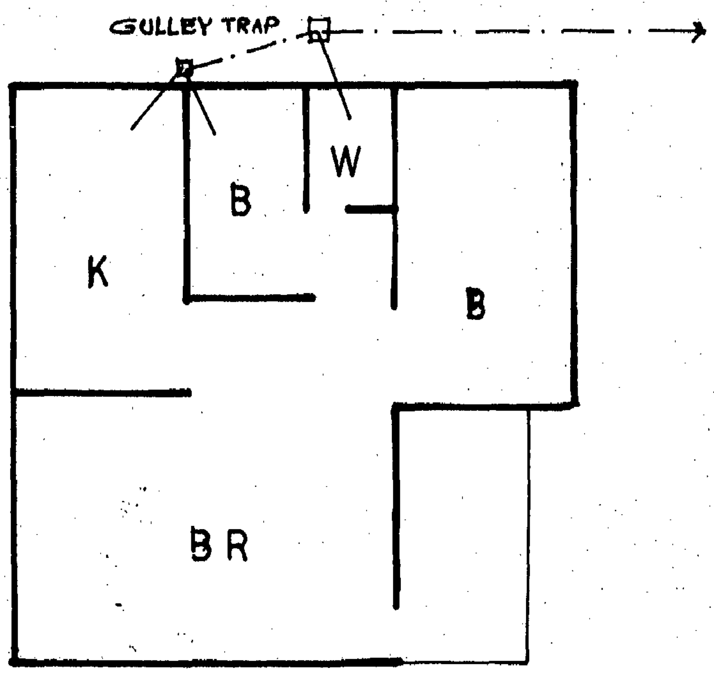


Alt-III.



BATH, W.C., TOILET SIZES





It is a very important element in housing and if not handled properly can upset the entire housing budget. A toilet portion costing Rs.10,000/- may cost two and half times more if not planned properly.

Electrical Services

It is also very important element affecting the cost of a building. It is one of the area where architects/engineers/users greatly depend upon the electrical contractors. Though it is not as big element as others, but it is observed that due to lack of knowledge in this field, the builders invest more money than required and thus substantially can upset their budget.

Management

It is a very important aspect in the house construction Management aspect rather should be considered from the planning stage itself.

It is a general impression in majority of places that architects can contribute more towards the beautification of the buildings. It is only because that architects/engineers have not been able to justify the importance of the management aspect to the majority of people. The common man has a general impression that architects or engineers are more useful for large scale construction which is not true. It should not be forgotton that design of one dwelling unit is a base for any housing scheme. If one dwelling unit is properly conceived, all goes well afterwards.

During construction, a number of other aspects are forgotton. Some of them are quality of bricks, size of bricks, proportion of the material and quality of plaster. These are the aspects which can be well controlled through management.

1.1.8 Present Situation on Cost Reduction Measures

As already mentioned, housing is being promoted through two sectors in India :

1. Public sector
2. Private sector

Public Sector

In almost all public sectors, housing is dealt by engineers and architects. Architects are designing the houses as per laid norms and engineers are constructing them as per specifications.

Study of various plans reveal that they hardly design with scientific approach and cost reduction measures which is very much clear from the following observations :

1. Thickness of the walls, in some cases external one have been reduced from 23 cm to 15 cm or 11.5 cm.
2. Mortar suggested for the masonry work is of thinner grade.
3. Plaster work on external walls is being avoided.

4. Second class specifications for flooring are being adopted.
5. Low specifications for doors and windows are being used.
6. Structural elements such as roof slab are being made as thin as possible.
7. Sun projections are being avoided.
8. Other elements like plinth protection etc., are being eliminated.

Above said observations clearly reveal that whatever cost reduction measures have been suggested or being adopted by the expert engineers can not said to be cost saving measures. These are rather resulting in great discomfort and structural risk. It is one of the basic reasons that neither the government is convinced nor the people living in the houses, houses constructed by these agencies.

Architects are also not doing indifferently. In almost all institutions, their approach is the same. In fact architects lay the foundation in housing the people. So, they are required to consider every aspect at the planning stage but the survey reveals the other story.

For the sake of cost reduction plinth area of dwelling unit is being reduced, thus converting the habitable rooms further smaller. Saving is being advocated through minimization of number and sizes of windows, interior details without any scientific bases, thus resulting in discomfort.

Comfort and functional aspects are the basic tools in housing and very simple fact should not be forgotton that no body accepts the cost reduction measures at the cost of above said basic needs.

So there should not be any hesitation in accepting the very fact that architects are still not in a position to suggest the cost saving parameters which can be achieved through planning and designing.

In short it can be said that by now we have been advocating the measures just for doing sake.

Private Sector Housing

Private sector housing is being promoted through individual, and private builders.

Survey reveals that hardly 10 % consult architects and engineers for house construction. People generally get the basic design from the architects or engineers and then depend upon contractor for all aspects related to house construction. Starting from the estimate to completion of house, the house owner is at the mercy of the contractor skill. With the result the contractors avail full advantage of the innosense of the people.

Same storey is with the professional builders and architects. They first think about their own profit rather than the merciful conditions of the house owners.

In the private sector there is much more sorry state of affair. People are just confused due to non-availability of proper planning and designing norms which can lead them to construct their shelters within budget.

1.2 SCOPE AND OBJECTIVES

1.2.1 Need of the Study

Determination of elements are the basic fundamentals in any type of housing. Housing is whether undertaken by public enterprise or private one, value of these elements are to be found out, to determine the overall cost. Today not only the government but even every individual is confused about its value.

In the government agencies, plans are prepared by reducing the sizes of the amenities and using low cost specifications, just to achieve the false cost reduction. With the result substandard houses are provided to the people at the cost ofcomfort and functional values. Survey has proved that neither government is satisfied about the type of houses being constructed nor the occupants, who are accepting these houses, because of no other alternatives. Same state of affairs remains with the individuals and private agencies also.

Survey has indicated that more than 90 % of people are at the mercy of the contractors and the market value of the materials. It is also pity that only 10 % people consult architects for better planning. It is also fact that practising architects do not pay much attention to the cost reduction measures with the simple reason that it does not contribute to their earning.

Survey has revealed that 100 years old methodology is still adopted by the government agencies in house construction. The plans are prepared without analytical study and estimates are prepared on broad items such as superstructure, roof, walls, wooden work, plastering and so on. This only gives the estimate irrespective of the plan quality.

And the result is with us today. Government is not able to provide the house to a common man within his affordable limit.

1.2.2 Type of Housing Elements to be Included in the Study

Though I shall study and bring out the economics of every element, in general yet more detailed study will be confined to those elements which need to be considered at the planning stage only before construction.

As is clear from the table 1, 2 for costing given in the Chapter 4 also that 80 % of the total cost of the building is consumed by mere four items i.e.

1. Brick work
2. Roofing
3. Doors and windows
4. Plastering
5. Services

So my study will include analysis of those elements which will have direct bearing on items mentioned above.

1.2.3 Scope of the Study

Though the scope of study is too wide yet I am confining my study to analysing those aspects which will be helpful in framing out the guidelines of various types of housing elements.

1.2.4 Objectives

Study reveals that work carried in this direction is still at macro level i.e. common man is still engaged in counting the number of bricks, cement bags and steel. Inspite of research carried out by various research centres on various cost reduction parameters, people are still confused. There are still no framework on guidelines regarding the economic parameters which a common man whatsoever category he belongs to, can pick up for his house at planning stage itself according to his budget.

So the objective of the study is to bring out the optimum economical parameters of housing elements so that these may be useful not only to individual or private sector agencies but also to public sector enterprises.

By knowing these economical parameters, it will be more convenient to know the cost of housing elements in advance and thus adjust the budget accordingly. This study will also be very useful to practicing architects and engineers in convincing the house builders/owners more scientifically.

CHAPTER-2

REVIEW OF LITERATURE

2.1 ROLE OF VARIOUS NATIONAL AND INTERNATIONAL CONFERENCES ON LOW COST HOUSING

Various conferences at national and international level are held at different avenues time to time and duely attended by experts from different fields. Papers on various aspects on housing are presented. Minutes on all aspects are made and recommendations suggested but unfortunately these recommendations never take the concrete shape and real users remain blank about its use.

The very purpose of these seminars and conferences are to invite the intellectuals and have their views on various aspects of housing.

In a single conference held in the C.B.R.I., Roorkee in 1984, about more than two thousands papers were presented by various experts. Likewise papers in thousands might have been presented in various other seminars and conferences, but the sorry state of affair still remains the same, i.e. we are still not in a position to provide a house to any category according to his affordable limit.

2.2 ROLE OF PUBLIC SECTOR HOUSING AGENCIES

Development Authorities and Housing Boards

Development authorities and housing boards were established to promote the housing activities in the states and their role was defined. Main objectives of these development authorities and housing boards are

1. To acquire the land at the cheaper rates, develop it and sell it in the form of plots.
2. To develop the economical plans for different categories, construct and sell.
3. To raise their own financial resources to expediate the housing activities.

So a lot of money was spent on the establishment employing architects, planners and engineers. Architects designed the houses, planners provided the layouts and engineers constructed the buildings. But again the real aspects i.e. cost reduction parameters were forgotten. These authorities and housing boards more or less adopted the same norms and standards which were suggested by their financial agencies like HUDCO i.e. adoption of low specifications. So the result was not encouraging. Though number of houses were constructed, but again the real people for whom the houses were constructed, came forward in less number due to increased cost in construction. With the result, the houses were occupied by the people lying in one step higher category, thus again upsetting the entire planning of the agencies.

N.B.O.

National Building Organization has been established with the main idea of extending the low cost technology and measures on various aspects on housing to its real users. N.B.O. gath^rs the information from various resources and present it in the form booklets. But again this organisation is dependent upon the research organisations like C.B.R.I. and the reports based upon seminars/conferences. It does not have its own research centre which can work on various cost reduction aspects. Recently this organisation has developed some type plans for L.I.G. and M.I.G. categories which have not become so popular due to many reasons.

C.B.R.I.

Central Building Research Institute at Roorkee is engaged in the research on various parameters of buildings for the last 38 years. Its main aim is also to evolve the low cost technology in buildings and it has succeeded in some of fields such as foundation, building material and structural components which can give the economy upto 25 % if used properly.

Some of the building components, in which C.B.R.I. claims to achieve economy are under reamed piles in foundation precast units such as channel units, R.C.C. planks, brick panels, R.C.C. ribbed slab in roofing, clay tiles in flooring, stone blocks for walling, thin lintels and chhajjas over doors and windows. Inspite of this a lot of work has been done in the institute on economical specifications, light and ventilation aspects.

Despite this, a number of seminars and conferences are organised by the institute to make the people familiar with the scientific work being done in the institute.

It is the only research laboratory in which every effort of the scientist is towards the economy of buildings and I will not hesitate in saying that it is a place where common man can have a ray of hope because any type of information related to building aspect can be attained from here.

HUDCO

Housing Urban Development Corporation is government financial agency which provides the loan to weaker sections for the construction of houses and purchase of land. Quite a meager amount 15 % is provided to M.I.G. class. That is also if some low cost technology is adopted by them. Housing loans are not provided to individual builders. Practically it is more or less E.W.S. and L.I.G. categories which are benefitted by the HUDCO loans.

Sole aim of this organisation is to provide maximum financial assistance so as to encourage the housing programmes in the country. HUDCO has its own norms and standards for low cost houses based upon economical specifications. So while providing the loans construction agencies are advised to stick to low cost housing norms as far as possible. The main construction agencies which are getting benefit from this organisation are housing boards, development authority and some other public sectors.

2.2.1 Observations

Following are the observations on the role being played by the above agencies :

1. System of working of most of the agencies is traditional.

2. A lot of amount is being spent by these agencies on development part, rather than analysis aspect.

3. These agencies adopt the norms and standards on low cost housing being suggested by the govt.

4. Private sectors hardly get any assistance from the financial agencies like HUDCO.

5. Neither the E.W.S. nor M.I.G. people are satisfied with the houses provided by these agencies due to substandard work.

6. Main aim of these agencies are to provide the land at the cheaper rates to the house builders but unfortunately, plots sold by these agencies prove to be very expensive in comparison to pvt. land.

7. Financial agencies like HUDCO should not only provide the loans, but should also have a check on the proper use of funds based upon their own norms and standards.

8. National building organization should give more publicity to the work done by various research organisation towards various economic factors of housing. It should also give the demonstration to the common man regarding the use of technology in cost reduction.

9. There is a lot of useful work done in the C.B.R.I. Roorkee which can be used for analysis of different building elements for cost reduction. So there is

a need to compile them and present them in such a way that even a common man should be able to pick up the required information without much difficulty.

2.3 ROLE OF PRIVATE SECTOR IN HOUSING

Private sector agencies can play a great role in promoting the housing activities because of more faith of the people in them. But unfortunately it is not so because of vested interest of the practicing architects and engineers. Cost of a building is a major tool for any private architect as his fee is governed by it. The more is the cost of house or building, more will be their fee. The cost of a building is also a important tool for a common man thinking to construct his house as his entire budget largly depends upon it.

The most unfortunate part of this is that even eminent practicing architects and engineers who should contribute a lot towards this burning problem, devote very little time, or rather show no keeness in this direction. It will not be out of way to say that these undertakings lack in spirit in participating on low cost housing projects if such competitive projects are floated.

2.3.1 Types of Private Sector Housing Agencies

There are three main types of private sector housing agencies :

1. Housing through pvt. builders and promoters
2. Co-operative housing societies
3. Individual housing

Housing Through Private Builders

Under this, housing is promoted through private builders. Some of the plans collected from the private builders clearly show that their approach in housing is towards high income group. Even M.I.G. class can not afford them. Their sole aim is commercial and earn maximum profit.

Co-operative Housing Societies

Co-operative housing societies are nothing but different groups of house owners who share the total housing activities collectively. They purchase a piece of land together, engage the common private architects/engineers/contractors and then share the total cost of the building.

Housing done through co-operative societies prove cheaper on the whole as many expenditures related to development of land, purchasing of material in bulk and supervision charges are commonly shared.

It is not necessary that these builders are themselves qualified. But these builders own their architects and engineers who on their behalf, design and construct the houses.

These builders purchase the land, and develop it in the form of housing colonies adopting their own designs, techniques and specifications. These houses are then sold as a free hold property or on 99 years lease basis.

Though a large number of houses are being constructed by these agencies but still these are directed towards very high income groups using very rich specifications. But due to lack of knowledge and facilities, housing through co-operative societies is only popular in metropolitan cities.

Some plans have been collected from housing co-operative societies for observations.

Individual Housing

More than 80 % of the housing is being promoted through individual housing in the places where housing boards and development authorities do not exist. Under this housing, work is undertaken by the individual house owners. Entire housing activity from the purchase of land to the construction of building is shared by the individual only. For preparing the design of the house, the owners engage architects, engineers on individual basis and get the approved plans from them.

In construction, they may or may not engage architects/ engineers depending upon their paying capacity.

Survey indicates that if in metropolitan cities, 50 % people engage architects as their consultants, the %

reduces to 10 % in towns and further goes down to 2 % in small places. The sole reason for this is the lack of consciousness in people about the field of architecture and their impression about the capability of architects and engineers.

2.3.2 Observations on the Work Done by Pvt.Sector Agencies

It will not be wrong to say that if any substantial work in this direction has been done, it is through private sector agencies only.

Number of multistoreyed housing activities are getting multiplied in Delhi, only because of private sector. This type of activity is one way good for increasing the number of houses but whether it is serving the common man who has limited resources, is still a question. So for achievement sake, it can be said that pvt. builders are providing the houses to more and more people by virtue of speedy design, construction and management. Discussion with the private builders and owners were held which indicates that for private builders maximum profit is the main aim but at the same time, they provide the houses in time. It is one of reasons that people feel happy in getting the accommodation from pvt. promoters irrespective of the cost and functional efficiency of the plans. These private builders suggest the measures, specifications suitable to high income people. They do not want to indulge themselves in analysing the cost saving factors due to lack of time and vested interest.

In the coperative housing, everything depends upon the architects/engineers will. Coperative housing is suitable for all the three category people i.e. L.I.G.,M.I.G and H.I.G. At the moment, it is more economical than any other housing as most of expenses are shared in engaging architects/engineers, contractor and material procurement.

It is one of the reasons that very little attempt is made by the architects to provide the efficient and affordable accommodation to the people and that is why one finds M.I.G. people in such type of housing societies.

Private individual builders depend upon their own resources for house construction. Every individual engages their own architect and contractor. It has been observed that most of builders in this category give labour contract. Other efforts regarding the material procurement is done by themselves. These are the most affected people. Due to lack of knowledge and resources, they multiply the cost of their building and are the ultimate sufferers. It has been seen that they depend upon the knowledge of the people who had already constructed the houses and thus are misguided on many aspects. With the result cost of their buildings generally exceeds the budget limit.

CHAPTER-3

METHOD AND PROCEDURE

Review of the literature and survey report clearly shows that there is a dire need for a simple method and procedure to arrive at the bud of the problem.

The whole method and procedure has been put under three broad columns :

3.1 Evaluation of the literature study.

3.2 Field survey and evaluation of observations and findings (under construction buildings).

3.3 Data collection and its evaluation with respect to cost reduction measures.

3.1 EVALUATION OF THE LITERATURE STUDY

Literature study is the basic media for any scientist or research scholar to know about the subject and work done on that. This will convey to any researcher about the existing position and, what and where are the gaps which need to be covered up to make the study more useful.

So keeping this very principle into mind, I have tried to evaluate the study related to the subject and make some positive suggestions.

3.1.1 International Conferences and Seminars on Low Cost Housing

After studying the various papers on different aspects on low cost housing, one finds many aspects which can be of great importance and can help in reducing the cost of building. But the very fact is that aspects remain in the paper only and hardly reach to the users. The main reason which I could find is that most of the seminars/conferences are attended by the intellectuals/experts only, not by the real users. So they remain in the dark about the outcome. So instead of speaking on papers, something concrete should come out. There should be an attempt to compile all the useful information regarding the cost reduction measures now and formulate a sort of guidelines for the builder's/owner's use.

There is a need to analyse the economical parameters suggested during conferences and arrive at the optimum solutions which may be useful not only to scientists and professionals but also to a common man.

Otherwise there is no use of such big shows costing lacs of rupees every year, if these do not convey anything useful to actual users. Effort should be made to present these guidelines on cost reduction in a very simple form to enable a common man to understand.

3.1.2 Cost Reduction Measures Being Adopted by Different Research Institutions, Especially CBRI, Roorkee

Central Building Research Institute is considered to be pioneering research laboratory in India working on various cost reduction parameters in buildings. It has developed alternate roofing schemes to replace insitu one, economical clay units to replace cement concrete flooring, economical pile foundations for areas of back cotton soils, thin lintels and chhajjas. A lot of study has been done on space standards, ventilation and lighting aspects. If one visits the institute like C.B.R.I., gathers a plenty of information in the form of literature, publication etc.

If this is so, where are the loop holes ? I have tried to throw some light on it.

Foundation

In foundations some useful work has been done with the development of under reamed piles but its use is limited to the area where black cotton soil is there.

Walling

Stone blocks have been developed as a replacement of bricks in areas where stones are available and cheaper than bricks. So its use is again limited to those areas where stones are available in abudant and where soil is not suitable for making of bricks.

Roofing/Flooring

Prefabricated roofing components such as channel units, R.C.C. planks, brick panel units, cored units cellular units ribbed slab etc., have been developed by the C.B.R.I. to replace the traditional R.C.C. slab in mass construction of houses, but its real use is yet to be seen in large scale.

The public sector agencies are still afraid of using this technology for so many reasons. Amongst them notable are :

1. They consider these units still under experimental stage.
2. These techniques do not save to that extent as claimed by the C.B.R.I. in actual practices.
3. It is very difficult to get trained masons for this work. So very few contractors come forward to accept this.

Doors and Windows

15% to 20% of total cost of building is consumed by the doors and windows. But very little work has been done in this direction in the institute. Economical thin lintel cum chhajjas have been developed but its application is almost negligible. Very useful method known as LUX GRID Method for determining the lighting aspect in relation to window sizes has been developed in the institute but the thorough investigation of plans shows that very little use has been taken from this.

Plastering/Finishing

One does not find any major break through in plastering work of walls. People still use sand mortar for this. Due to non availability of good lime and trained labour, the application of lime, for plastering work has reduced to a greater extent.

Flooring

Nothing concrete has been suggested by this institute as a replacement of traditional floor finish. Clay tiles have been developed in the institute but its use on large scale is yet to be seen.

3.1.3 Achievements Made by NBO and HUDCO

N.B.O. and HUDCO are two such organisations which should contribute a lot in this direction. The main objective of the N.B.O. is to extend the research in various fields to the users through various means such as advertisement, distribution of publications, and demonstration where as the foremost aim of HUDCO is to provide housing loan to various public sector agencies. It prefers to give loan to those agencies first which give more weightage of housing to economically weaker sections. It is one of the reasons that 75% of the loan distributed by the HUDCO is for E.W.S.

HUDCO also provides loans to those agencies who show their readiness to work under their norms and specifications. That is why, only public sector enterprise comes forward to use scientific technology on experimental basis.

It has been observed that private sector agencies hesitate in adopting these techniques on experimental basis. Same case is with the individual owner or builder.

N.B.O. on the other hand is doing all type of extension work related to buildings. It organises seminars and demonstrations on various economic aspects of buildings. Discussion with various groups of builders and users reveal that unless every aspect of cost reduction is demonstrated in the same building, it is not going to be of much use. Some of the builders are also of the opinion that there should be availability of ready made stock of building components with full guarantee to the users or builders in the market.

There were few more suggestions from the users. They want HUDCO to start giving building components in the form encouragement to those agencies only for loan who opt for usir the low cost technology, thus serving more usefully than simply providing the loan to weaker sections.

Thus obviously one finds clear gap between the low cost technology being developed and users and there is no doubt that HUDCO, N.B.O. can play vital role to fill up this gap. There is a need to develop confidence amongst the people about the use of economical aspects and its significance.

3.2 FIELD SURVEY, DATA COLLECTION AND OBSERVATIONS

3.2.1 Survey of the Houses Under Construction at Different Stages

A survey of houses under construction at various stages was conducted and following observations and findings were made :

1. 75% to 80% of the people are always in favour of strong foundation and prefer bigger and deeper foundation than required.

2. More than 80% people prefer higher plinth level due to the problem of water logging.

3. More than 80% to 90% of the people prefer 23 cm thick walling on external side.

4. Almost all people expressed their lack of knowledge about the thickness of the internal wall.

5. More than 95% people prefer to put more steel and cement in the roof slab for more safety and stability.

6. 90% to 95% of the people who do not engage architects and engineers as their consultants, depend upon the knowledge of the contractors.

7. It has been observed that in private sectors, almost 95% people spend on the finishing items such as rough cast, design in cement plaster and so on.

8. It is seen that sufficient amount is absorbed on the component like front compound wall, gate design etc.

9. More than 90% of the house owners depend upon carpenter's knowledge for the wooden work which constitute more than 16% of the total cost of building.

10 Most of the people are not in a favour of less height of the habitable rooms. They prefer 3m to 3.3 m as room height.

11 For all type of sanitary work, the owners depend upon the knowledge of the sanitary contractors or masons.

3.2.2 <u>Discussion with Individuals House Builders/Owners</u>

Some discussion were held with the owners of the houses and following observations were made :

1. More than 80% house owners were of the opinion that plans do not give them actual idea of space unless building reaches plinth level.

2. The drawing of the house plan which is supplied by the architects or engineers, is insufficient to give the complete picture of the house.

3. More than 70% people can not afford architects/ engineers as their consultant for better planning due to their higher charges.

4. Almost all people were of the view that if proper guidelines available to them, then only these can be helpful to adjust the budget at the planning stage itself.

5. More than 80% people know little about the work done by the research organisation on cost reduction measures, 10% people know but are afraid of using it due to new one.

6. Almost all were of the opinion that a better economy can be achieved due to better management at the site which does not succeed due to contractor.

7. Some house owners were very critical about architects and engineers who do not give them proper guidance during planning stage.

3.2.3 Discussion with Practising Architects, Engineers and Private Builders in This Context

Private architects and engineers were approached for their comments on cost reduction measures. Comments of some of them are :

1. No doubt cost reduction measures are most needed today but for that, there should be proper guidelines.

2. Practice can not be run through low cost house design.

3. No time to do the research on cost reduction measures.

4. Cost reduction affects their profit, so they do not suggest cost reduction measures intentionly.

5. Some of them were of the opinion that latest knowledge should be made available to them by the research organisation.

6. There is a need to combine research and practice for better output.

3.2.4 Survey of the Completed Houses and Discussion with the Owners

A survey of some of the completed buildings were made and following observations were made :

1. Owners were more surcastic about architects and engineers as they are of the opinion that the plan which they get from the architect is not at all enough for actual estimate.

2. According to them cost difference in proposed estimate and actual estimate comes out to be 30% more, which is quite a substantial amount.

3. Some of the owners were of the opinion that there is a need for the economical solutions for doors and windows design which according to them consumes more than 20% of the total cost.

4. They, want some definite guidelines about sanitary and water supply work which also consumes a lot of amount according to them.

5. According to them, there is a need for proper management during the planning as well as construction stage to avoid wastage which is quite enough. One is required to know in advance raw wastage occurs and what are its remedies.

6. They are of the opinion that there should be some standard economical sizes for the rooms.

CHAPTER-4

DATA COLLECTION, SURVEY REPORT, CASE STUDIES AND THEIR ANALYSIS

Survey reports and case studies provide any scientist or research scholar a solid ground to arrive at the footing of the problem. For that thorough analysis is desirable. In this chapter an attempt has been made to analyse the data collected from various resources which will provide the basis for justifying the optimization ways of cost reduction parameters.

4.1 ANALYSIS OF DATA COLLECTED FROM THE HOUSING AGENCIES AND MARKET

Actual data was collected from the market related to the material available in the offices, markets and was analysed to study the various aspects. The places which were surveyed in this context are Delhi, Roorkee, Dehradun as per table attached.

4.1.1 Data Collected From U.P. Housing Board

U.P.Housing Board which is one of the leading public sector agency at the moment in U.P. was approached for different building aspects, to know about their system of working and approach. Following information was gathered from them.

Building cost Break up

An information regarding the building cost break up was gathered from the office of the U.P.Housing Board office at Roorkee and Dehradun on the basis of which this organisation is working at the moment.

The table clearly shows that 80 % of the cost of building is consumed in superstructure, roofing, doors and windows and plastering. 'Except roofing where enough study has been made for different parameters, proper analysis of other elements like superstructure, door/window and plastering is still needed to be done as these three items alone consumes 60 % of the total cost of the building.

Labour/Material cost break up

The table shows that 40 % of the cost is absorbed by two items such brick, timber and 10 % each by cement and steel. So this aspect of the building requires to be checked at the planning stage only.

Development cost break up

For the overall cost, other elements related to development of surrounding are also required to be analysed. The table enclosed suggests the cost break up of different elements for development. It is clear from the table that read, water supply and electrification alone has consumed about 56% of the total development cost. So this factor must be kept into mind at the planning stage.

4.1.2 Timber Data

Timber data for the study of different elements was collected from Delhi, Dehradun and Roorkee markets for factual

ROUGH ESTIMATION FOR COSTING .

Table-1

ITEM	COST %
LABOUR	30 to 35 %
FOUNDATION UPTO PLINTH LEV.	15 to 20 %
SUPER STRUCTURE	80 to 85 %
SECOND STOREY	75 to 85 % of Ist Storey
DIRECT COST	85 %
OVERHEADS DUE TO SUPERVISION ESTABLISHMENT, INCIDENTAL	15 %
SANITARY AND WATER SUPPLY	7 to 9 %
ELECTRIC INSTALLATION WITHOUT FANS	7 %
ELECTRIC FANS	5 %

Source : U.P.Housing Board.

COST BREAK UP (MAIN BUILDING COMPONENTS)

Table-2

Earthwork in Excavation and Filling	1/2 % to 1 %
Foundation Concrete	4 % to 6 %
Damp Proof Course	1 %
Brick Work	34 %
Roofing	20 %
Doors and Windows	16 %
Plastering	10 %
White/Colour washing/Painting	2 %
Miscellaneous	4 %

COST BREAK UP (LABOUR AND MATERIAL)

ITEM	RATE %
BRICK	25 %
CEMENT	10 %
STEEL	10 %
TIMBER	15 %
LIME	5 %
LABOUR	30 %
MISCELLANEOUS	5 %

Source : U.P.Housing Board.

DEVELOPMENT COST BREAK UP

ADOPTED BY U.P. HOUSING BOARDS AT
ROORKEE

Table-3

ITEM			COST/ACRE
EARTH WORK		Rs.	1000/-
ROAD			25000/-
WATER WORK	EXTERNAL		10000/-
	INTERNAL		20000/-
WATER SUPPLY	EXTERNAL		11000/-
	INTERNAL		9000/-
DRAIN AND CULVERT			15000/-
PARK AND LANDSCAPE			10000/-
ELECTRIFICATION	EXTERNAL		6000/-
	INTERNAL		13000/-
COMMUNITY FACILITIES			5000/-
TOILET			34000/-
12% CONTINGENCY CHARGES			16000/-
		Total	190000/-

1.5 Lac/Acre or
3.7 lac/Hect.

Source : U.P.Housing Board.

PLINTH AREA RATES ADOPTED BY U.P. HOUSING BOARDS

Table-4

Type of House	Cost/Sq.M. from 1.4.84	Cost/Sq.M. from 1.4.85
E.W.S.	870	950
L.I.G.	1060	1160
M.I.G./H.I.G	1100	1210
SELF FINANCING SCHEME	1160	1275

BOUNDARY WALLS ARE NOT INCLUDED IN THE ABOVE RATES

Source : U.P.Housing Board.

analysis.

Wooden Sleepers

Data related to the sizes, shape and quality for the variety of wood such as sal, deodar, seesham and teak was obtained from the markets as per table enclosed. This data shows that there is 35 % wastage in seesham wood logs when these are cut into sizes. These tables also illustrates the qualitative difference between the different types of woods.

These tables also give us the sizes which should be kept into mind at the time of designing of door and windows.

Timber size

Various sizes of timber available in the market and forest research institute, Dehradun were obtained as per table attached.

The table shows that as there are a lot of sizes available, so full advantage of this should be taken while deciding the wooden section for the doors and windows as it can help in reducing the cost of the building to a great extent.

Commercial Board

Data related to commercial ply boards was obtained from Delhi and Dehradun markets. There are various sizes of the pjy boards as is clear from the table enclosed but the table also indicates that all ply boards are available in two width sizes i.e. 3'-0'' and 4'-0'' though the variation in length have been found.

DATA FOR TIMBER

Table-5

Type	Availability	Size	Cost (Rs.)
DEODAR	Sleepers commonly available	10'x10''x5''	750/- - 850/-
		10'x8''x5''	
	Not commonly available	8'x10''x5''	Rs.550/- 650/-
		6'x10''x5''	Rs.450/- 500/-
SAL	Avail ble in cut s s	5''x2$\frac{1}{2}$''x7'	Rs.200/- per Cu.ft
		4''x2$\frac{1}{2}$''x3 to 7'0''	
	Available in logs	3'-0-18'-0	
	But prove	In length	Rs.200/-per Cut.Ft
	Cost s	Diameter	Cut. Ft.
	some t	2'0''-6'0''	
	good from ide		
SEESHAM	Available in logs	2'-3'.0 Dia 5'-7' in length	Rs.130/- 170/- per Cu.Ft.cutting charges extra Rs.3/- per C.Ft.
TEAK	Oogs common	10'-0'' long	Rs. 280/- per
		dia 3'-4'	Cu.Ft.
		10'.0 long	Rs. 350/- per
		4'-5' dia	Cu.FT.

Source : Main Timber Market, Paharganj, Delhi.

WOODEN DATA ON CUT SIZES

Table-6

SAL

SIZE	RATE(Rs.)	SIZE	RATE(Rs.)
9'x5''x$2\frac{1}{2}$''	150.10	8'x4''x$2\frac{1}{2}$''	112.25
8'x5''x$2\frac{1}{2}$''	125.50	8'x4''x$2\frac{1}{2}$''	93.00
7'x5''x$2\frac{1}{2}$''	110.75	7'x4''x$2\frac{1}{2}$''	81.90
6'x5''x$2\frac{1}{2}$''	80.00	6'x4''x$2\frac{1}{2}$''	60.00
5'x5''x$2\frac{1}{2}$''	59.40	5'x4''x$2\frac{1}{2}$''	43.80
4'x5''x$2\frac{1}{2}$''	48.30	4'x4''x$2\frac{1}{2}$''	35.15
3'x5''x$2\frac{1}{2}$''	23.30	3'x4''x$2\frac{1}{2}$''	16.50

Source : U.P.Forest Corporation, Dehradun.

WOODEN DATA CUT SIZES

Table-7

DEODAR

SIZE	RATE(Rs.)	SIZE	RATE(Rs.)
9'x5''x3''	191.20	9'x4''x3''	137.85
8'x5''x3''	155.10	8'x4''x3''	114.05
7'x5''x3''	136.20	7'x4''x3''	100.60
6'x5''x3''	100.00	6'x4''x3''	72.25
5'x5''x3''	73.00	5'x4''x3''	53.75
4'x5''x3''	59.00	4'x4''x3''	43.35
3'x5''x3''	28.00	3'x4''x3''	20.20

Source : U.P.Forest Corporation, Dehradun.

COMPERATIVE STUDY OF TIMBER

Table-8

DEODAR	Available in Sleepers, Soft wood, Labour charges are less, contains a lot of oil and a lot of knots.
SAL	Available in cut sizes commonly Logs prove costly as sometimes these are not good from inside hard wood, tendency of warping.
SHEESHAM	Available in logs only, logs are not uniform in size there is average 30 % wastage due to cutting.
TEAK	Generally available in logs, logs are straight. There is only 2 % wastage. Even wastage can be used for beading purpose considered to be best wood

Source : Forest Research Institute, Dehradun.

ORDINARY PLY WOOD (COMMERCIAL)

Table-9

Thickness	Size	Rate Commercial	Rate Water Proof
3 mm	8'x4'	2/90 per S.FT	4/42 per S.FT
	8'x3'		
	7'x3'		
	7'x4'		
	6'x3'		
	6'x4'		
	5'x3'		
	5'x4'		
4 mm	5'x4'	3/45 ''	5/50 ''
6 mm	''	4/80 ''	7/30 ''
8 mm	''	5/60 ''	8/90 ''
12 mm	''	7/75 ''	11/26 ''
19 mm	''	12/0 ''	14/00 ''

Source : Timber market, Delhi.

SUNMICA SHEETS/LAMINATED BOARDS

Table-10

	Thickness	Size	RATE Glazed Plain Finish	RATE Mat.Finish
Sunmica	1 mm	8'x4'	Rs. 255/-	Rs. 275/-
	1.5 mm	8'x4'	Rs. 455/-	Rs. 475/-
Laminated Boards	12 mm	9'x6'	Rs. 21.75	
		12'x6'	per S.F.T.	

TEAK PLY ONE SIDE/BOTH SIDE

	Thickness	Size	Rate
One side	4 mm	Same as for	7.50 per S.F.T.
	6 mm	Commercial ply	10.25 ''
	9 mm		- -
	12 mm		13.75 ''
	19 mm		18.00 ''
Both side	12 mm	Same	15.50 per S.F.T.
	19 mm	''	23.35 per S.F.T.

Source : Timber Market, Delhi.

COMPERATIVE STUDY OF TIMBER BEADINGS

Table-11

	Type	Size	Rate/Cost
DEODAR	Window shutter	1/2''x3/4''	30 paisa/R.FT
	Jali shutter	2''x1/2''	Rs. 1/- per R.FT
	Door Frame	$1\frac{1}{2}$'' Taper	Rs. 1.50 per R.FT
	Pannel Door	3/4''x3/4''	Rs. 1.50 per R.FT
TEAK	Window shutter	1/2''x3/4'' in Taper	75 paisa/R.FT
	Jali shutter	2''x1/2''	Rs. 2.00 per R.FT
	Door Frame	$1\frac{1}{2}$'' Taper	Rs. 3.00 per R.FT
	Pannelled Door	3/4''x3/4''	Rs. 3/- per R.FT

If all Beadings are cut from the sleepers directly then cost/rate becomes double

Source : Timber Market, Dehradun.

Teak ply boards

- available in two widths, 0.9m, 1.2m
- available in different thickness such as 4,6,9,12,19 mm
- available with one side or both side teak face.
- cost variation per sq.ft. is upto 58 %

Sunmica sheets/Laminated boards

- available in two widths 0.9m, 1.2m
- thickness available are 1,1,5,12 mm
- sizes available are 2.4x1.2, 2.7x1.8 m, 3.6x1.8 m
- cost variation upto 44 %

Beading sizes

Though it is a small but important item as survey reveals that providing the beadings in the doors and windows has become sort of fashion. For beading, not only material is consumed but also the labour. The different sizes available in the markets with rates are enclosed. As the rates of beading material and labour are per R.F.T. So more is the length, more will be the material and labour consumed.

4.1.3 Glass

Glass is a very important item as it is largely used in window for lighting. It has different sizes, thickness and quality. As irs clear from the table also, that cost of the glass depends on the quality and thickness of the glass. Study also reveals that there is variation in rates of glass upto 25 % from one thickness to other.

DATA FOR WINDOW

GLASS SIZES AVAILABLE IN THE MARKET

Table-12

Thickness	Size	Whole sale Rate	Rate/Sq.Ft.
3 mm	122x169/154	63/- to 59/-	5/50 to 6/-
	107x168/154	'' ''	
	92x168x154		
4 mm	214x122/184	86/- to 80/-	8/- to 8/50
	214x108/184		
	214x92/184		
4.8 mm	Same	95/- to 103/-	9/- to 10/-
5.5 mm	Same	107/- to 115/-	12/- to 13/-

Source : Glass Market at Paharganj, Delhi.

4.1.4 Flooring Materials

It is becoming fashion to create the pattern in the floors by means of glass strips and using thicker and thicker glass. The study shows that there is a wide range of cost between the glass strips of one thickness and other. As the people are generally not aware about the cost difference, so they go to market and get the strips as suggested by the contractors or architects. As there is variation upto 50 % between different thickness, so this factor can also help to put the restraint at the initial stage.

Same case is with the use of moisic chips in the flooring. There is a tendency to use the thicker and more mosaic chips in the floors, thus adding more to cost.

4.1.5 Sanitary and water Supply Fittings

There is a variety of range of fittings available in the market as cost differs from 40 % to 80 %.

As sanitary and water supply is a expensive element so it is necessary to know in advance the type of fittings, range of cost and factor, which affect the cost of this element. The fitting, which are required in toilet, bath and W.C. are enclosed.

4.2 SPECIFICATIONS BEING ADOPTED BY U.P.HOUSING BOARDS, DEVELOPMENT AUTHORITIES, N.B.O. AND C.B.R.I.

It is a very important element. Every body wants good specifications to be adopted in their houses. Survey reveals

DATA FOR FLOORING

GLASS STRIPS

Table-13

Type	Size/Thickness	Rate
DANEDAR	28 x 3mm	Rs. 40/- for 100'.0
PLAIN	28 x 3 mm	Rs. 44/- ''
DANEDAR	33 x 3 mm	Rs. 45/- ''
PLAIN	33 x 3 mm	Rs. 48/- ''
PLAIN	33 x 4 mm	Rs. 65/- ''
PLAIN	33 x 5 mm	Rs. 85/- ''

Source : Glass Market at Delhi

MOSAIC CHIPS

Table-14

Grade	Rate/Bag white	Rate/Bag coloured
0	Rs. 18/-	-
1	Rs. 22/- to Rs.40/-	Rs. 24/- onwards
2	''	''
2B	''	''
3	''	''
3B	''	''

Source : Mosaic Chips Market at Dehradun.

DATA FOR W.C.FITTINGS

Table-15

Item	Size	Rate
Seat	18'',20'',23''	Rs.100/- to Rs.112/- Rs.132/
P.Trap China		Rs.28/- to Rs.36/-
P.Trap C.I.		Rs.26/- to Rs.48/-
Foot Rest		Rs.13/- to Rs.32/-
Cistern		Rs.195/- to Rs.210/-
Flush pipe (G.I.		Rs.30/- to Rs.65/-
Brass Union		Rs.10/-
Ball Cock		Rs.20/- to Rs.35/-
Bracket		Rs.8/-
Soil pipe	2'ϕ-4'ϕ length 6'0''	
C.I.		Rs.60/-,Rs.70/-,Rs.82/-
A.C.C.		Rs.12/-,Rs.14/-,Rs.15/-
Horn Dor Bend		Rs.30/- to Rs.60/-
S.W.P. pipe	2'0'' length 10 cm ϕ	Rs. 11/-

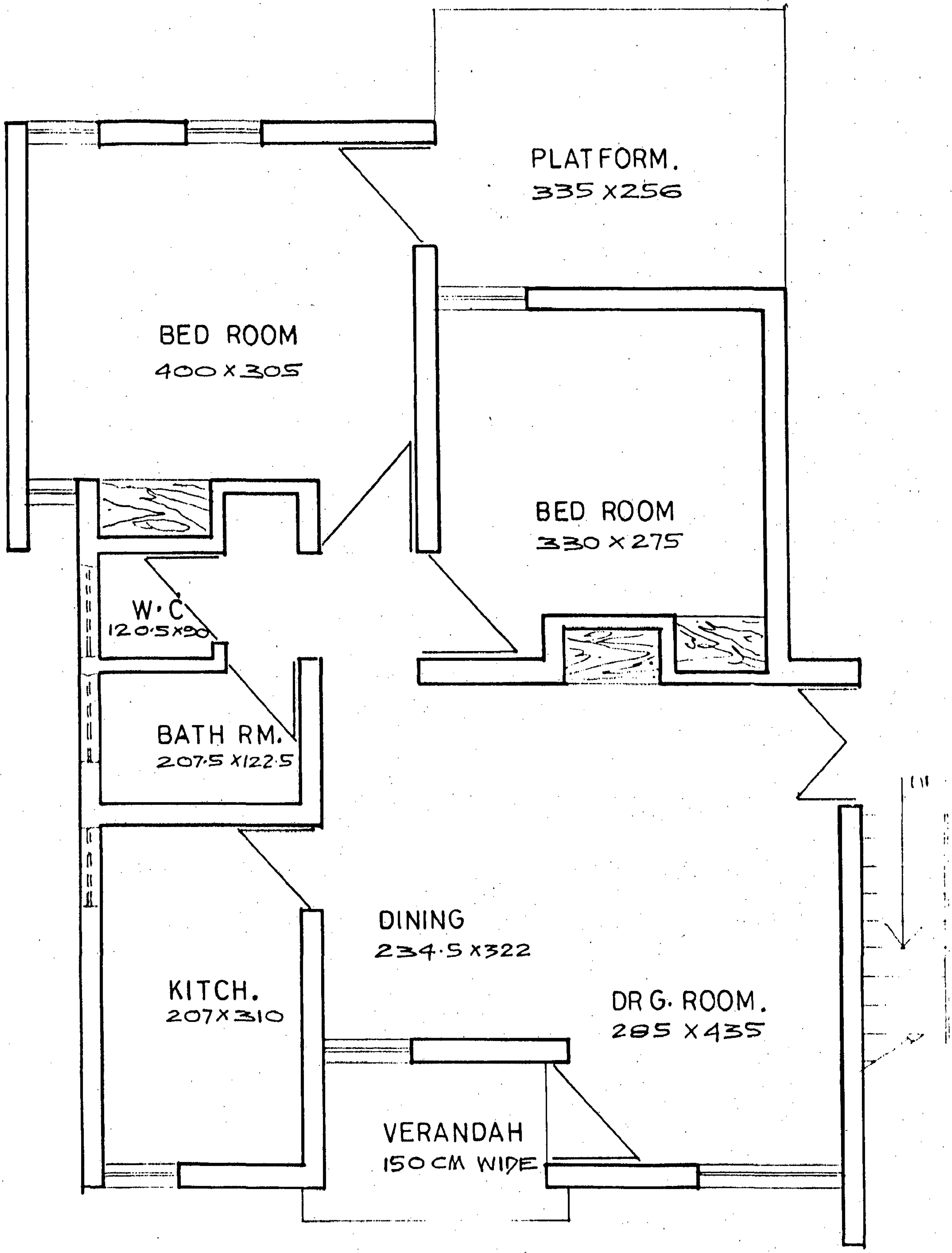
Source : Sanitary and Water supply fittings market at Delhi, Dehradun.

DATA FOR BATHROOM FITTINGS

Table-16

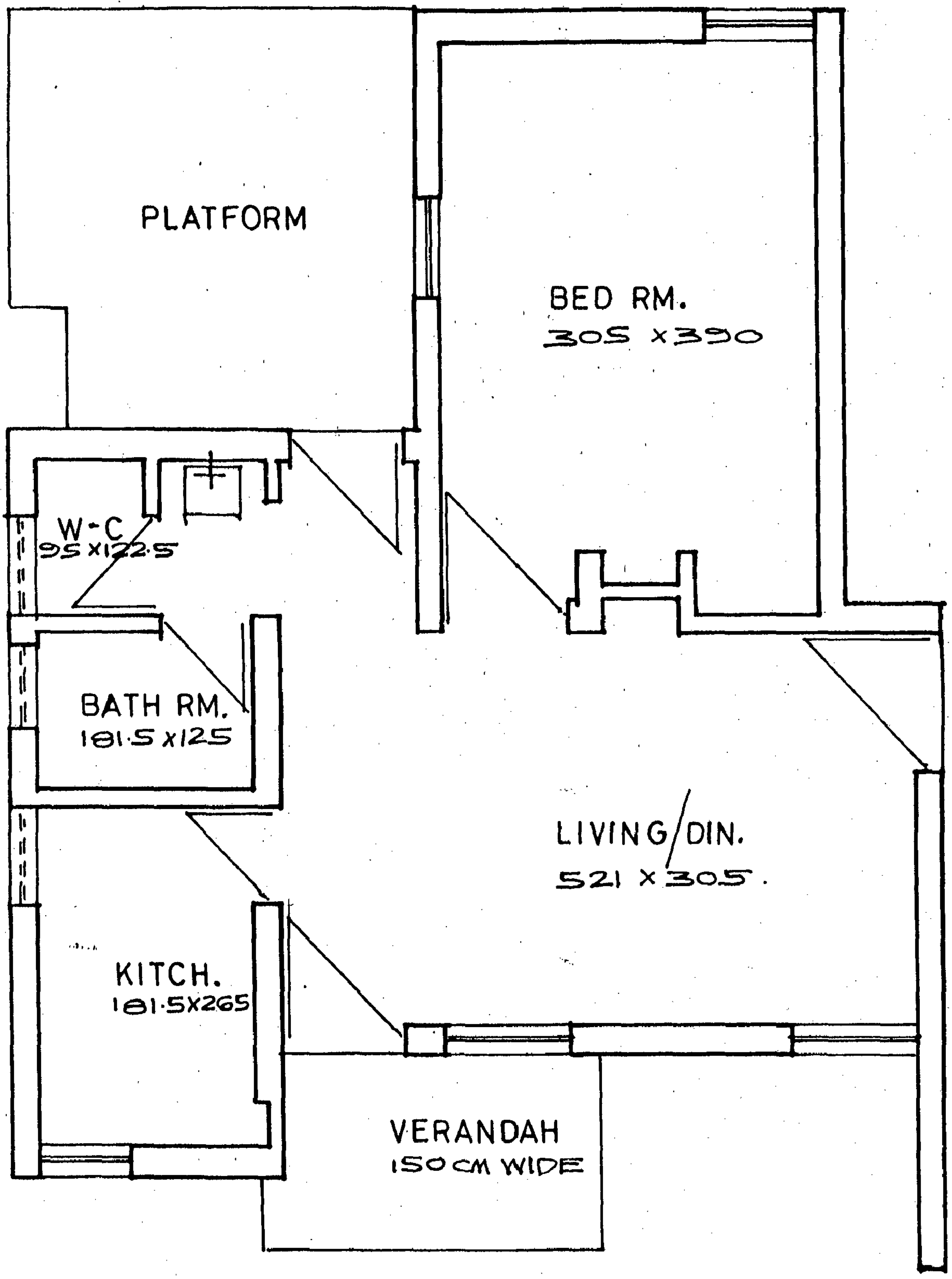
Item	Size	Rate
Shower		Rs. 12/- to Rs.60/-
Shower Arm		Rs. 20/-
G.I. pipe	1/2'' ϕ	Rs.5/- per R.F.T.
	3/4'' ϕ	Rs.6/- per R.F.T.
Elbow Tap		Rs. 3/- per piece
Brass		Rs.14/-
Cromium		Rs.48/- to Rs.60/-
Floor Trap		Rs.12/- to Rs.33/-
Gulley Trap with Shutter		Rs.52/-
Main hole shutter		Rs.24/- to Rs.75/-
Rain water pipe		
A.C.C.		Rs.13/- to Rs.15/-
C.I.		Rs.60/-
Wash Basin		
White	12'x18''	Rs.140/- to Rs.190/-
Colour	16'x22'	Rs.210/- to Rs.245/-
Traps combined mixer tap		Rs.32/- to Rs.48/-
Waste pipe		Rs.7/- to Rs.25/-
P.V.C. waste		Rs.15/- to Rs.20/-
Pipe		Rs.6/- to Rs.12/-

Source : Sanitary and water supply fittings market at Delhi, Dehradun.



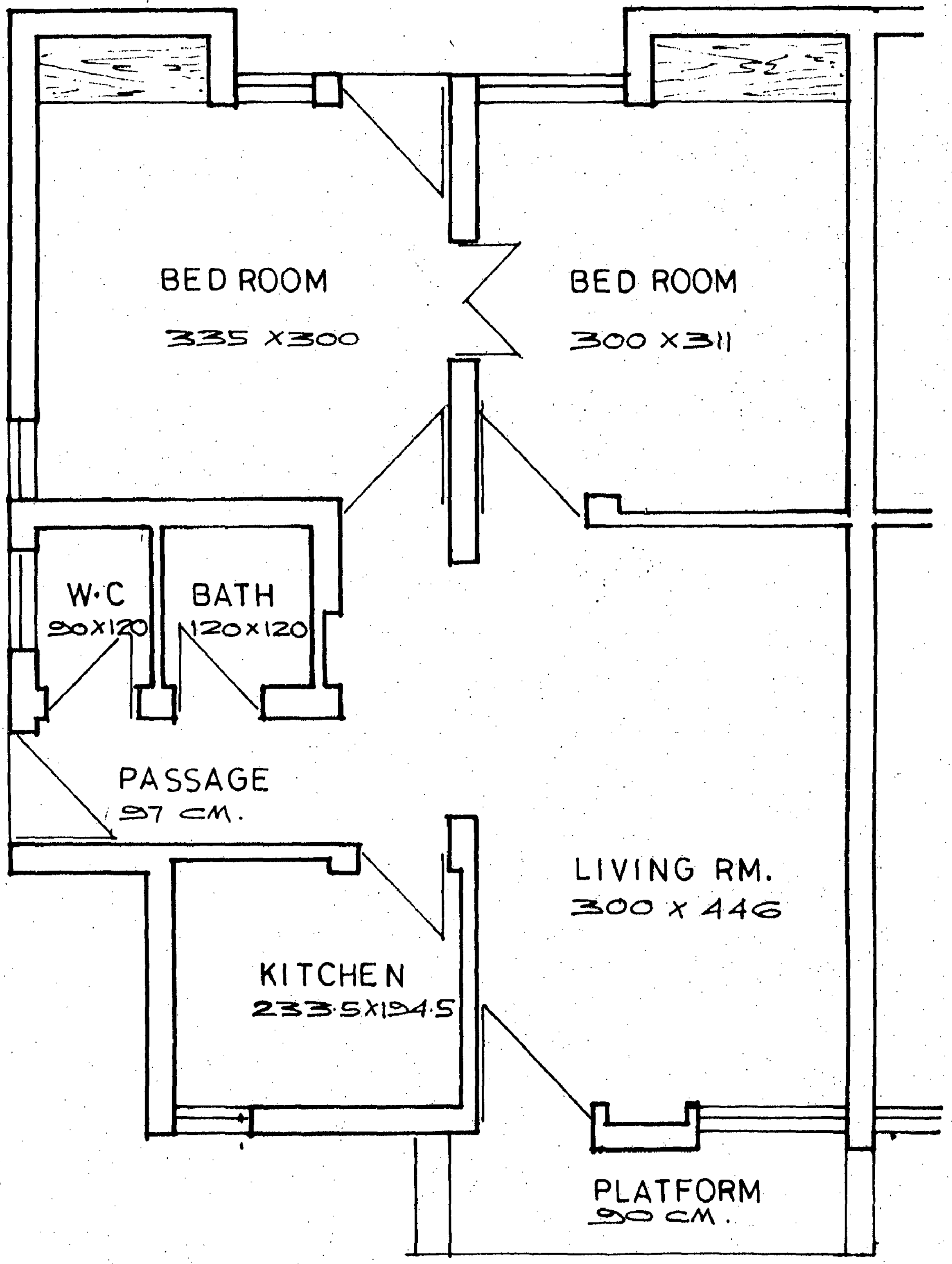
PLAN-1

THREE ROOMED SCIENTIST APARTMENT, C.B.R.I.



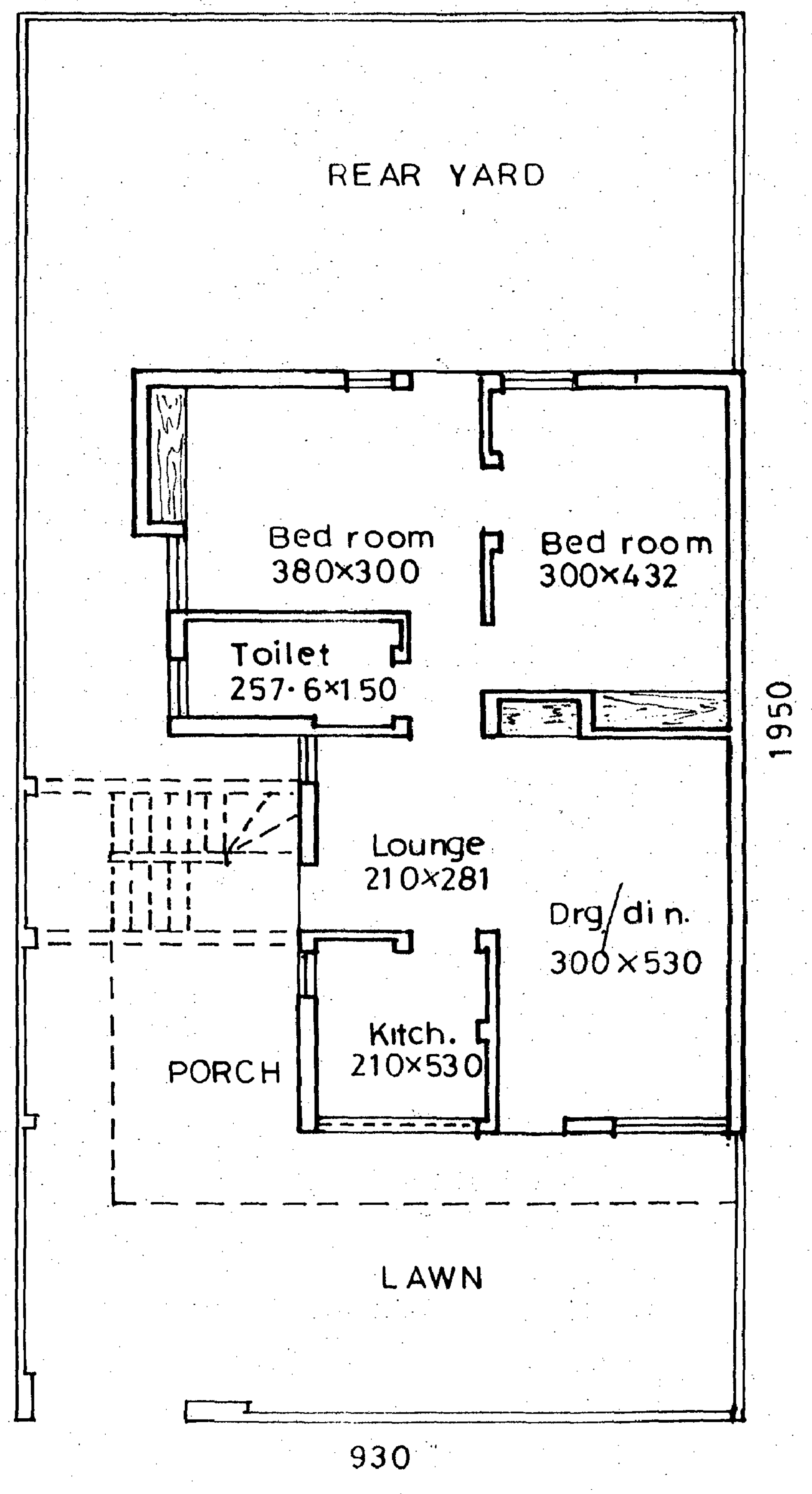
PLAN - 2

TWO ROOMED SCIENTIST APARTMENT, C.B.R.I.



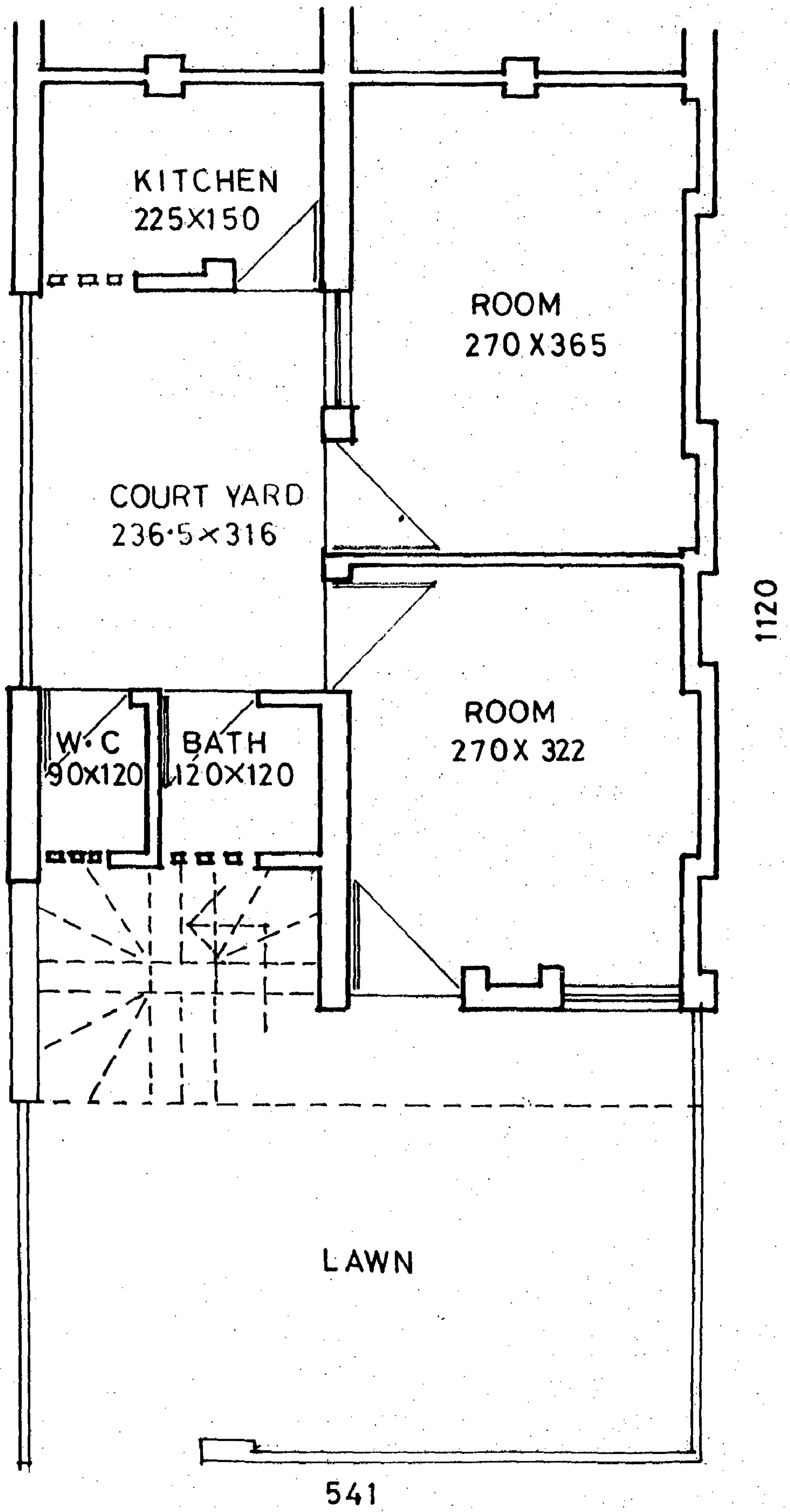
PLAN-3

M.I.G. HOUSE, U.P. HOUSING BOARD



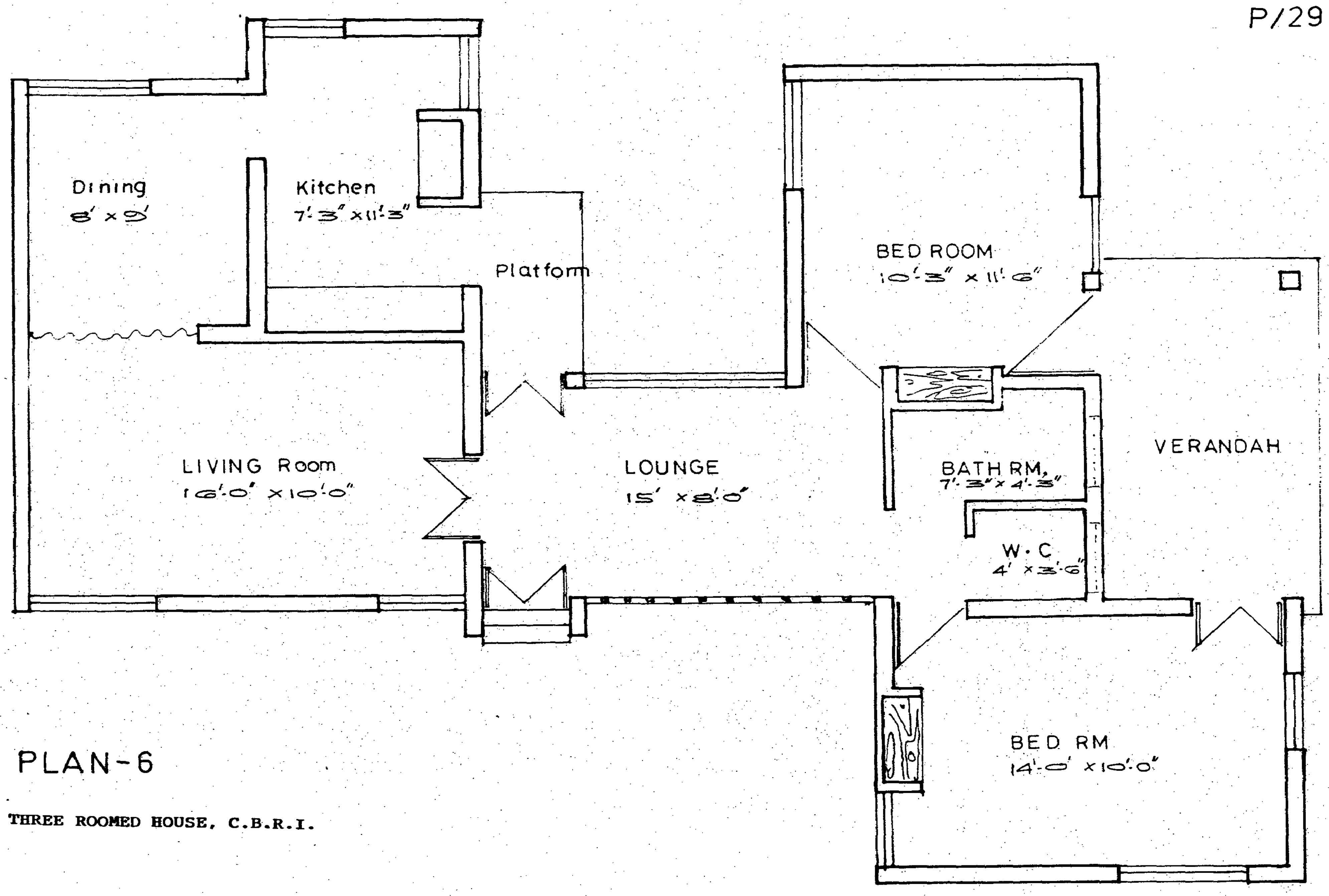
PLAN-4

M.I.G. HOUSE, U.P. HOUSING BOARD



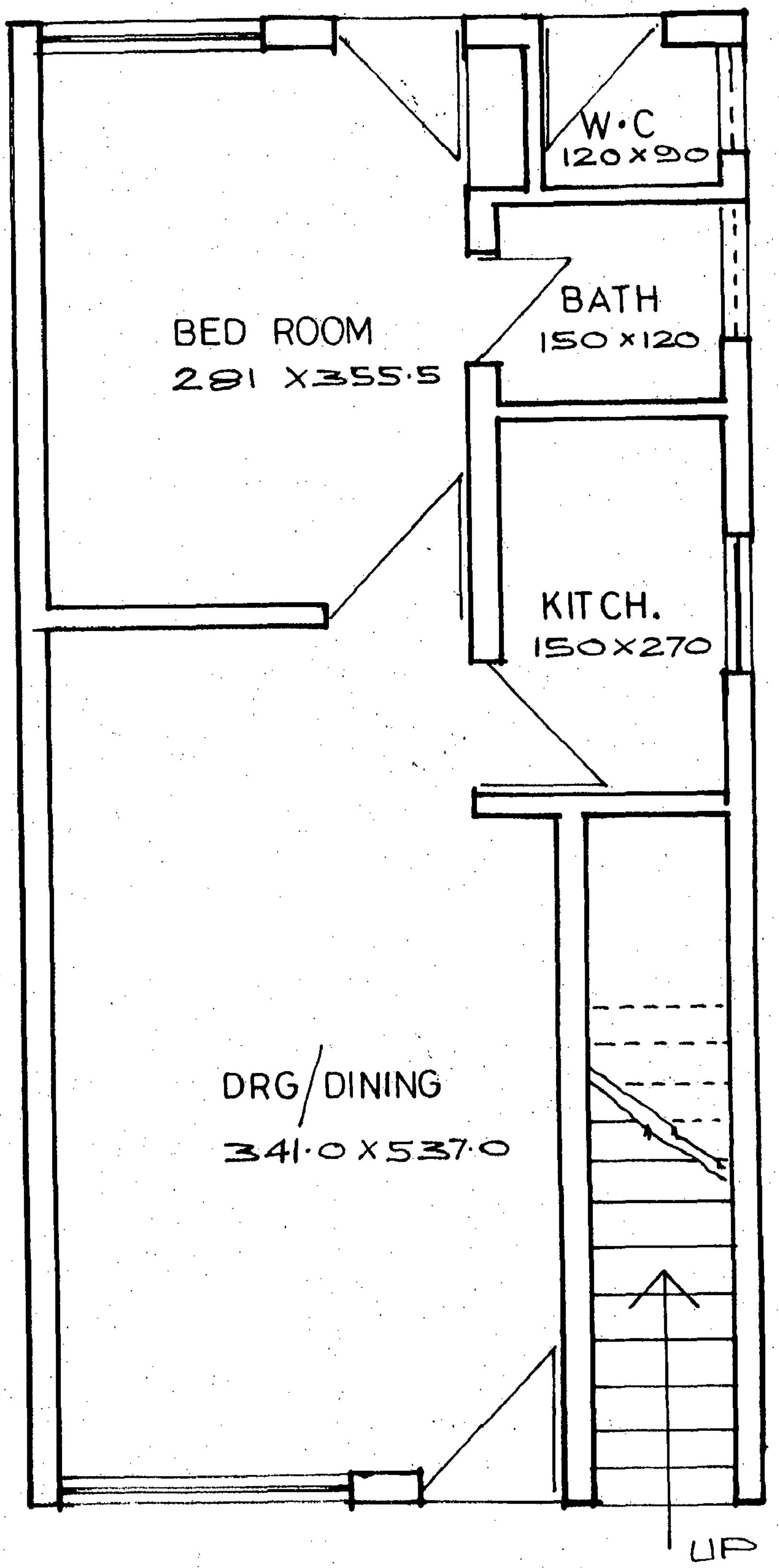
PLAN-5

L. I. G. HOUSE U.P. HOUSING BOARD



PLAN-6

THREE ROOMED HOUSE, C.B.R.I.



PLAN-7

TWO ROOMED HOUSE, N.B.O.

that almost 95% people opt for good specifications for those items which have direct bearing on structure and maintenance.

Specifications being adopted by various agencies are enclosed. This clearly reveals the lower standard of specifications generally being adopted by the Housing Boards, N.B.O. and development authorities. In some cases, item of good or Ist class specifications such as brick work, wood, flooring are being avoided.

People in general are not clear about the definition of low lost specifications proposed by N.B.O. and HUDCO. They are still not able to decide whether the specifications suggested by these agencies are low in quality or low in cost without affecting the quality of construction work as is clear from the specifications given.

4.3 COLLECTION OF HOUSE PLANS DEVELOPED BY U.P.HOUSING BOARDS, DELHI DEVELOPMENT AUTHORITIES, N.B.O. AND C.B.R.I.

Different house plans were collected from the housing agencies and analysed keeping the various aspects into mind.

The study of these plans shows that different aspects related to various parameters such as plan form, space utilization, circulation area, economical services, finishing, door and window details, room size, cupboard size are least attended to though very important. Although various anthropometric studies on space use and human activities are available but unfortunately these are hardly in practice and

SPECIFICATIONS ADOPTED BY DIFFERENT ORGANIZATIONS

C.B.R.I.- E.W.S.

Foundation	:	c.conc. 1:8:16 with stone block masonry in cm 1:7
Superstructure	:	Stone block masonry in c.m. 1:7
Roof	:	R.C. solid planks resting on partially precost R.C. beams
Flooring	:	25 mm thick c.conc. 1:2:4
Joinery	:	Secondary Species of timber
Finishing	:	Inside plastering outside pointing

D.D.A - E.W.S.

Foundation	:	Lime concrete
Superstructure	:	Brick work in lime mortar
Roof	:	Precast R.C.C. channel units
Joinery	:	Kail wood
Flooring	:	25 mm c.c. conc. 1:2:4
Finishing	:	No plastering outside lime mortar plaster inside

N.B.C.C. , E.W.S.

Foundation	:	Lime concrete
Superstructure	:	Second class brick work in lime surkhi sand mortar 1:1:6
Roof	:	Precast R.C.C. funicular shells
Flooring	:	25 mm thick c.c.
Finishing	:	Inside walls plastered and outside walls pointed
Joinery	:	Kail wood

D.D.A. - E.W.S.

Foundation	:	Lime concrete
Superstructure	:	Brick work in lime mortar
Roof	:	R.B. slab
Finishing	:	No plaster outside lime plaster inside
Flooring	:	25 mm c.conc. 1:2:4
Joinery	:	Kail wood

Rajasthan Housing Board - E.W.S.

Foundation	:	Lime concrete
Superstructure	:	Precast stone block masonry in lime mortar
Roof	:	75 mm thick stone slab
Flooring	:	25 mm thick c.c.
Joinery	:	Second grade wood
Finishing	:	Pointing with cement sand mortar

D.D.A. L.I.G.

Foundation	:	Lime concrete
Superstructure	:	Brick work in lime mortar
Roof	:	Precast RCC channel units and RCC slab
Flooring	:	25 mm thick C.C. 1:2:4
Joinery	:	Kail wood
Finishing	:	Plastering inside in cement lime mortar no outside plastering

U.P.Housing Board - E.W.S.

Foundation	:	Lime cinder concrete
Superstructure	:	First class brick work in cem.mortar 1:8
Roof	:	Reinforced brick

Flooring	:	25 mm thick c.c. in both W.C. and mud flooring at other places
Finishing doors	:	Inside and outside plaster in c.m.1:6 cheer wood
Windows	:	R.C.C. jali

N.B.C.C. - L.I.G.

Foundation	:	Lime concrete
Superstructure	:	Second class brick work
Roof	:	40 mm precast RCC funicular shells
Flooring	:	25 mm c.conc.
Joinery	:	Kail wood
Finishing	:	Inside plaster outside pointing

D.D.A. - L.I.G

Foundation	:	Lime concrete
Superstructure	:	Brick work in lime flyash mortar
Roof	:	R.B. slab
Flooring	:	25 mm c.conc. 1:2:4
Joinery	:	Kail wood
Finishing	:	No plaster outside lime mortar plaster inside

C.B.R.I. - L.I.G.

Foundation	:	C.Conc. 1:8:16
Superstructure	:	Second class brick work in mortar 1:7
Roof	:	Precast RCC channel units, solid planks, brick arch job.
Flooring	:	25 mm c.conc. 1:2:4
Joinery	:	Secondary species timber
Finishing	:	Plastering and pointing

STANDARD GENERAL SPECIFICATIONS OF BUILDING WORKS ADOPTED BY

U.P.HOUSING BOARD

Sl. No.	Description	EWS Houses	LIG House	MIG Houses	HIG Houses	Remarks
1	2	3	4	5	6	7
1.	Foundations	Width of foundations as per design. Depth from P.L.75cm in ordinary soil for load bearing walls and 53 cm for non-load bearing walls.	Same as in column 3.	Same as in column 3 but depth of load bearing walls from P.L. to be 80cm and for partition 60 cm	Width as per design depth of foundation below P.L. 90cm load bearing and 60cm for non-load bearing walls.	Where the soil is loose and/or filled up foundation shall be taken upto completed earth for which specific sanction is necessary.
2.	Foundation concrete	Lime concrete 100:16:32 (100 parts 40mm size O.B.B-16 parts lime powder made from unslaked lime 32 part surkhi) where L.C. is uneconomical cement concrete 1:6:12 with 1 part cement 6 part fine sand (F.M. 1.25) and 12 parts O.B.B.40mm may be used its thickness(compacted) shall be 15cm for load bearing walls and 7.5mm for non-load bearing partitions.	Same as in column 3	Same as in column 3.	Same as in column 3	

1	2	3	4	5	6	7
3.	Height of plinth	23 cm above G.L.	Same as in column 3	30 cm above G.L.	30 cm above G.L.	The plinth should be above or at the level of the crown of the road in front.
4.	Damp proof course	20mm thick cement concrete 1:2:4 with one coat of bitumen of required grade. Plinth plaster 12mm thick in cement coarse sand mortar 1:6 shall be done on external surfaces of outer walls just below plinth and DPC layer shall be made upto plastered width of wall.	Same as in column 3.	Same as in column 3.	Same as in column 3	
5.	Foundation and Plinth masonry	Ist class brick work in 1:3 white lime and surkhi mortar or in any other approved economic equivalent mortar	Same as in column 3	Same as in column 3	Same as in column 3	Consumption of cement should be minimised as far as possible
6.	Super-structure masonry	Same as for foundation and plinth upto 23cm walls 7.5 cm thick walls shall be in 1:4	Same as in column 3	Same as in column 3	Same as in column 3 except for walls which are	-do-

1	2	3	4	5	6	7
		cement coarse sand mortar and 11.5cm thick walls shall be in 1:6 cement sand mortar of 1.25 F.M.			highly loaded shall be cons-tructed with rich mortar as per design.	
7.	Lintels and Chhajjas	R.B./RCC as per design where it is possible to provided RCC precast thin lintels,they shall be invariable provided.	Same as in column 3	Same as in column 3	Same as in column 3 where larger span open-ings are there RCC lintel beams as per design shall be provided	
8.	Roofing	All R.B.slabs as per design but in those areas where RCC is comparatively econo-mical RCC labs shall be provided.	Same as in column 3	Same as in column 3	Same as in col.3 but where R.B.slabs are not possible for bigger span slabs RCC slabs as per design shall be laid.	
9.	Chaukhat for doors	35x25x5mm angle iron vertical legs only	Angle iron frame made of 35x35x5mm san-ction and hold fast fixed in masonry with CC 1:2:4 blocks of 20x10x8cm size.	I.B.commercial type flush door shutters in rooms 30mm thick,and outer solid core.		

BUILDING SPECIFICATION COMMONLY ADOPTED BY CENTRAL PUBLIC WORKS DEPARTMENT

Sl.No.	Element	Specifications
1.	Foundation and Plinth	Excavation in Ordinary soils; cement concrete (150mm thick) 1:5:10 in beds Brick work in cement mortar 1:6:40mm thick D.P.C. consisting of cement concrete 1:2:4 with bitumen coating on top, sand filling (100 mm thick) in plinth.
2.	Walling	Brick work in cement mortar 1:6, RCC work in lintels
3.	Roof	RCC roof slab with lime concrete terrace (average 115 mm thick) having bitumen coating underneath.
4.	Floors :	
	a) Ground Floor	40mm thick cement concrete 1:2:4 laid over cement concrete (75mm thick) 1:5:10. Cement concrete (75mm thick) 1:5:10
	b) First Floor	RCC slab with 40 mm thick concrete floor finish
5.	Joinery	Timber Frames, 40mm thick timber panelled shutters for doors and fully glazed shutters for windows
6.	Finishes	Levelling top of wall surfaces with cement mortar 1:3:12 mm thick cement plaster 1:6 on smooth sides of walls and 27mm thick cement plaster 1:6 on rough sides of walls, 20mm thick cement plaster (1:3) skirting and dado internally white-washed and externally colour washed, painting wood work with an oil paint.
7.	Stairs	RCC waiste and steps
8.	Fittings and Fixtures	Precast RCC shelves, M.S.round bars in windows, chullah in kitchen

remain on the paper only. So there is a need for comprehensive analysis of those elements which actually affects the cost of the building right from the planning to completion of the construction work.

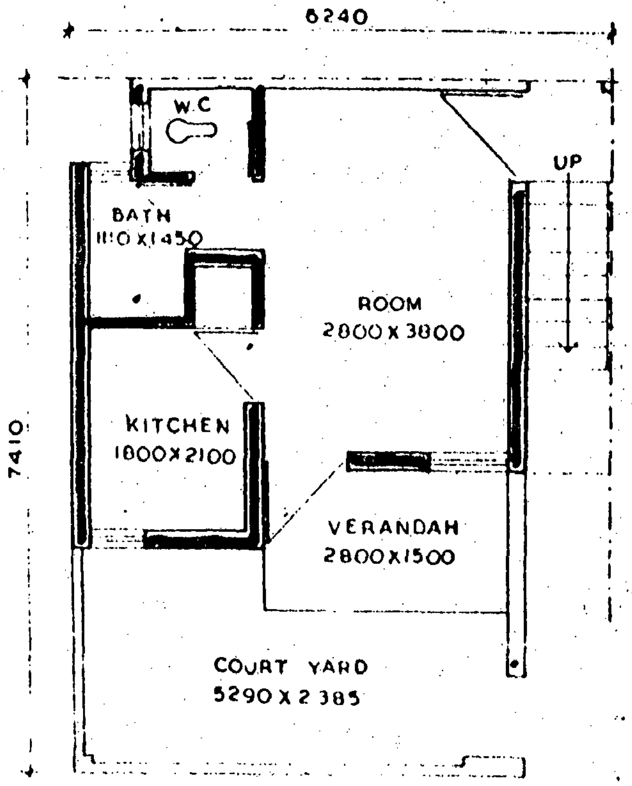
4.4 REVIEW AND RESEARCH OF CASE STUDIES

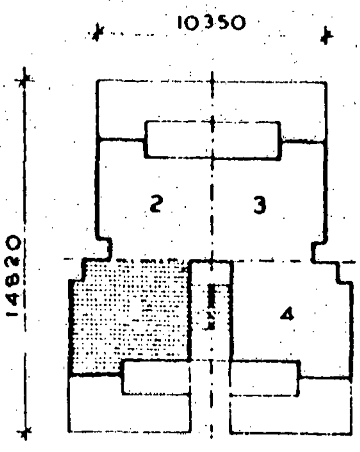
Some building plans with specifications have been collected from D.D.A., U.P.Housing Board, N.B.O. and C.B.R.I. for reviewing the various economical aspects. Some observations have been made plans and specifications with observations are enclosed.

OBSERVATIONS

1. Due to two outside doors, a lot of space goes in internal circulation.
2. Elimination of one out side entry will not only increase the internal efficiency of plan but also reduce the cost by one door.
3. It has been observed in almost all plans that there is door in the kitchen which is not desirable.
4. There is no standardised width of room in all plans. Even the overall sizes of room vary.
5. No. of side ends in the layout plan can further be reduced by replanning the layout.
6. Houses have been designed widthwise as is clear from the plans. This will increase the road width.
7. From the plans it appears that building blocks have not been grouped together considering the parameters like use of common wall.
8. Specifications adopted clearly show that there is no standardisation in specifications.

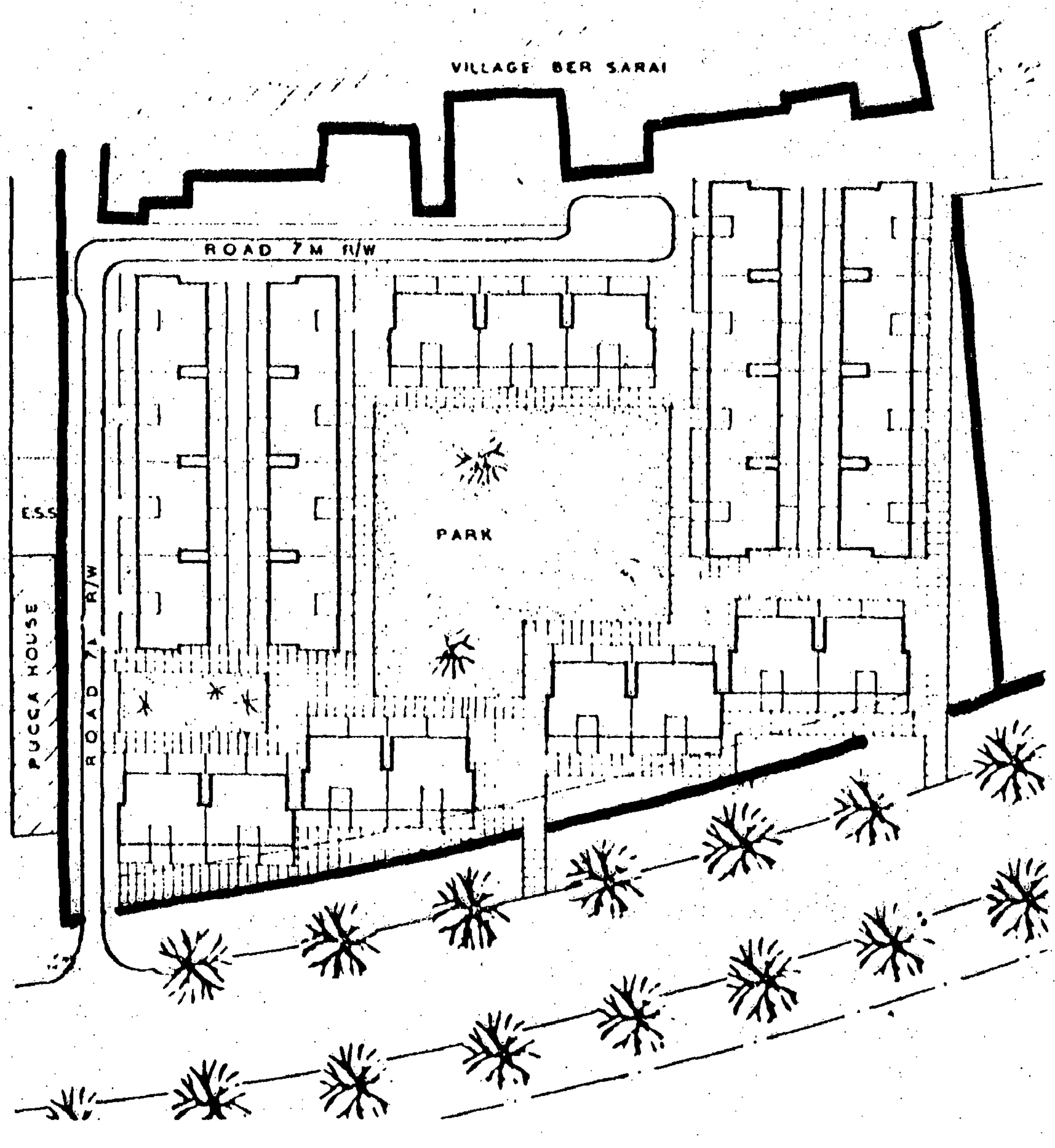
PLAN-E_1



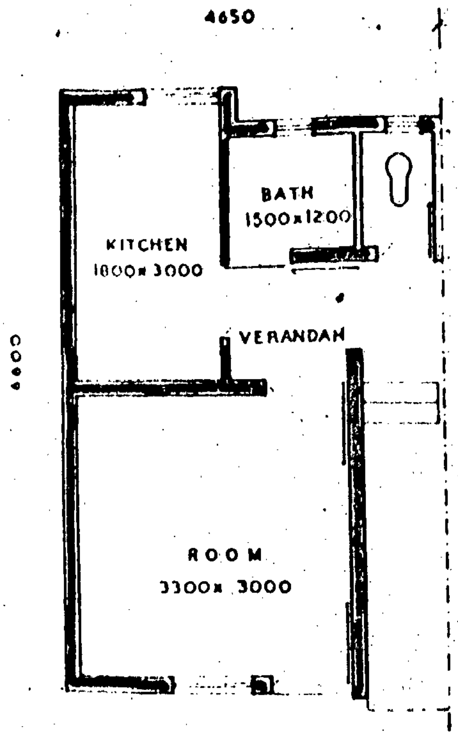


KEY PLAN

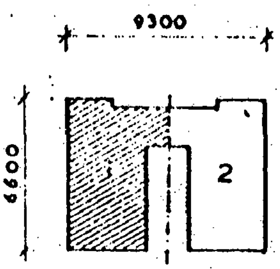
E.W.S. HOUSE BY D.D.A., PLINTH AREA $26.2M^2$



PLAN E_2

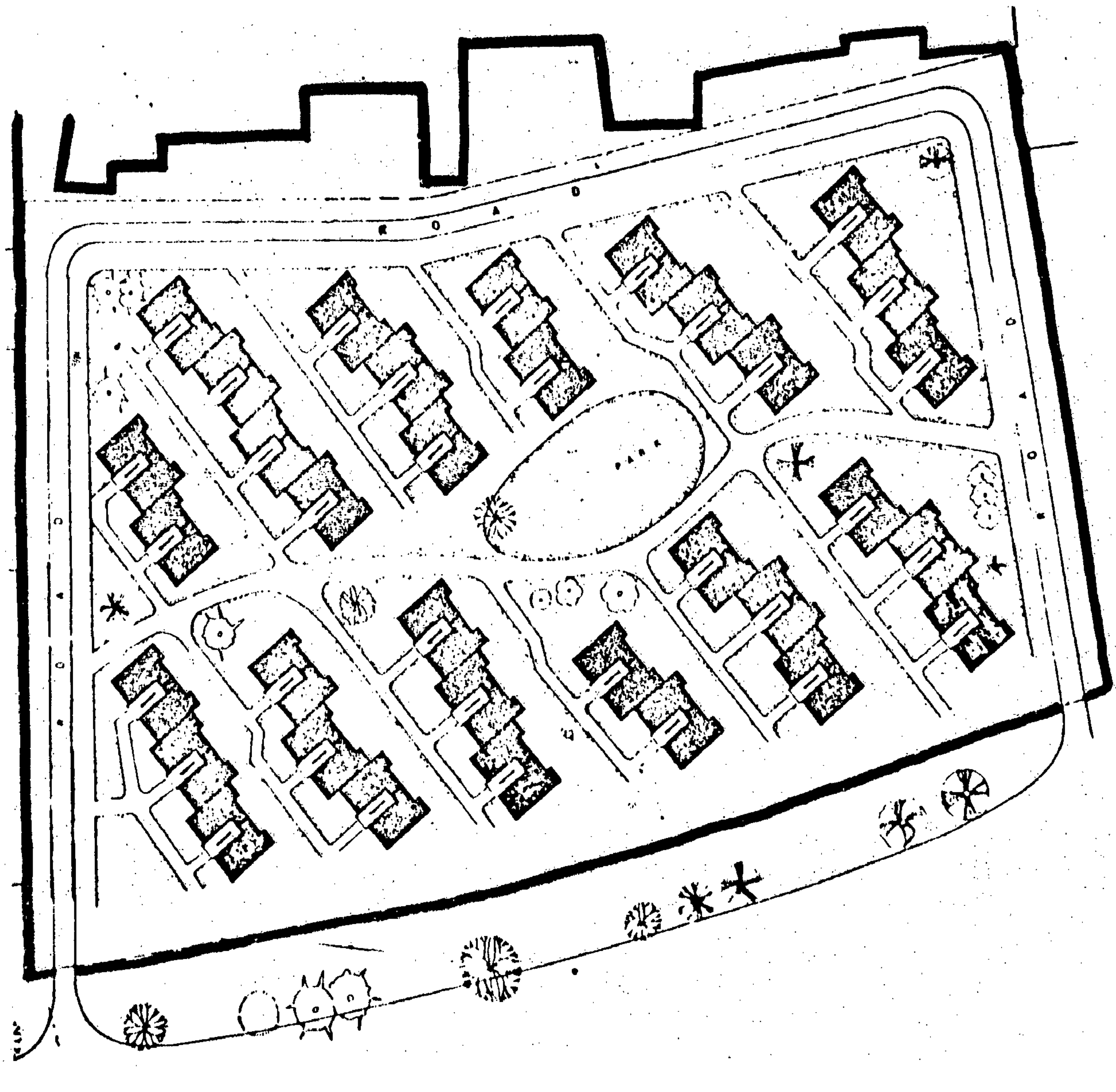


UNIT PLAN



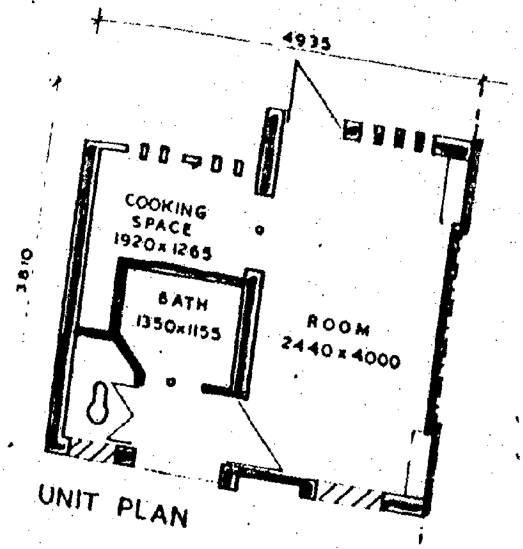
KEY PLAN

E.W.S. HOUSE BY C.B.R.I., ROORKEE, PLINTH AREA $28.6M^2$

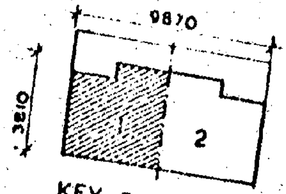


P/33

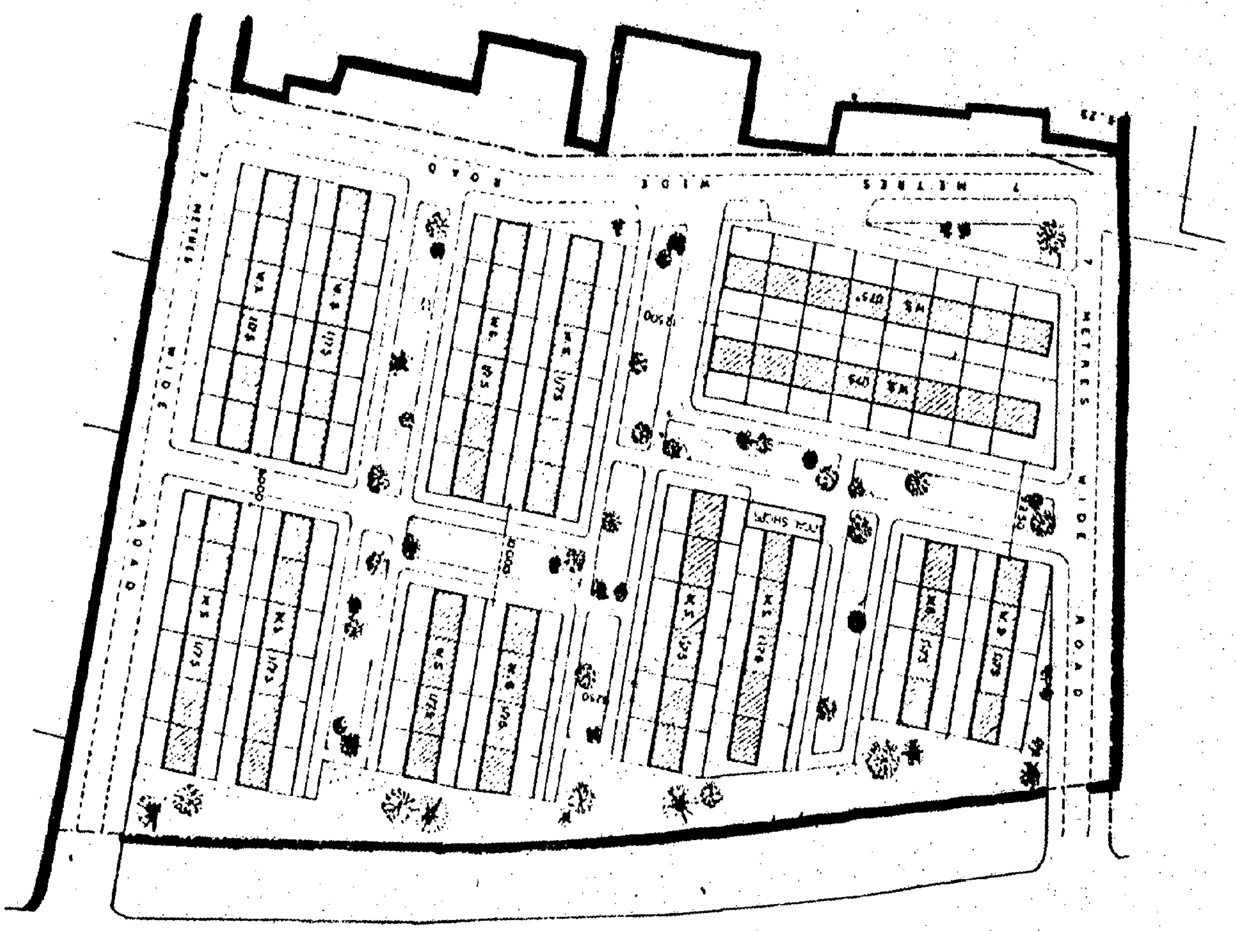
PLAN E_3



UNIT PLAN



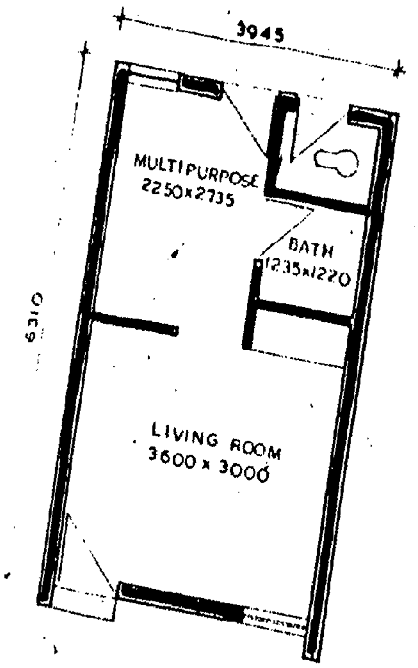
KEY PLAN

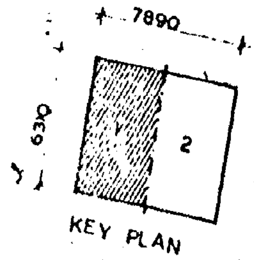


E.W.S. HOUSE BY U.P. HOUSING BOARD PLINTH AREA - 19.2M^2

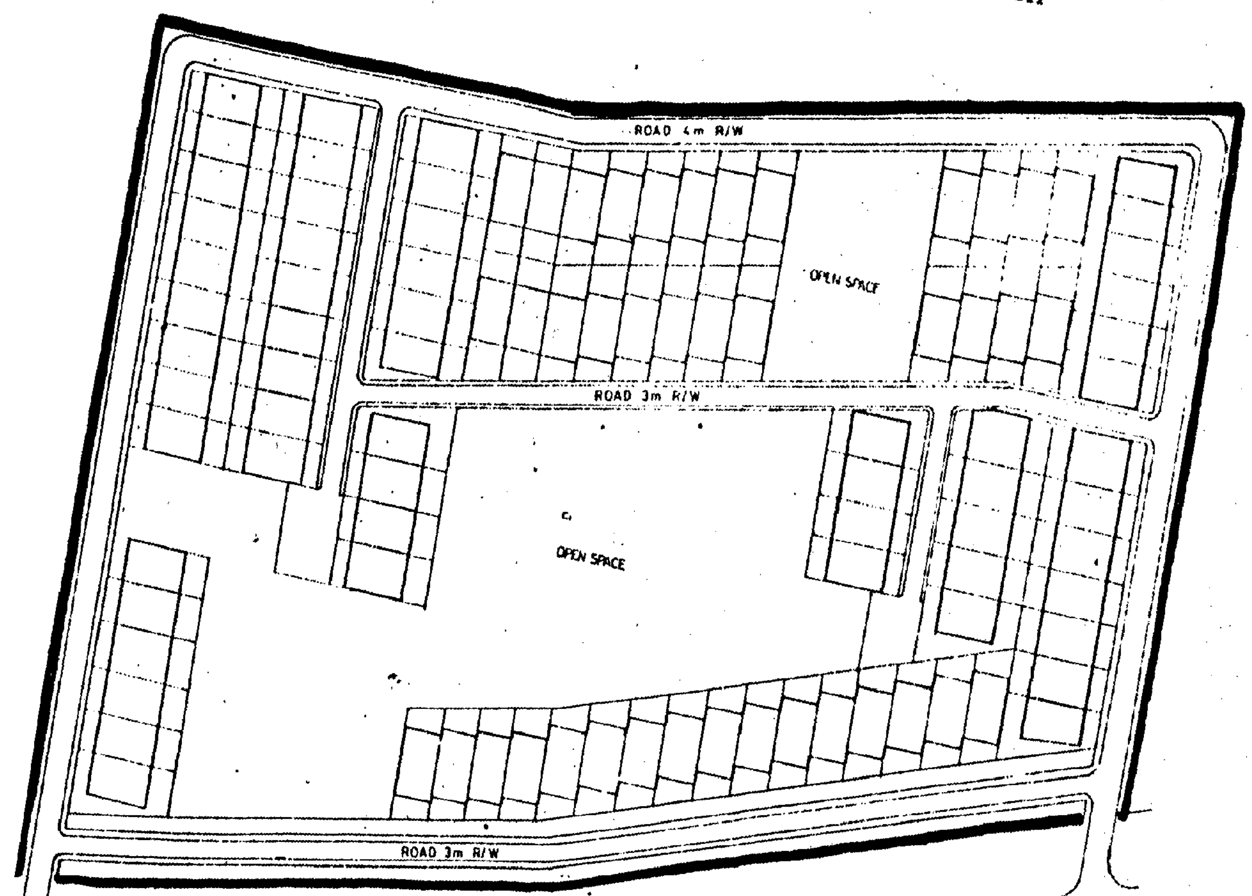
P/34

PLAN E4

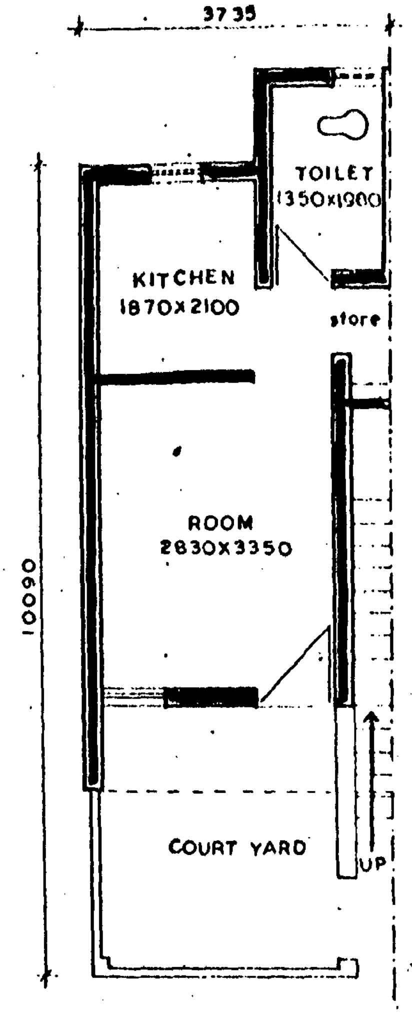


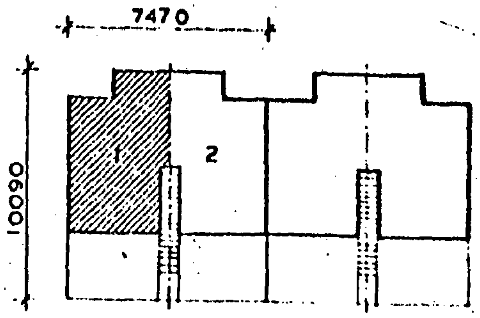


E.W.S. HOUSE BY U.P. HOUSING BOARD PLINTH AREA - $25M^2$



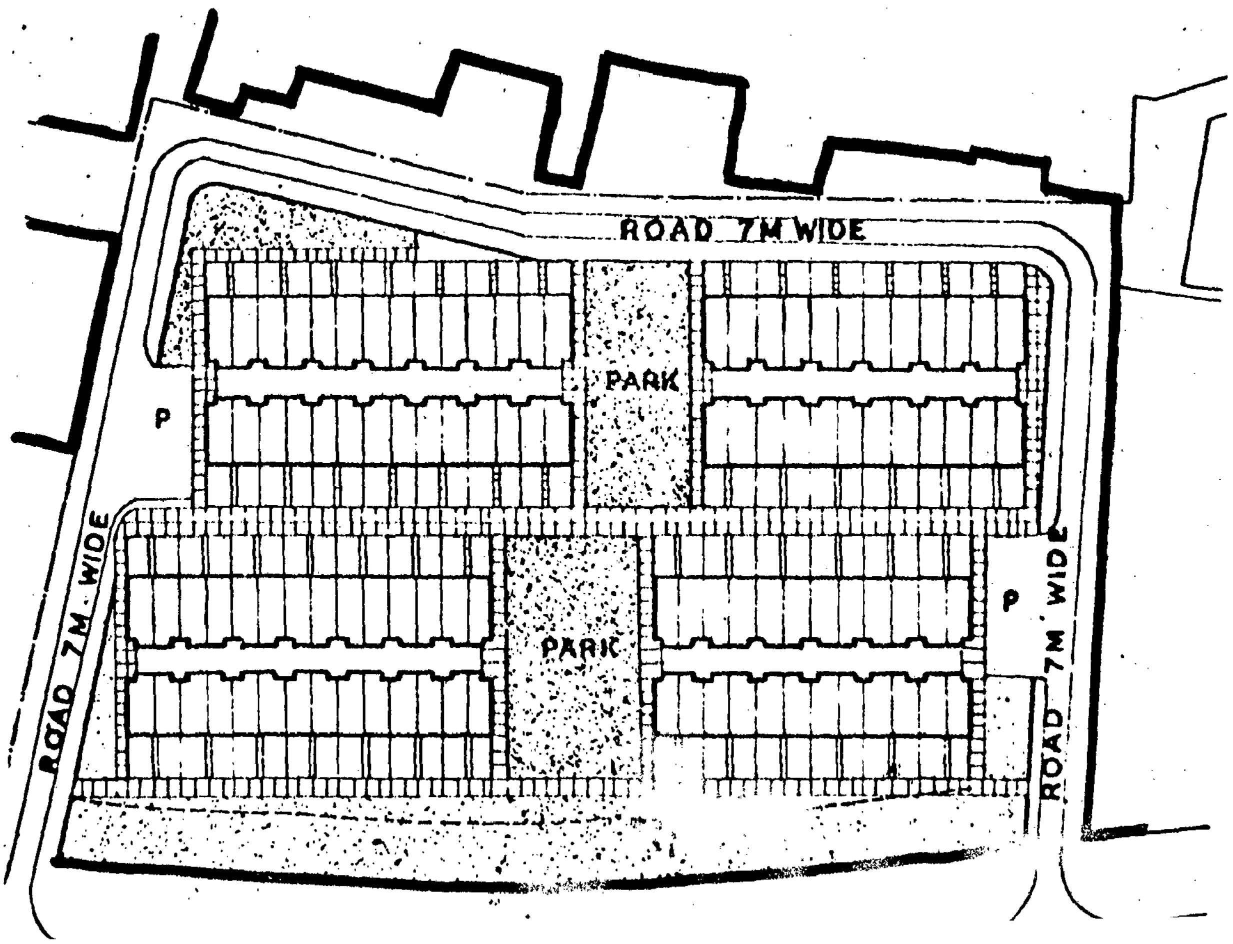
PLAN E5





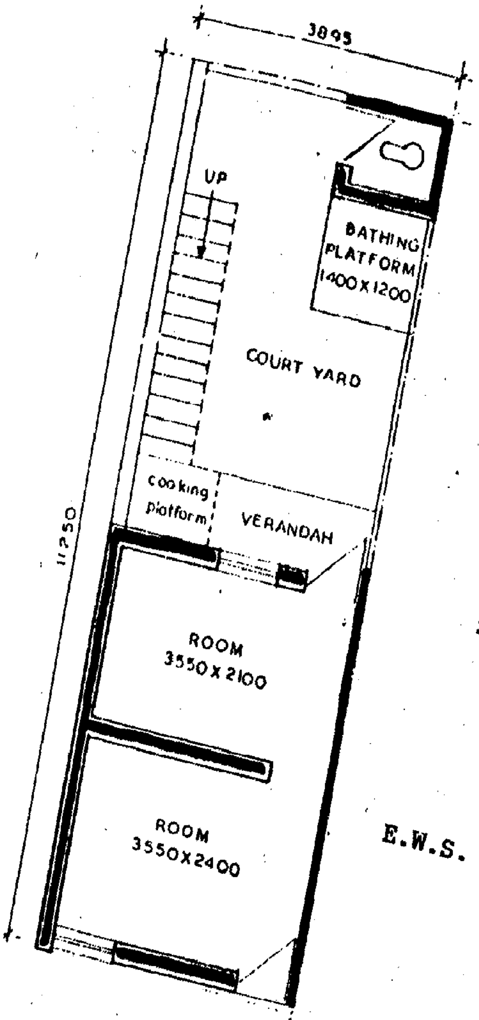
KEY PLAN

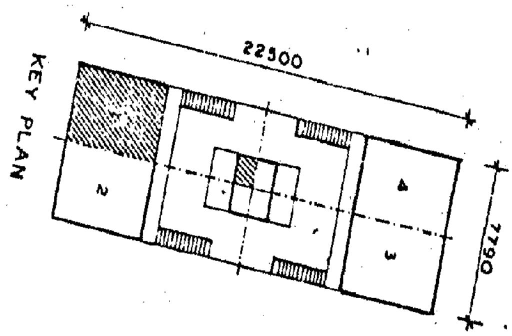
E.W.S. HOUSE BY D.D.A., PLINTH AREA - $23M^2$



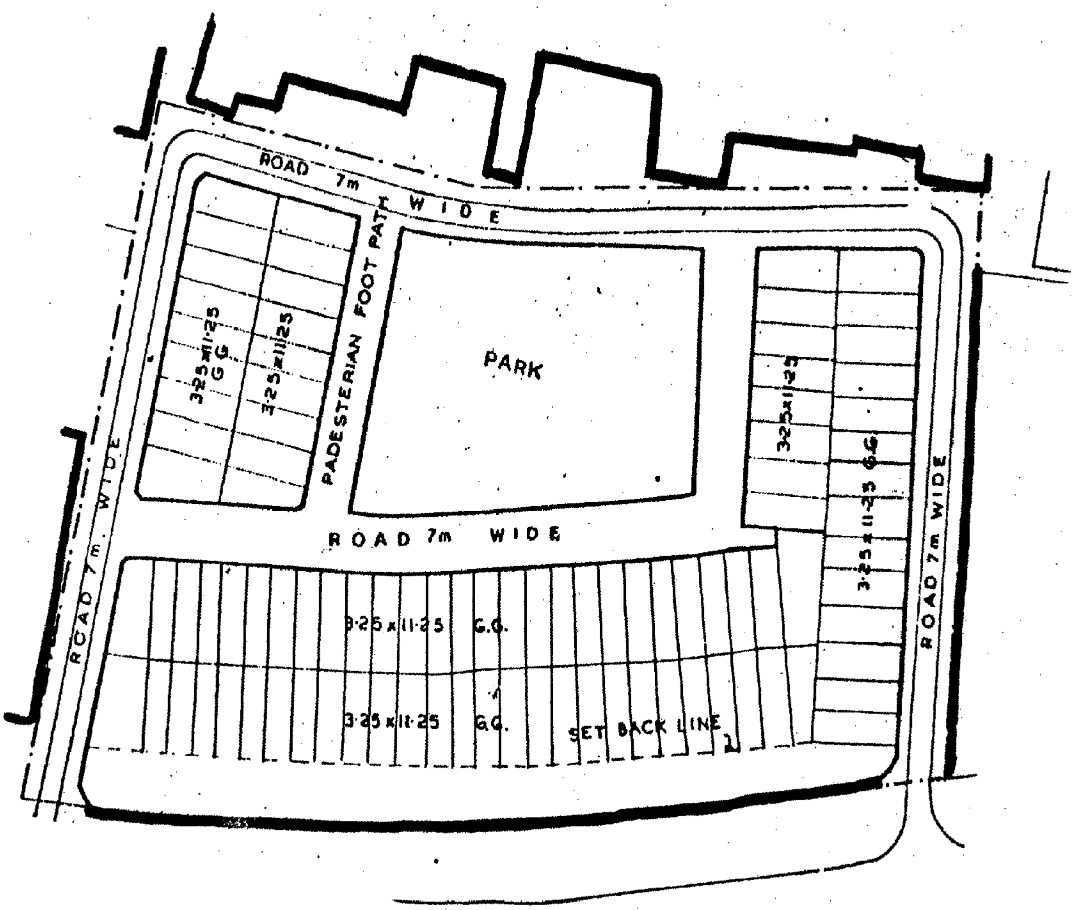
P/36

PLAN E_6

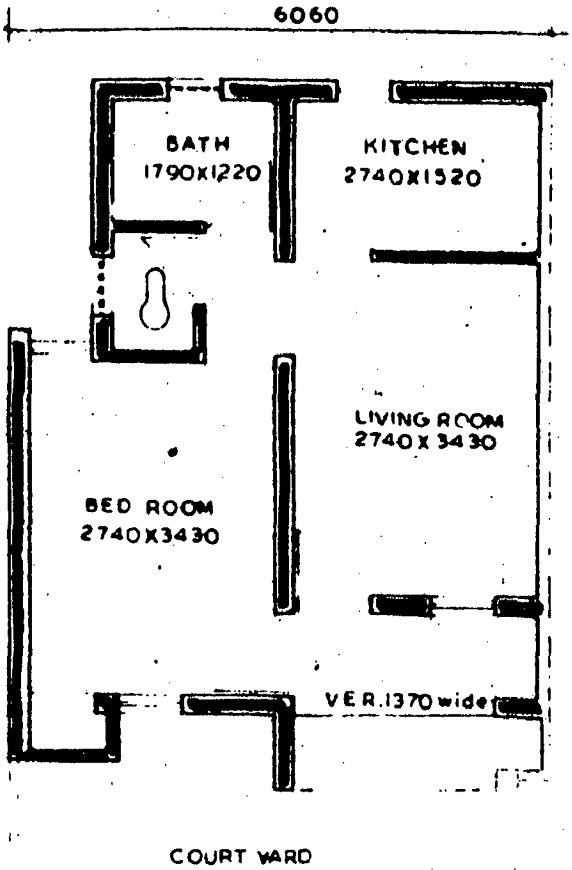


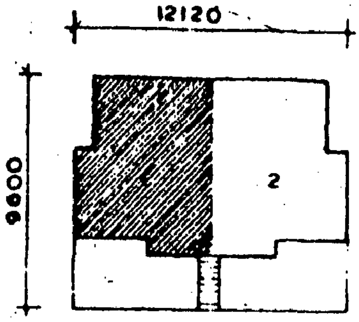


E.W.S. HOUSE BY N.B.O. PLINTH AREA - 22.7 M^2



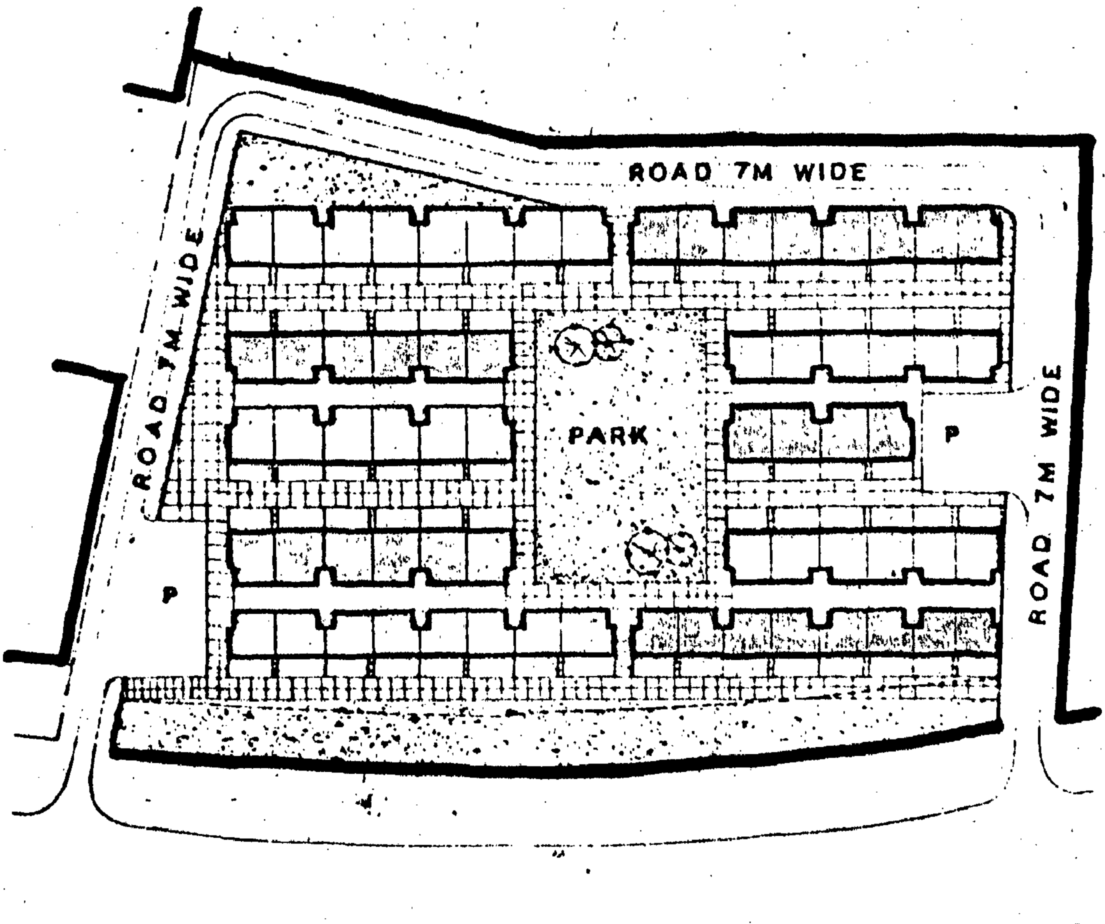
PLAN L_1



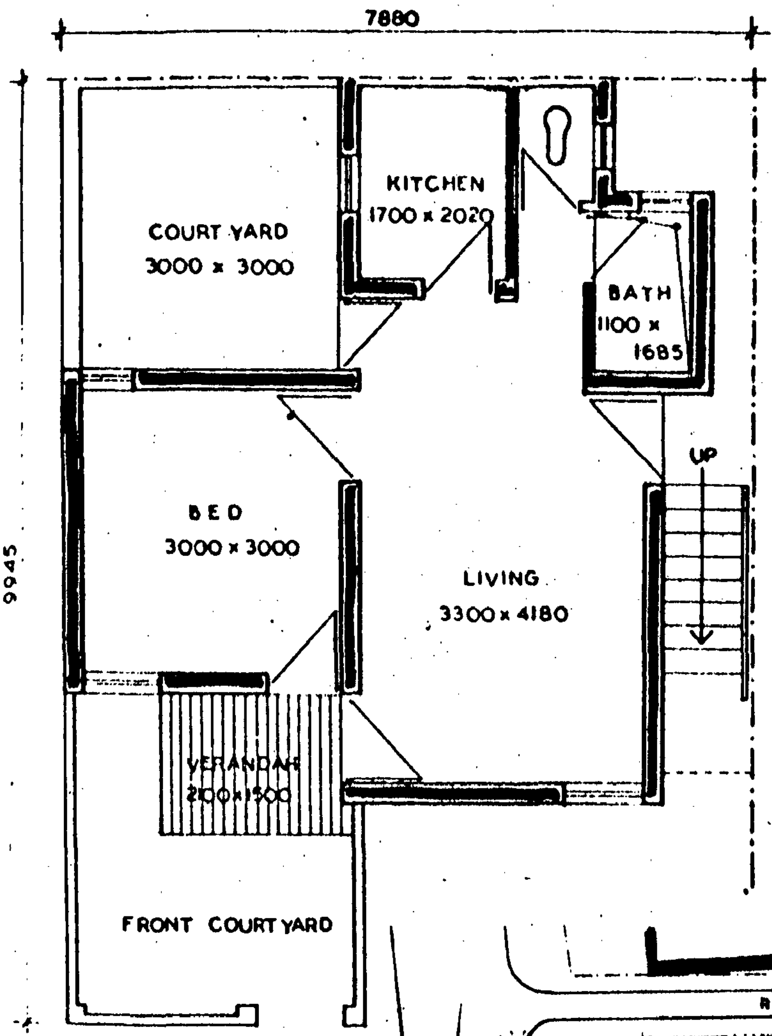


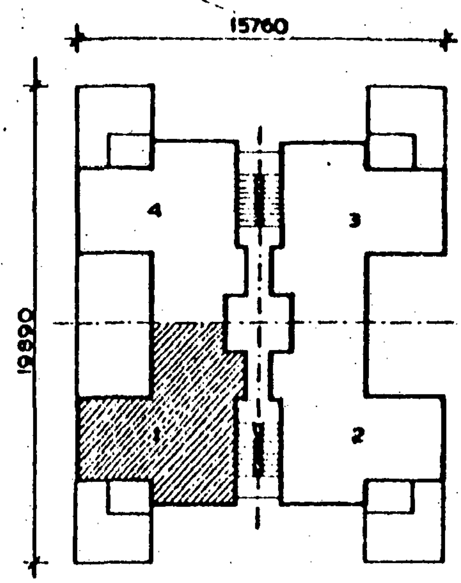
KEY PLAN

L.I.G. HOUSE BY D.D.A. PLINTH AREA -37.56 M^2

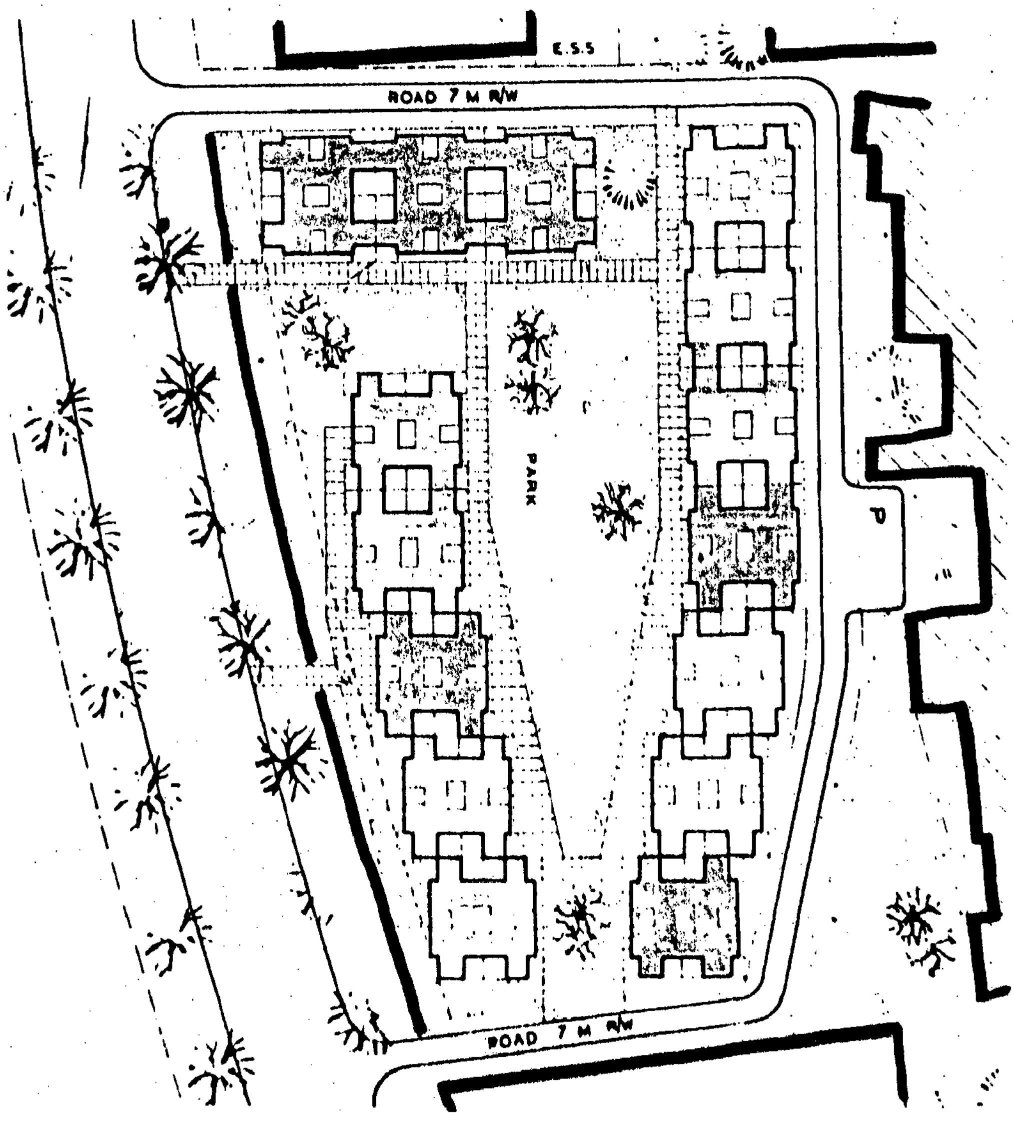


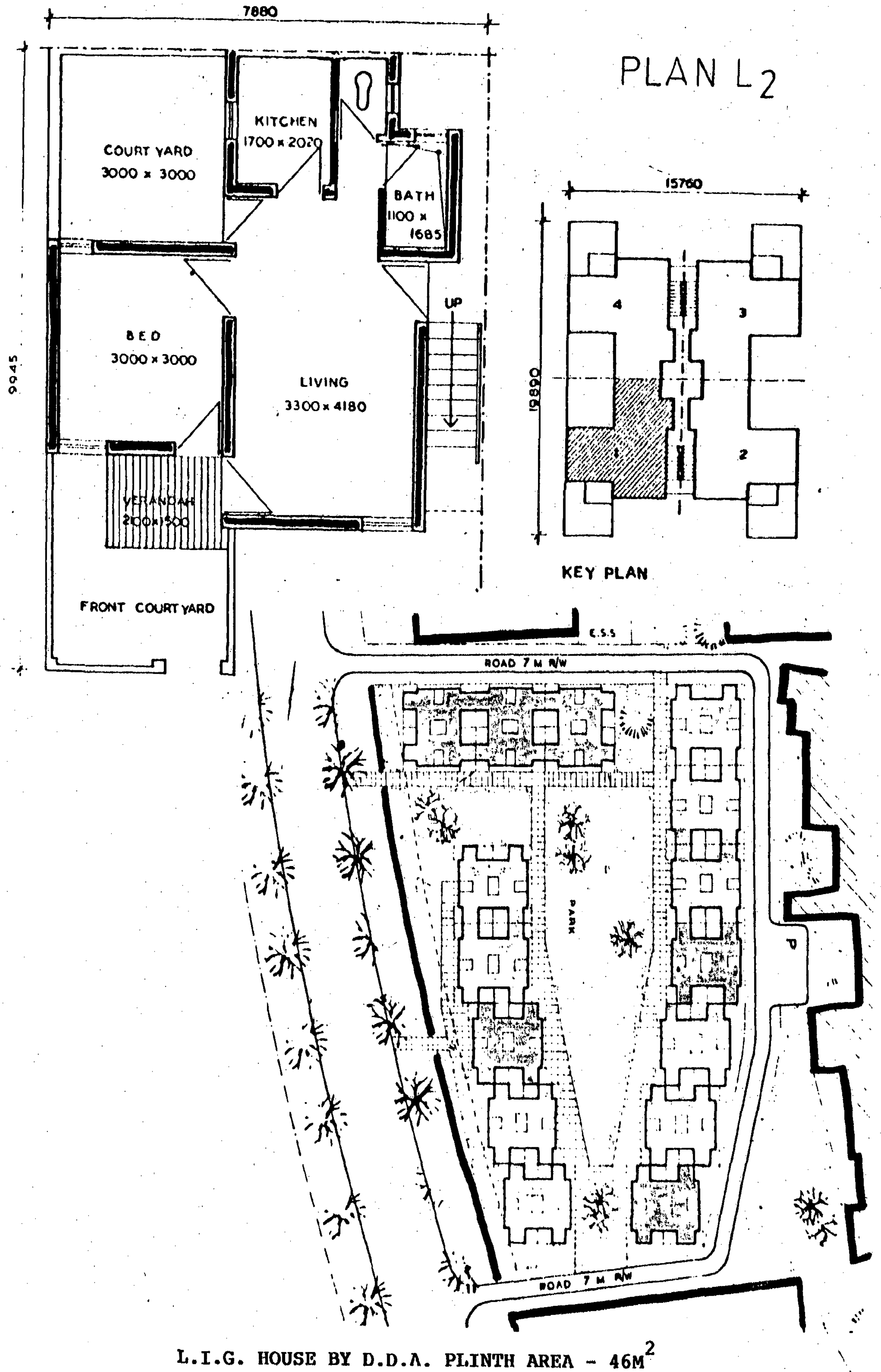
PLAN L_2





KEY PLAN

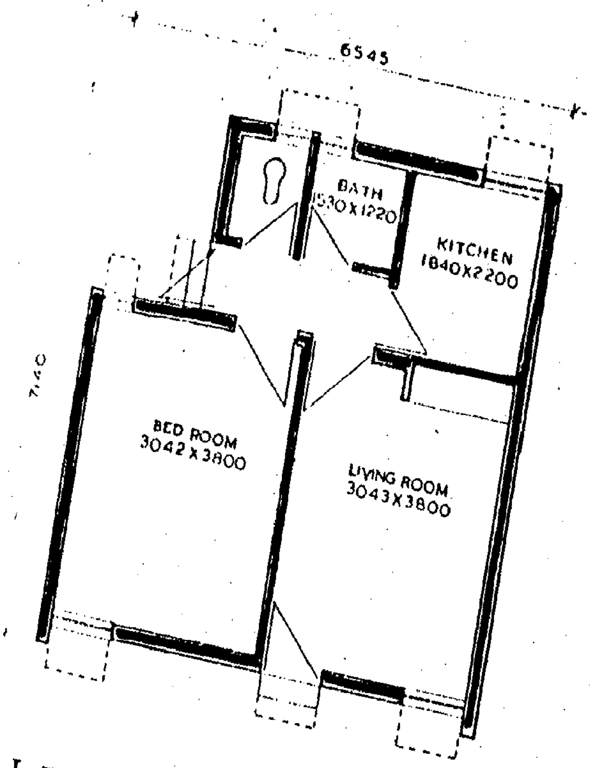


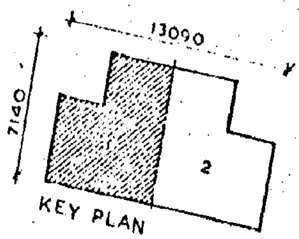


L.I.G. HOUSE BY D.D.A. PLINTH AREA - $46M^2$

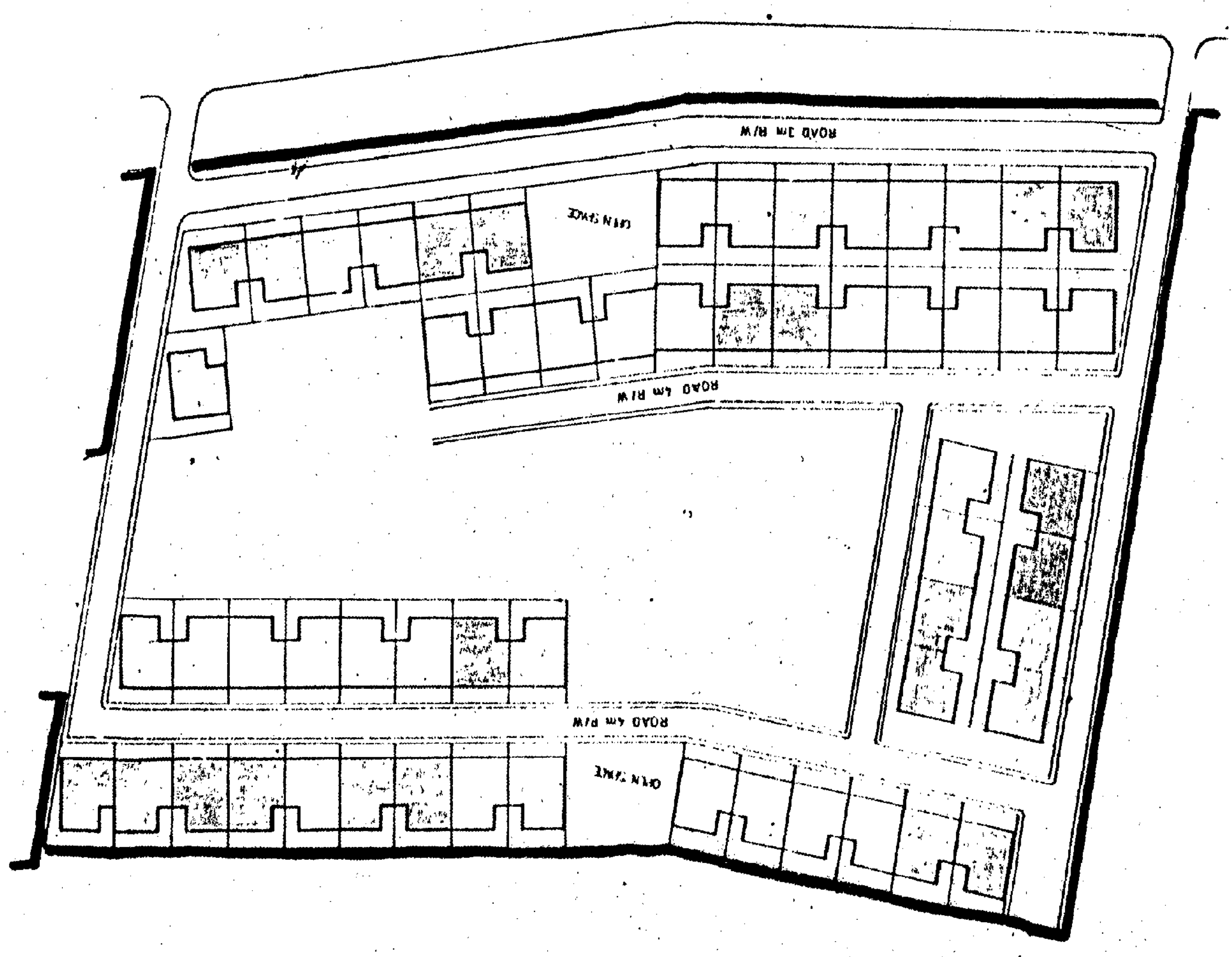
P739

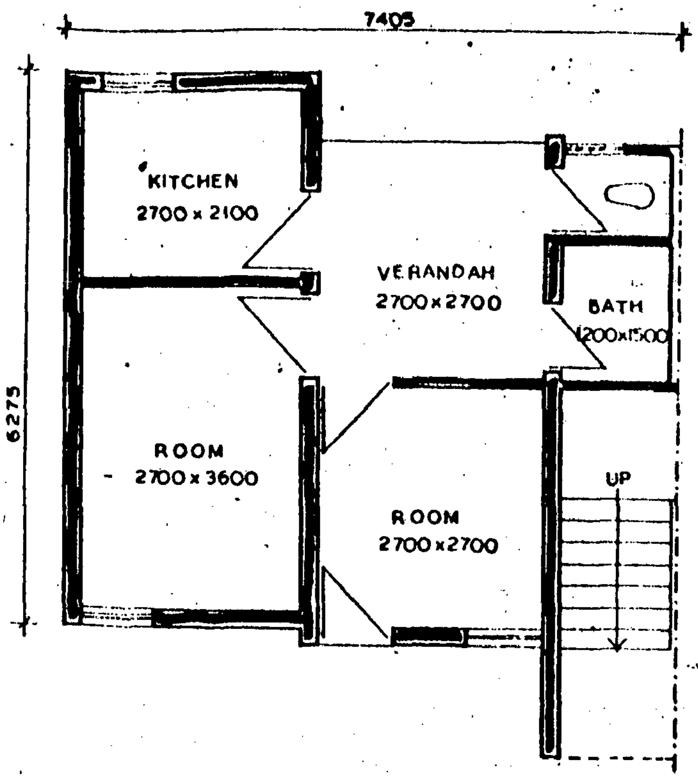
PLAN L_3



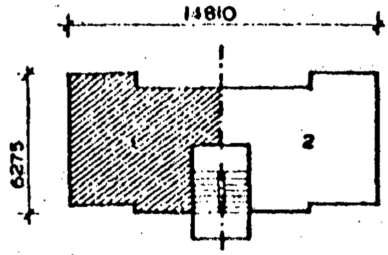


L.I.G. HOUSE BY N.B.C.C. PLINTH AREA - 40 M^2



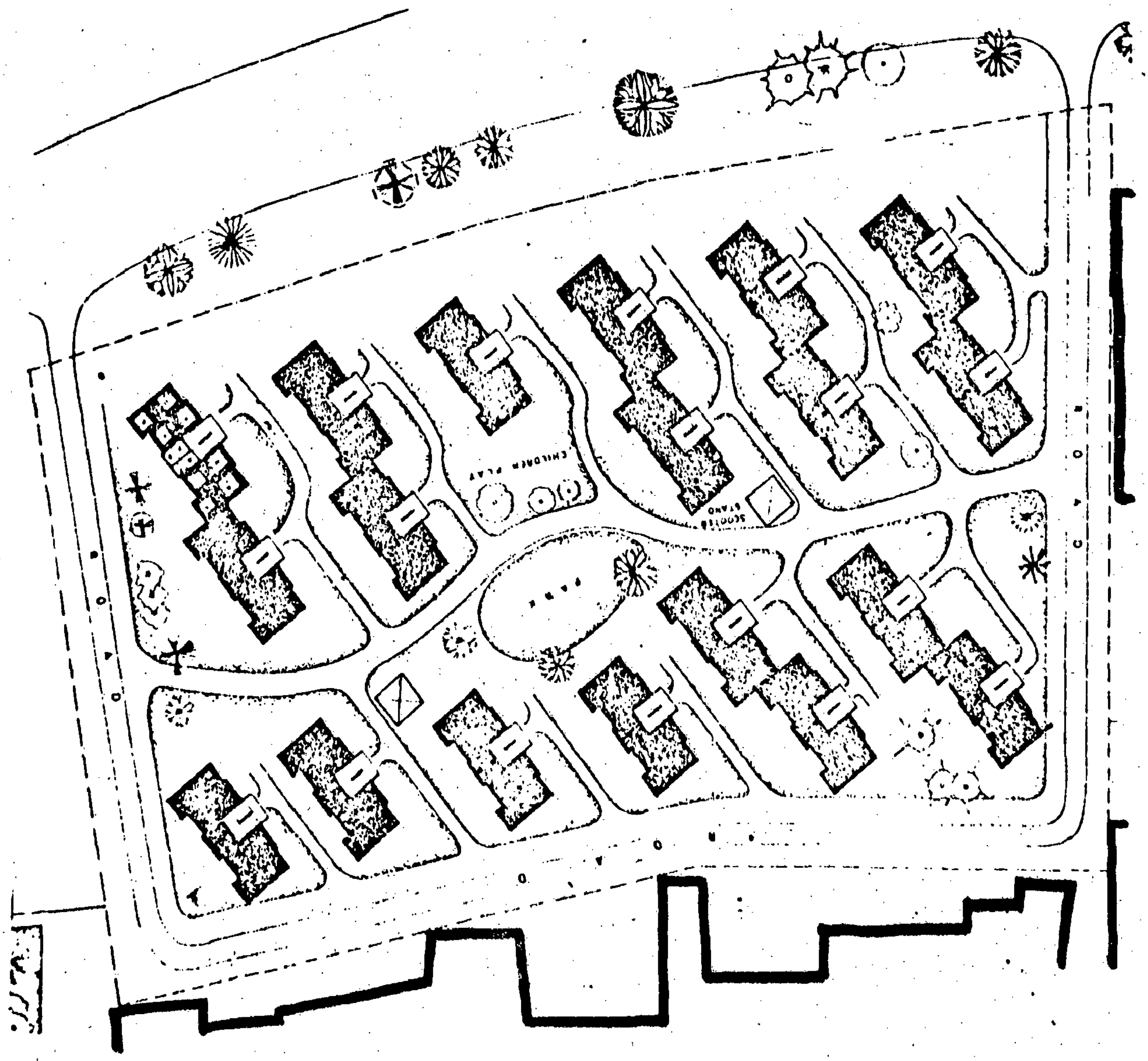


PLAN L4



KEY PLAN

L.I.G. HOUSE BY C.B.R.I., ROORKEE PLINTH AREA - 42.15M^2



M.I.G. HOUSE BY C.B.R.I. THREE ROOMED SCIENTIST APARTMENTS, C.B.R.I.

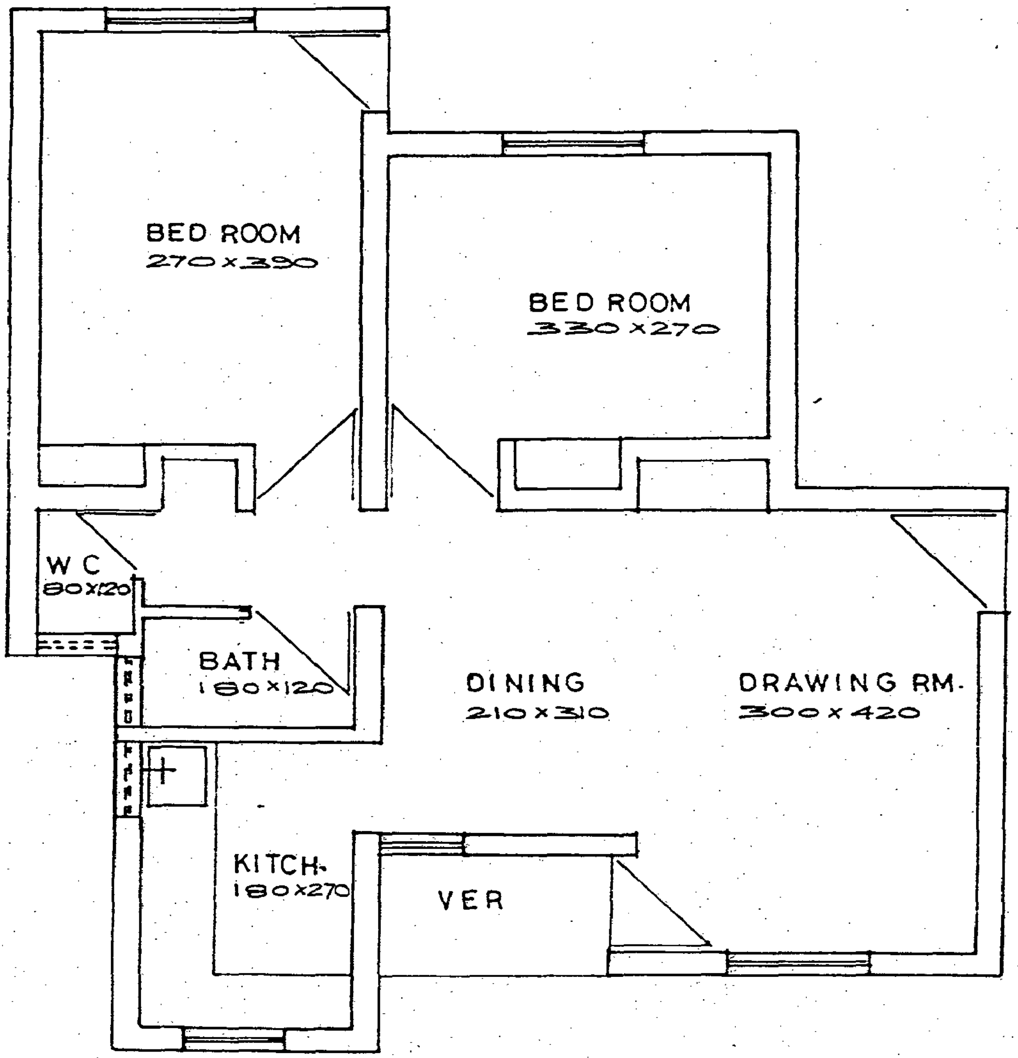


fig M-1

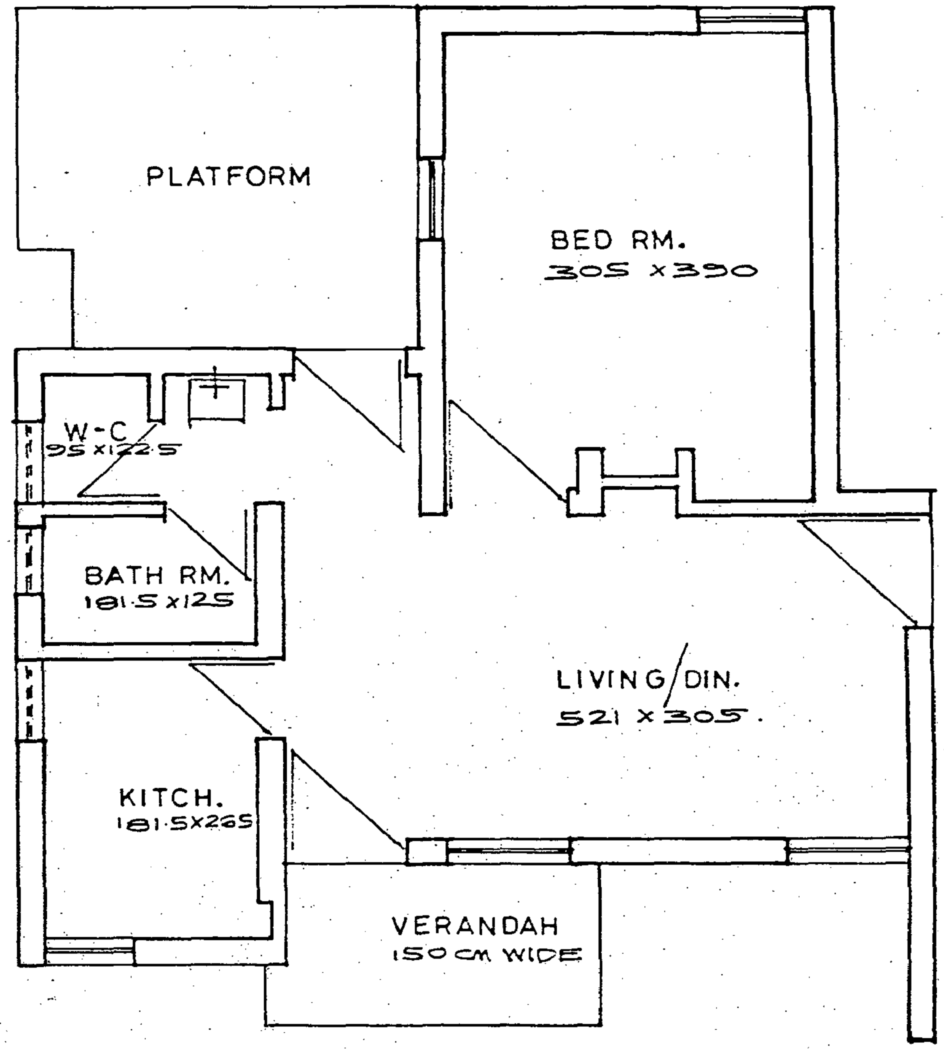


fig M-2

M.I.G. HOUSE BY U.P. HOUSING BOARD

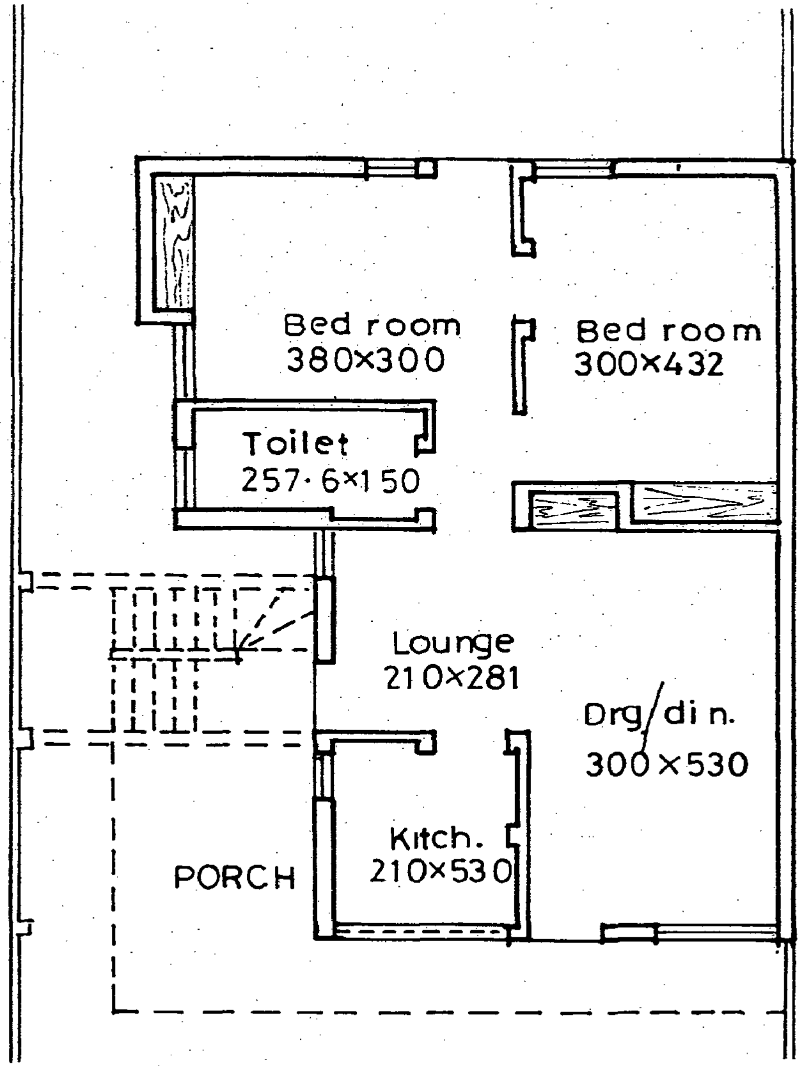


fig-M-3

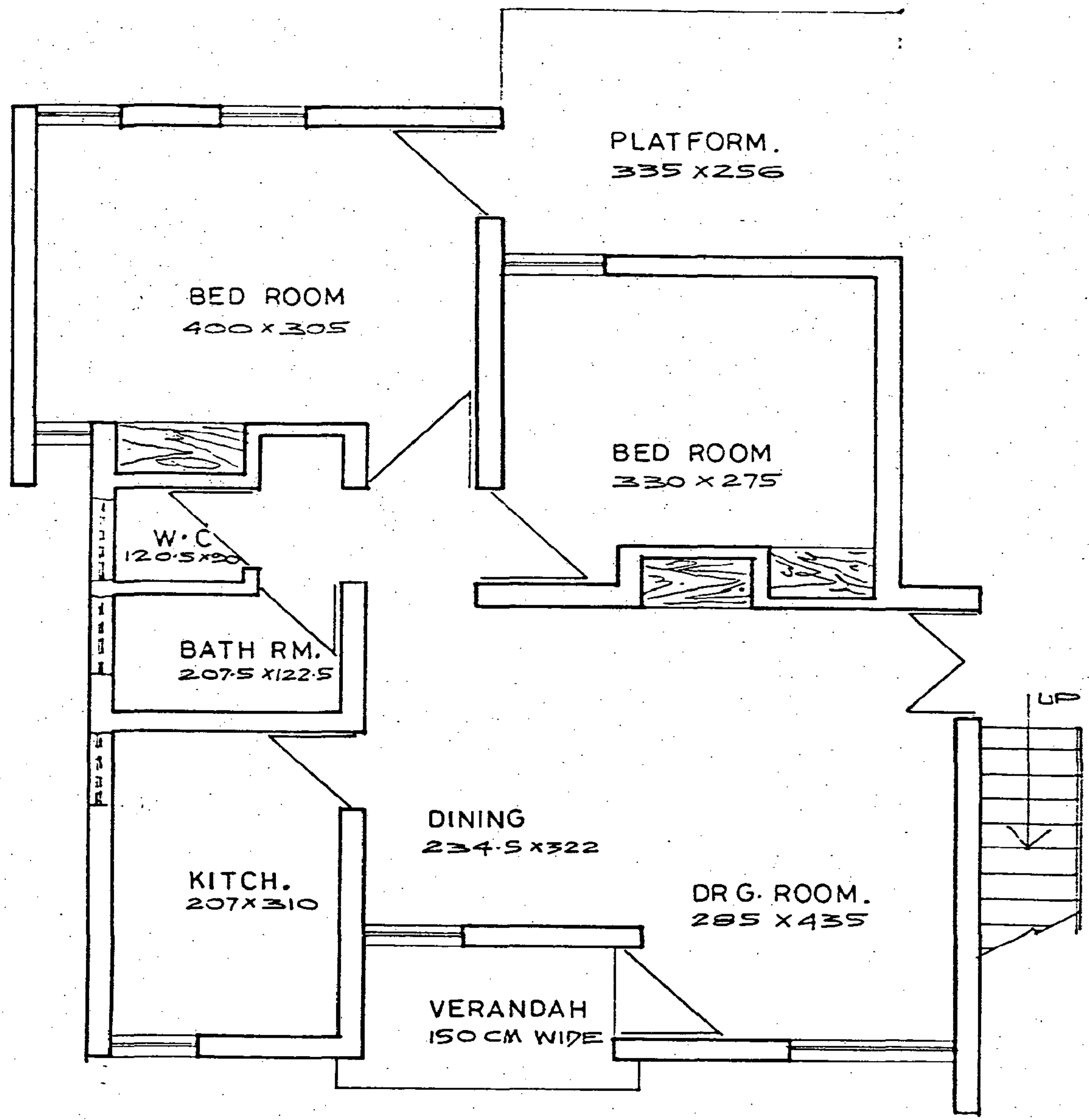


fig M-4

M.I.G. HOUSE BY C.B.R.I.

ANALYSIS

Sl. No.	Plan No.	E_1	E_2	E_3	E_4	E_5	E_6
1.	Plot area M^2	46.23	-	-	-	37.68	43.8
2.	Plinth area M^2	26.20	28.5	19.3	25 M^2	23.0 M^2	22.70
3.	Floor area	20.70	19.90	15.1	19.6M^2	18.68 M^2	20.25 M^2
4.	Accommodation						
	Room	2.8x3.8	3.3x3.0	2.44x4.0	2.60x3.0	2.83x3.35	3.55x2.4
	Ver.	2.8x1.5	1.5x1.0	1.2x0.9	-	-	-
	Kitchen	1.9x2.1	1.8x3.0	1.92x1.26	2.25x2.73	1.87x2.1	3.55x2.1
	Bath	1.11x1.45	1.35x1.155	1.35x1.55	1.23x1.22	1.35x1.98	1.4x1.2
	W.C.	1.2x0.9	0.9x1.2	0.9x1.2	1.23x0.9	1.35x1.98	1.2x0.9
5.	Walling						
	External	23 cm	23 cm	23 cm	23	23	23 cm
	Internal	11.5	23cm,11.5cm	23cm,11.5cm	11.5	23,11.5	23 cm
6.	No.of door	5	6	4	4	2	3
7.	Specifications						
	Foundation	Lime conc.	Cem.conc. 1:8:16	Lime Cinder conc.	Lime conc.	Lime conc.	Lime conc.
	Superstructure	B.K.work in lime mortar	Stone block masonry in cem.1:7	B.K.work in cm. mortar	IInd class B.K.work surkhi sand mortar	B.K.work in lime mortar	Stone blocks

Sl. No.	Plane No.	L_1	L_2	L_3	L_4	L_5	L_6
1.	Plot area						
2.	Plinth area	37.58	46.00 M^2	40.0 M^2	42.15 M^2		
3.	Floor area	31.50	37.4 M^2	30.26 M^2	34.0 M^2		
4.	Accommodation						
	Living Room	2.74x3.43	3.3x4.18	3.043x3.8	2.7x2.7		
	Bed Room	2.74x3.43	3.0x3.0	3.042x3.8	2.7x2.7		
	Ver.	2.74x1.37	2.0x1.5	-	2.7x2.7		
	Kitchen	1.79x1.22	1.1x1.685	1.22x1.53	2.7x2.1		
	Bath	1.79x1.22	1.1x1.685	1.22x1.53	1.2x1.5		
	W.C.	0.9x1.22	0.9x1.2	0.9x1.22	1.2x0.9		
	Lobby	0.9x1.22	-	0.1x2.5	-		
5.	Walling						
	External	23 cm	23 cm	23 cm	23 cm		
	Internal	23,11.5 cm	23,11.5cm	23,11.5cm	23,11.5cm		
6.	No. of Door	7	8	7	6		
7.	Specifications						
	Foundation	Lime conc.	Lime conc.	Lime conc.	Cem.conc. 1:8:16		
	Super-structure	BK.work in lime mortar	BK.work in lime flyash mortar	IInd class BK.work	IInd class BK.work		

Sl. No.	Plan No.	L_1	L_2	L_3	L_4
	Roof	Precast R.C.C. Roof	R.B. slab	RCC precast Units	Precast RC slab
	Finishing	No.plaster outside lime mortar plaster inside	No plaster outside lime mortar plaster inside	Inside plaster outside pointing	Plaster and pointing
	Flooring	25 mm C.conc. IInd class	25 mm C.Conc.	25 mm C.Conc.	25mm C.Conc. 1:2:4
	Joinery	Kail wood	IInd class Kail wood	Kail wood	Secondary specie timber
8.	Combination of units	Grouping of two units	Grouping of four units	Grouping of four units	Grouping of two units
9.	Layout	As per plan L_1	As per plan L_2	As per plan L_3	As per plan L_4
10	Services	Located at the back, can be made more economical	Located in the centre of the block, can be made more economical	located at the back, can be made more economical	

Sl.No.	Plan No.	E_1	E_2	E_3	E_4	E_5	E_6
	Roof	R.B.slab	R.C.precast units	R.B.	Precast RCC units	RCC roof	7.5 stone slab
	Finishing	No plaster outside, lime plaster inside	Inside plastering outsite pointing	Inside and outside plaster 1:6 cm.	Inside plaster outside pointing	Inside plaster in cem. lime mortar no outside plaster	Pointing with cem.sand mortar
	Flooring	25mm cem.conc. 1:2:4	25mm thick c.conc.1:2:4	25mm C.C.in bath and WC and mud flooring at other places	25mm thick C.C.	25 C.C.thick 1:2:4	25mm thick C.C.
	Joinery	Kail wood	Secondary species of timber	Cheer wood	Kail wood	Kail wood	Second grade wood
8.	Combination of units	4 D.U. combined together	2 D.U.clubbed together	2 D.U. clubbed together	2 D.U. clubbed together	2 D.U. clubbed together	2 D.U. back to back
9.	Layout	As per plan E_1	As per plan E_2	As per plan E_3	As per plan E_4	As per plan E_5	As per plan E_6
10	Services	Centralised services at the back servicing 4 dwelling units	Located at the back	Not centralisted	Centralised but not properly located	Centralised at the back	Centralised services

OBSERVATIONS

1. Two doors from the front verandah have been provided. One of the doors can be eliminated.

2. There are seven doors in the house which can be reduced to four without affecting the privacy and security.

3. No uniform dimensions have been followed in the rooms, kitchen etc.

4. Kitchen, bath, W.C. have been located at the back. More economy can be achieved by proper location.

5. By providing internal courtyard instead of full back yard, substantial economy by virtue of common walls can be achieved.

6. Study of specifications reveal that reduction in cost of buildings have been suggested by lowering the quality of specifications such as adopting second class bricks, second class wood, avoiding the floors, outside plaster completely and so on.

7. In the layout, no standard planning has been adopted. In some of the plans, there is provision of back lane where as in many cases it has totally been avoided.

4.5 ANALYSIS OF CLIMATE REQUIREMENTS, THERMAL PERFORMANCE OF BUILDING MATERIAL, LIGHT AND VENTILLATION ASPECTS, ANTHROPOMETRIE STUDY AND FOUNDATION ASPECTS IN BUILDINGS

Data on above said parameters was collected and analysed. as per study enclosed. The study clearly shows that considerable quality and economy can be achieved by considering these elements.

Requirements for Building form in relation to climate

Climate	Element of Requirement	Purpose
Warm humid	Minimum building depth	For ventilation
	Mibimise west facing wall	to reduce heat gain
	Maximise south and north walls north wall	to reduce heat gain
	Maximise surface area	for night cooling
	Maximise window wall	for ventilation
Composite	Controlled building depth	for thermal capacity
	Minimise west wall	to reduce heat gain
	Limited south wall	for ventilation and some winter heatings
	Medium area of window wall	for controlled ventilation
Hot dry	Minimise south and west walls	to reduce heat gain
	Minimise surface area	to reduce heat gain and loss
	Maximise building depth	to increase thermal capacity
	Minimise window wall	to control ventilation heat gain and light
Mediterrean	Minimise west wall	to reduce heat gain(summer)
	Moderate area of south wall	to allow (winter) heat gain
	Moderate surface area	to control heat gain
	Small to moderate window	to reduce heat gain but allow winter light

Norms for Window Openings

1. 1/10 th of floor area for dry hot climate.

2. 1/6th of the floor area for wet hot climate.

3. 1/8th of the floor area of the floor area for intermediate climate.

4. 1/12th of the floor area for cold climate.

(Note 1) If a window is partly fixed, the openable area shall be counted.

(2) The area of the opening as given in (1) to (4) shall be increased by 25 % in the case of kitchen.

Source : National Building Code of India, 1983.

Thermal performance index and overall heat transmission of Roof section

	Basic	Interior	Exterior	U K.Cal/m^2	T.P.I. value
1.	-10 RCC	1.5 cm plaster	9.0 cm lime conc.	2.221	134
2.	-do-	-do-	5.0cm mud puska	2.056	122
3.		-do-	9.0 cm lime conc.	2.320	149
4.	11.5 Brick panel	-do-	7.5 cm lime conc.	1.977	132
5.	0.640	For slipy roof			
	A.C.C. sheet	Interior lining along the slopes		U values	T.P.I.
	A.C.C. sheet		-	4.24	378
	-do-	Air space x 2.5 fibre glass		0.932	104
	Country tiles	-		4.76	425
	Manglene tiles	-		3.422	322
	as compressed			4.419	390
	shaw board			0.826	102
	20 cm stone block	1.8 lime plaster	1.8 cm plaster	2.668	132
	30 cm stone block	1.8 lime plaster	1.8 cm plaster	2.187	89
	25.0 cm mud wall	-do-	-	1.430	79

This shows that R.B. Roof transmits 11 % less heat than R.C.C. roof.

Thermal Performance Index and overall heat transmission value of walls(Hot-dry climate)

	Basic	Interior	Exterior	U K.Cal/m2	T.P.I. value
1.	Walls (75 cm Bk.walls)	-	-		
2.	-do-	1.8 cm sundried Bks			
3.	-do-	7.5 cm			
4.	-do-	Air space + 7.5 cm sun dried bricks	1:8 cm plaster	1.579	101
5.	-do-	Air space + sundried bricks 1:8 cm	-do-	1.429	89
6.	23 cm brick panel	1:8 cm mud plaster	-do-	1.801	187
7.	15 cm cement conc. bricks	-do-	-do-	3.163	175
8.	15 cm stone block	-do-	-do-	2.92	161
9.	20 cm stone block	-do-	-do-	2.668	132
10	30 cm stone block	-do-	-do-	2.187	89
11	25.0 cm mud walls	-do-	-do-	1.43	79

Above table shows that
1) 20 cm stone block wall transmits heat 32% more than the 23 bk.wall.
2) 15 cm stone block wall transmits heat more than 23 cm bk. wall
3) Sundried bk. wall with air space transmits less heat than 23 cm bk. wall.

FOUNDATIONS

Depth of Foundation

The depth to which foundation should be carried depends upon three principal factors :

1) The securing of adequate beqring capacity
2) In the case of clay soils penetration below the zone where shrinkage and swelling due to seasonal weather changes are likely to cause appreciable movement and
3) In fine sands and silts penetration below the zone in which trouble may be expected from the front.

All foundations shall extend to a depth of at least 80 cm below natural ground level.

Where there is excavation diteh , pond wastes course, filled up ground which the building is to be erected which is likely to impair the stability a building either the foundation of such buildings shall be carried down to depth beyond the deterimental in fluence of such conditions or retaining walls or similar works shall be constructed for the purpose of shielding from their effects.

Types of Foundation

Spread Foundation

The angle of spread of outer edge of the ground bearing shall not be taken to be more than a quarter of a brick per course brick or $\frac{2}{3}$:1, for lime concrete or 1:1 for cem.conc.

Source : I.S. 1904-1961.

VENTILATION ASPECTS

Rate of Natural Ventilation

Direction of wind

Velocity of wind

Size of openings

Position of openings.

Convection effects arising from temp. or vapour pressure difference between inside and outside of the room and difference of ht. between the outlet and inlet openings.

Factors Necessitating Ventilation

1) To maintain carbondioxide concentration of air within safe limits and to provide sufficient oxygen content in air for respiration.
2) To control odour
3) To remove products of combustion
4) To maintain satisfactory thermal environments in a room.

Environmental factors like temp., relative humidity and air movement together with some other factors have a direct influence upon bodily processes. In hot climates like ours the temp. of the body is regulated by evaporation of the sweat. As the room air or especially the air around body becomes more nearly saturated due to humidity it becomes more and more difficult to evaporate perspiration and a sense of discomfort is felt. A combination of high humidity and

FIG 1

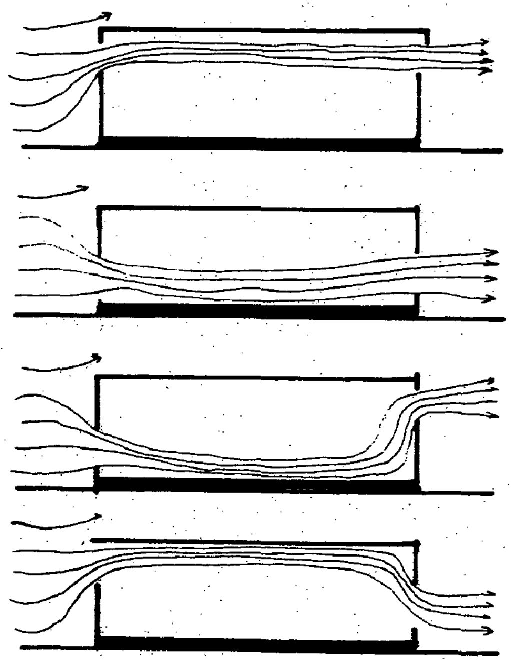


FIG 2

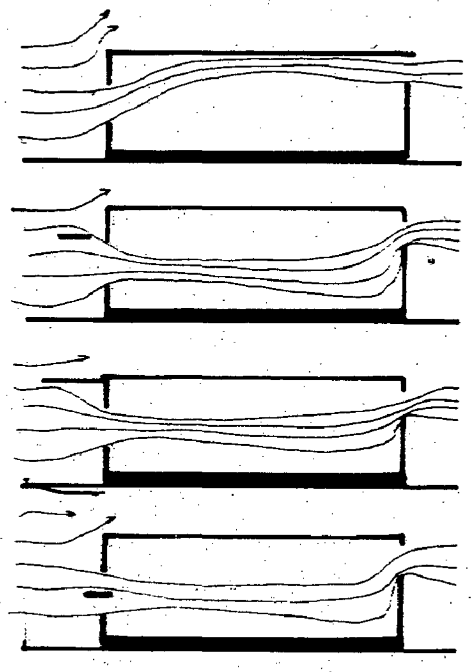


Fig. I shows the air flow related to the position of the inlet in the wall.

i) High inlet and outlet do not produce good air movement at the body level.

ii) Low inlet and outlet produce a good pattern of air movement, when it is required for cooling.

iii) Low inlet and high outlet also produce a low level wind pattern.

iv) The air flow at ceiling height produced by a high inlet is hardly affected by an outlet at low level.

Fig.II shows the effect of an external shade. All the sunshades, shown are equally effective at shading 45° sum.

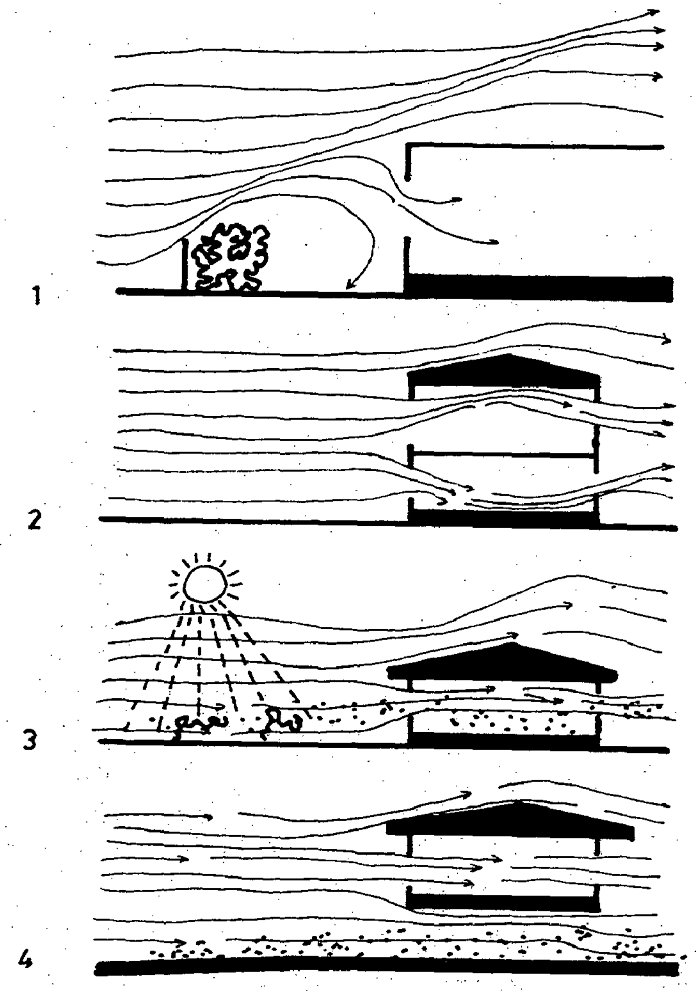
i) Projection shading devices produce on upward air flow in the room.

ii) A slot between wall and shade results in a more direct flow of air.

iii) Moving the position of the shade has the same effect but a larger shade is required.

iv) Louvers in the window give a more direct flow but the sun may heat the louvre and the louvre may heat the air as it enters the room.

Ventillation Aspects



FIG· 3

Fig. 3 shows the effect of external design on internal air movement.

i) Walls and vegetation close to buildings can divert wind away from the opening

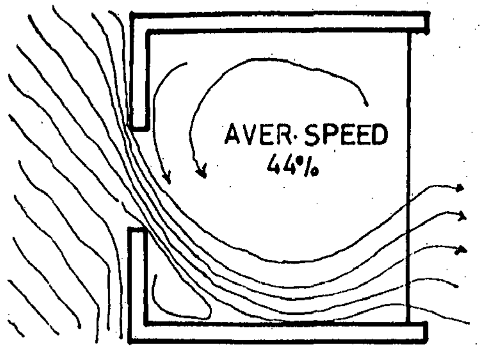
ii) Air movement in rooms on different levels can very even when windows are identical.

iii) Dark and dusty surface outside windows cause discomfort inside.

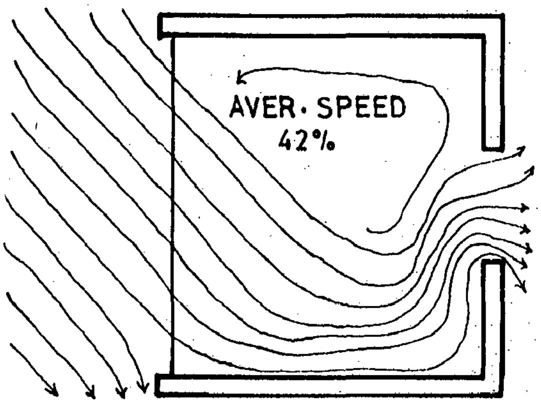
iv) Rooms raised off the ground received better air movement and less dust.

Ventillation Aspects

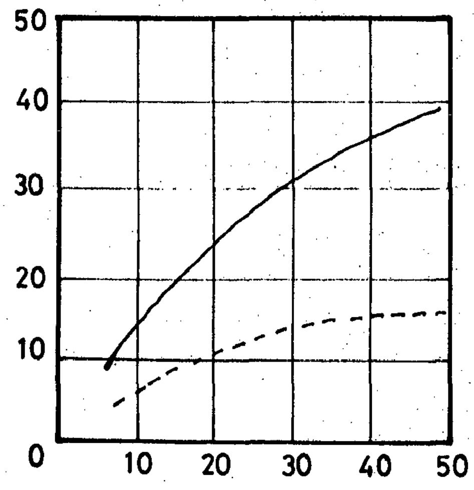
FIG-5



1



2



3

Fig. 5 Shows that internal wind speed does not increase significantly when window size is increased beyond about 40% of the wall area.

Fig. 3 Shows the effect of size of inlet and outlet on internal wind speed and distribution

i) A small inlet and large outlet will result in a high max. speed but poor distribution with large areas of rooms experiencing low wind speed.

ii) A large inlet and a small outlet will result in a lower max. speed but a better distribution of air movement over the room with only a small area having low speed.

iii) Graph assumes rooms which are close to square on plan and wind blowing directly on the face of the building.

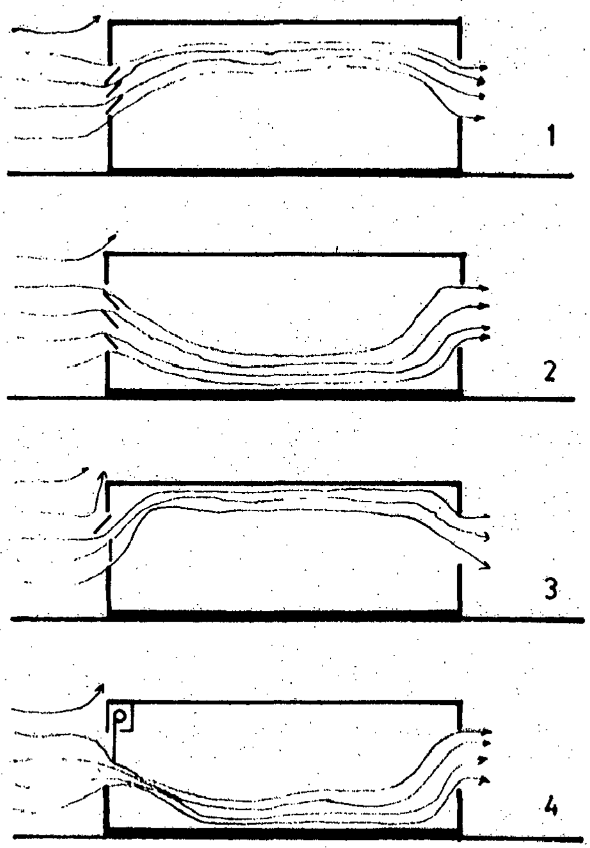
Fig. 4 Shows the effect of different types of windows opening.

i) Louvres can deflect the air stream upto the ceiling or down to the floor.

ii) Top hung outward opening windows cause an upward flow desirable in cold weather

iii) Partially open roller blinds can cause a downward flow.

FIG-4



1

2

3

4

Ventillation Aspects

air temp. prove very appressive. In such circumstances even a slight movement of air near the body gives relief.

Ventilation due to Wind Pressure

For natural ventilation system depends upon the effective use of wind forces. Wind forces are further dependent upon speed and direction, so ventilation is likely to be variable in quantity.

Minimum Standards for Ventilation

The minimum standards of ventilation are based on control of body odour or the removal of products of combustion depending on the requirements of each case.

Volume of fresh air required for the removal of noticeable body odour is influenced by the air space per person the volume decreases as the air space per person increases.

Air space/person m^3	Fresh air supply per /erson m^3/h
5.5	28.5
8.5	20.5
11.0 and upward	17.0

Recommended Values

Living Rooms and Bed Rooms

In case of living rooms and bed rooms, minimum of three air changes per hour should be provided.

Kitchen

Large quantities of air are needed to remove the steam, heat smell and fumes generated in cooking. For the requirements of kitchen in which cooking is done for a family of not more than five persons, minimum rate of ventilation of about three air changes per hour shall be provided.

Bath rooms and water closet

Considerable ventilation of bath rooms and water closets is desirable after use and equivalent of three air changes per hour shall be provided.

Rate of air flow

For a simple case of an isolated enclosure in which an opening is provided in each of two apposite walls, the rate of air flow through an opening, due to wind blowing on to the wall containing the opening is given by the expression

$$Q = KAV$$

where Q = the rate of air flow in m^3/h

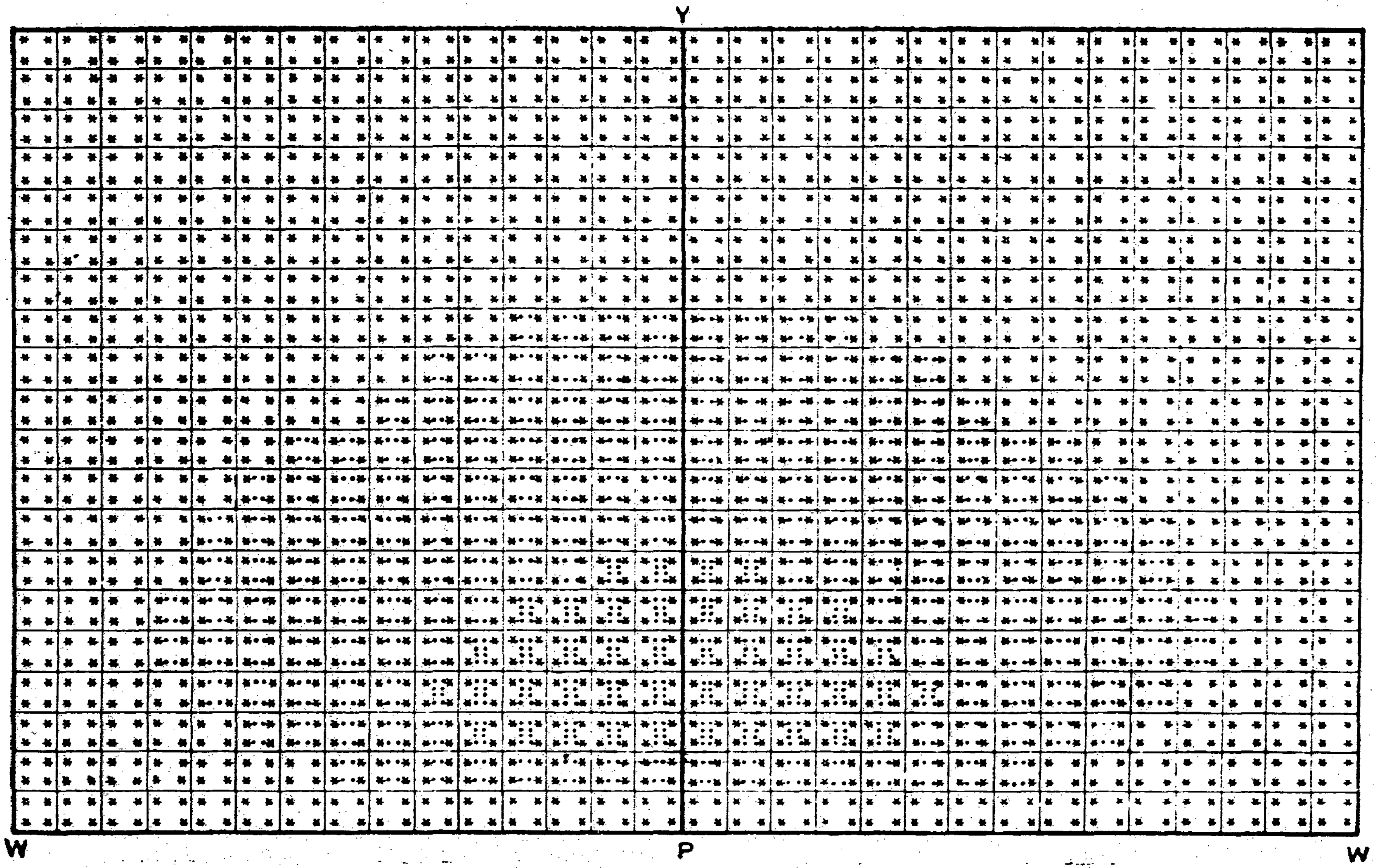
K = coefficient of effectiveness

A = area of smaller opening in m^2

V = wind speed in m/h

Source : I.S. 3362-1962

LUX-GRID I FOR DAYLIGHTING DESIGN OF WINDOWS IN ABSENCE OF EXTERNAL OBSTRUCTIONS



Source. C B R I Roorkee

<u>Recommended values of illumination for homes</u>

Kitchen	200 lux
Bath room	100 lux
Stairs	100 lux
Sewing and darning	700 lux
Reading (casual)	150 lux
Home work and sustained reading	300 lux

CHAPTER-5

DEVELOPMENT OF A METHODOLOGY FOR OPTIMIZATION

From the review of the literature study and survey report, it is clear that though work at different levels by the different housing agencies are being undertaken, but still it lacks comprehensive approach. With the result there is wide gap between thinking and practice. There is inter-communication gap between scientist, research scholars and people in practice or users. With the result the man investing the money in house construction is the ultimate sufferer.

Review of the specifications indicates that different housing boards and other construction agencies are reducing the cost by varying the specifications at the cost of risk and comfort.

11.5 cm thick walls are being treated as structural walls, in many buildings, plaster on external surfaces being avoided, rooms sizes being squeezed and basic elements like flooring etc. are being reduced to minimal at the cost of comfort.

'With the result, almost all public sector agencies are not able to impress the house builders or users with their design. These have just failed in providing the houses to them according to their affordable limits.

In private sector where common man depends upon his own efforts, is just confused due to non-availability of proper guidelines and knowledge. He depends upon the architects, engineers, contractors, carpenters and masons. The architects/engineers in practice due to buisy schedule, just do not get any time to think about the cost reduction parameters. Their most of time is devoted in preparing the working and construction details and in supervising the buildings. With the result they just can't pay much attention in preparing the various alternatives based upon the analysis of elements.

The general practice in private or public sector is that two or three alternatives are prepared, and then one of them is finalized by the dealing architect in consultation with the owner and then transferred to lower working staff for the preparation of detailed drawings and estimates.

Main drawback with this is that planner or designer is just unable to prepare the economical plans with complete analysis because he requires a lot of thinking for this which he generally tends to avoid due to time factor.

For any designer or planner, for evolving an economical proposal, the knowledge of material data and its economics is very essential. It is only after this that he becomes in a position to analyse the plan.

So keeping the difficulties being faced by the architects/engineers/scientists/users, there is a need for a comprehensive analytical study to arrive at the economical optimum parameters which will ultimately help the architects/engineers/users to understand the problem more easily and sympathetically.

5.1 PRESENT METHOD ADOPTED BY THE VARIOUS AGENCIES

Study of different drawings prepared by these agencies reveal that there is very little attempt from architects/researcher to develop the plans with the analytical approach. They prove the efficiency of plans on the basis of plinth and wall area ratio. Almost every plan developed passes through following efficiency procedure :

1. Plot area
2. Plinth area
3. Wall area
4. Carpet area
5. Plan efficiency

But the fact is that simply by reducing the wall area one can not justify the efficiency of plans.

To get effective efficiency, each element of the building is required to be analysed and its effectiveness is to be calculated.

Almost all housing agencies whether public or private follow the set procedure which is as given below :

1. Development of two or three alternative plans.
2. Discussion with user.
3. Finalization of one of the alternatives

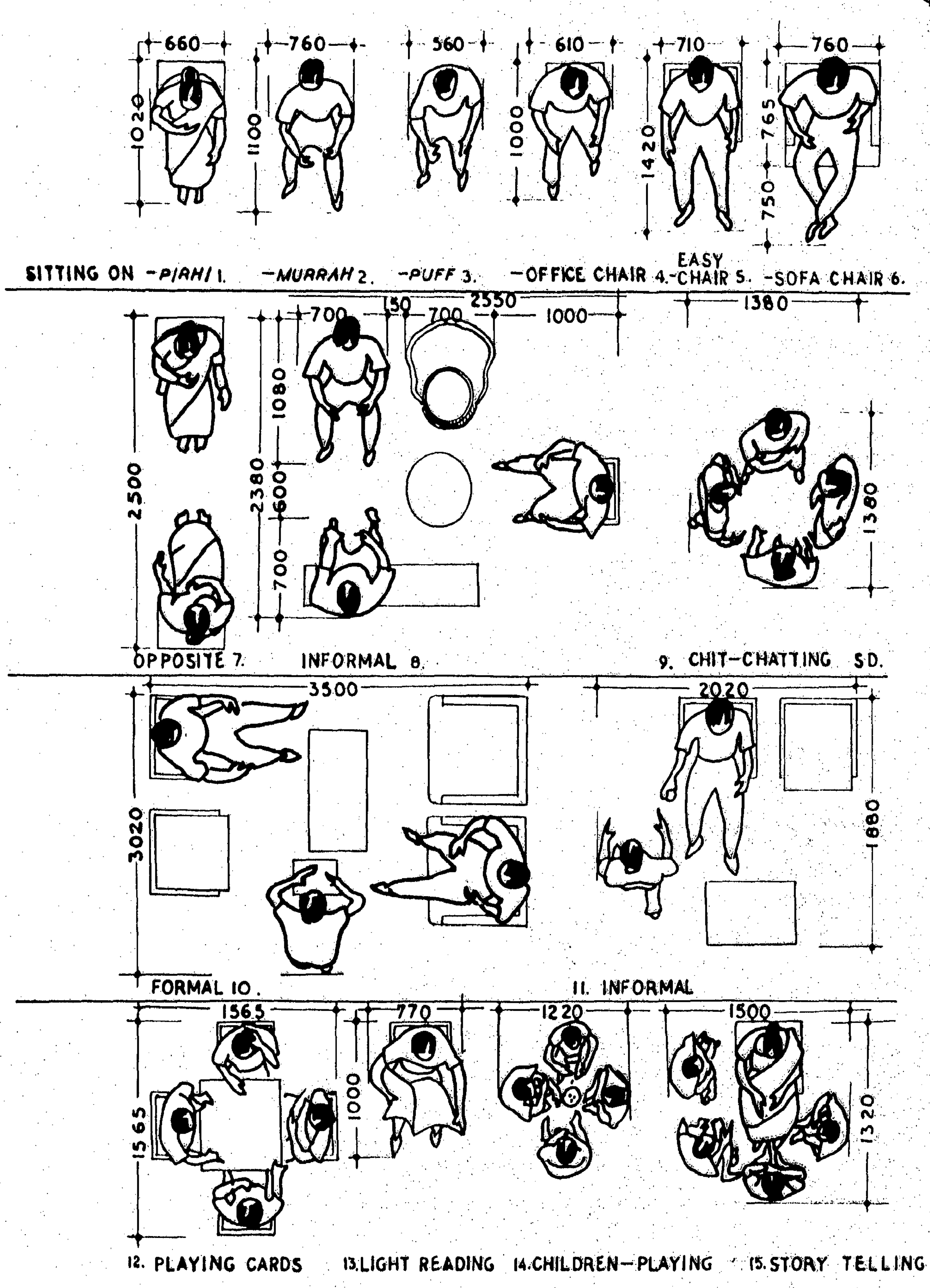
4. Preparation of preliminary drawings.
5. Preparation of preliminary specifications and estimates.
6. Preparation of working drawings architectural/ structural.
7. Preparation of detailed estimate
8. Site construction, supervision by respective architects/engineers.

Study of above parameters reveals that items 1 to 3 are the crux of whole building planning. Proper analysis of all parameters is most desirable at this stage. Unfortunately it is not being done by the housing agencies thus affecting the entire economy.

5.2 METHODS BEING ADOPTED BY THE RESEARCH ORGANISATIONS LIKE C.B.R.I.

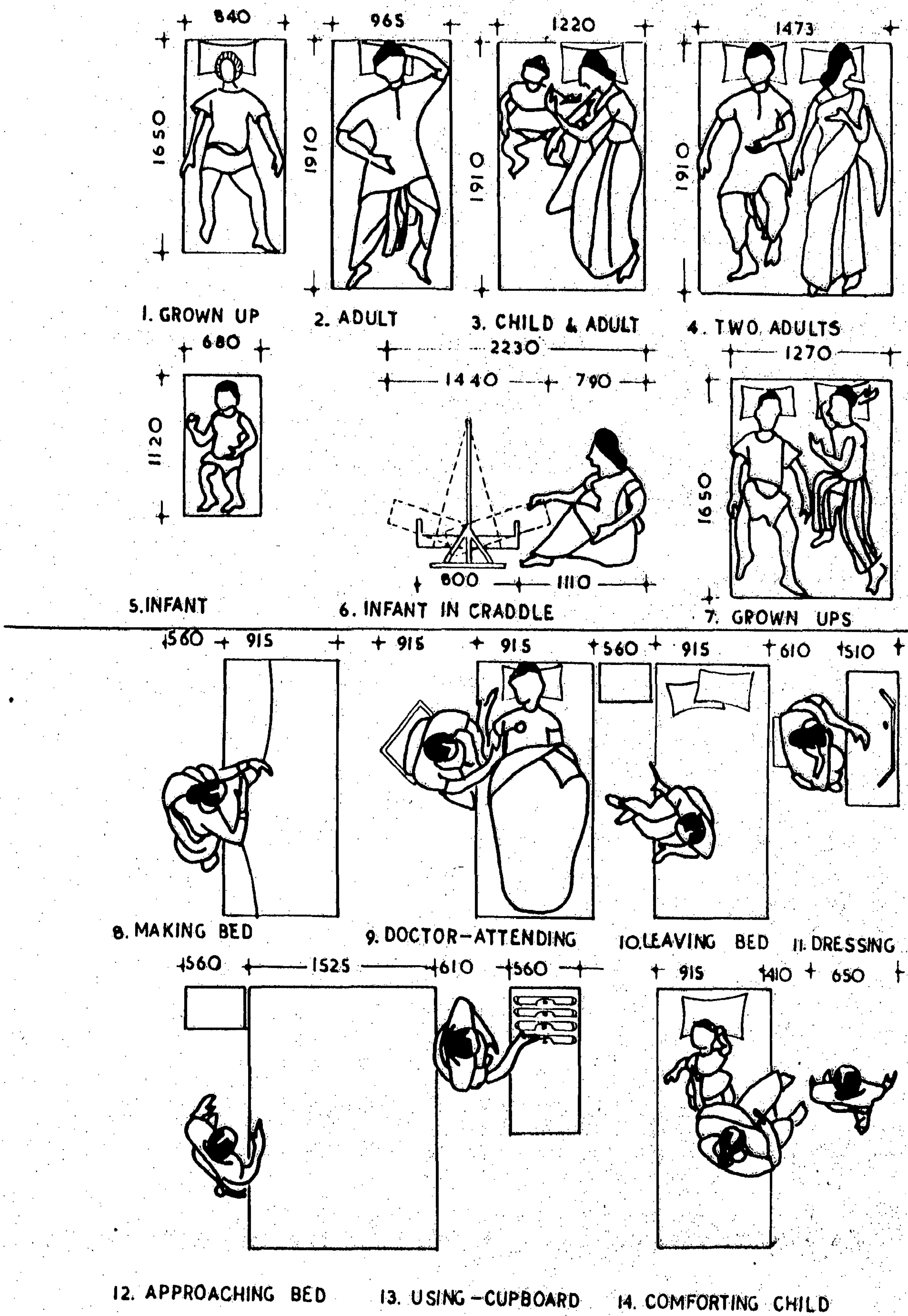
C.B.R.I. is one of the main research organisations working on various aspects of building such as planning and design, material, structure, light and ventilation etc. But the study shows that there is hardly any building where one finds comprehensive application of these parameters. It is all due to one simple reason that the plans prepared by the architects are not analysed in the early stages with respect to cost, thus resulting in higher cost. At present approach being adopted by the institute is almost same as in other organisations for many reasons.

ANTHROPOMETRIC STUDIES LEISURE & LIVING



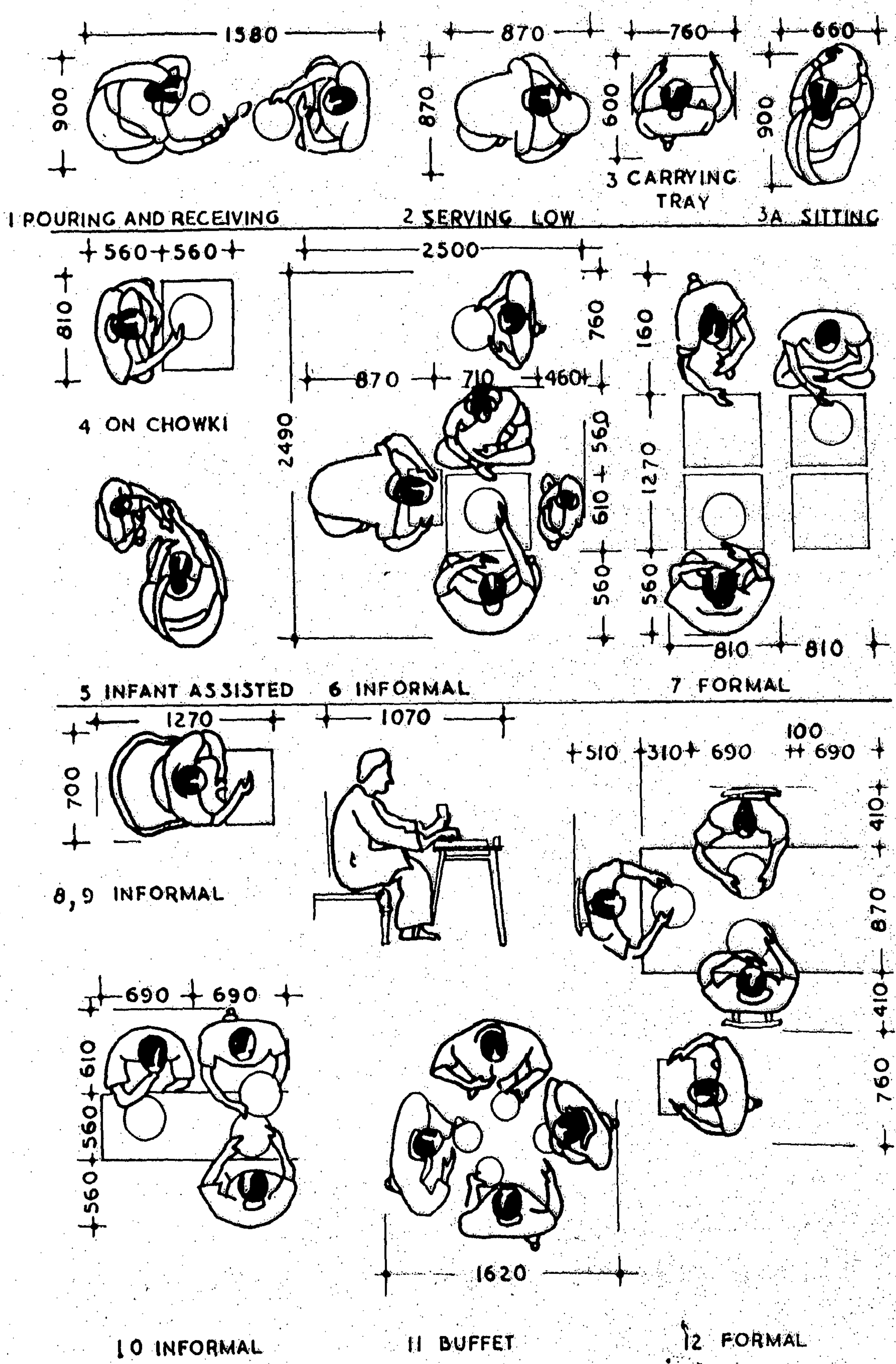
Source: CBRI Roorkee

ANTHROPOMETRIC STUDIES RESTING & SLEEPING



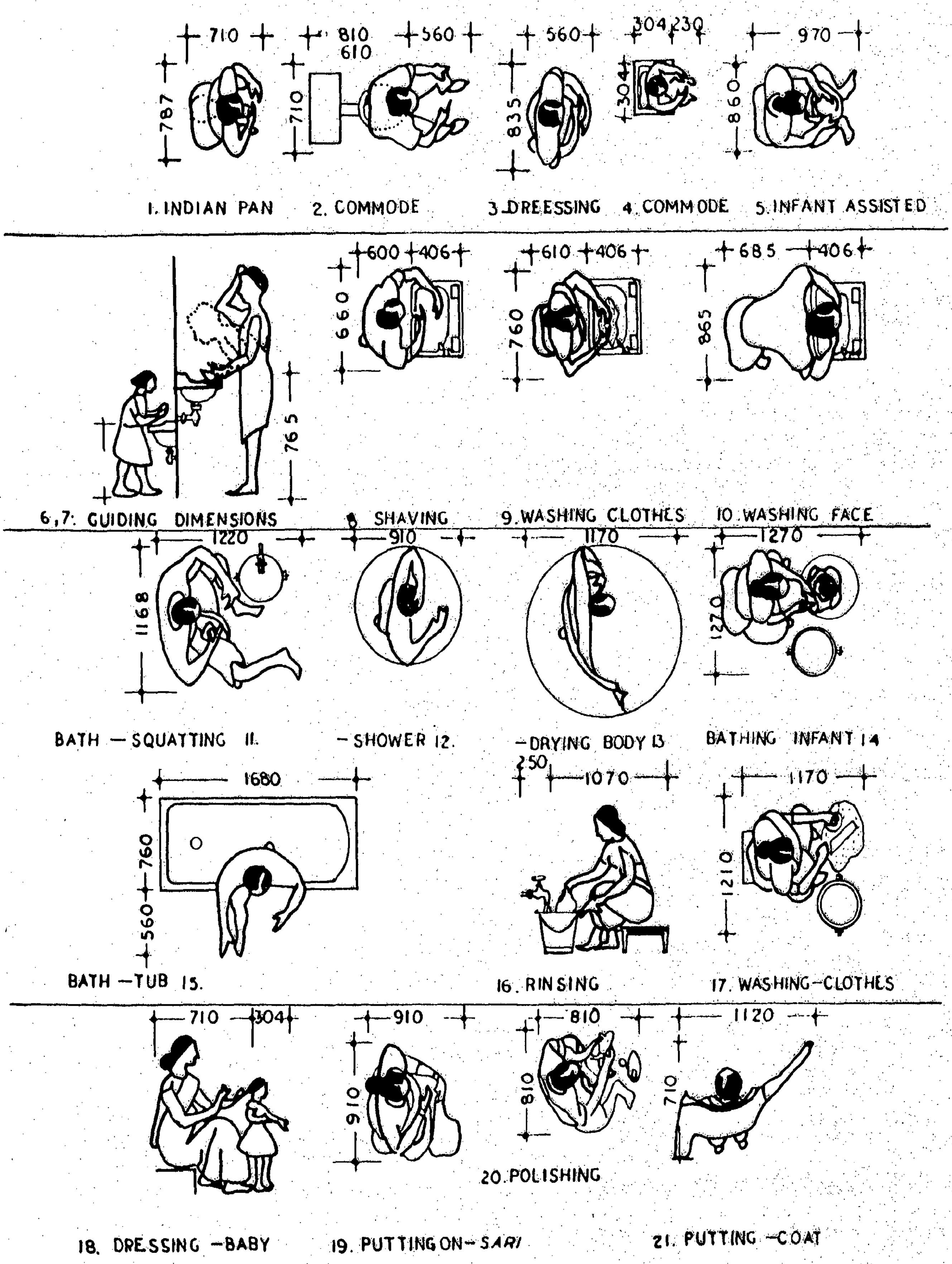
Source: CBRI Roorkee

ANTHROPOMETRIC STUDIES SERVING AND EATING



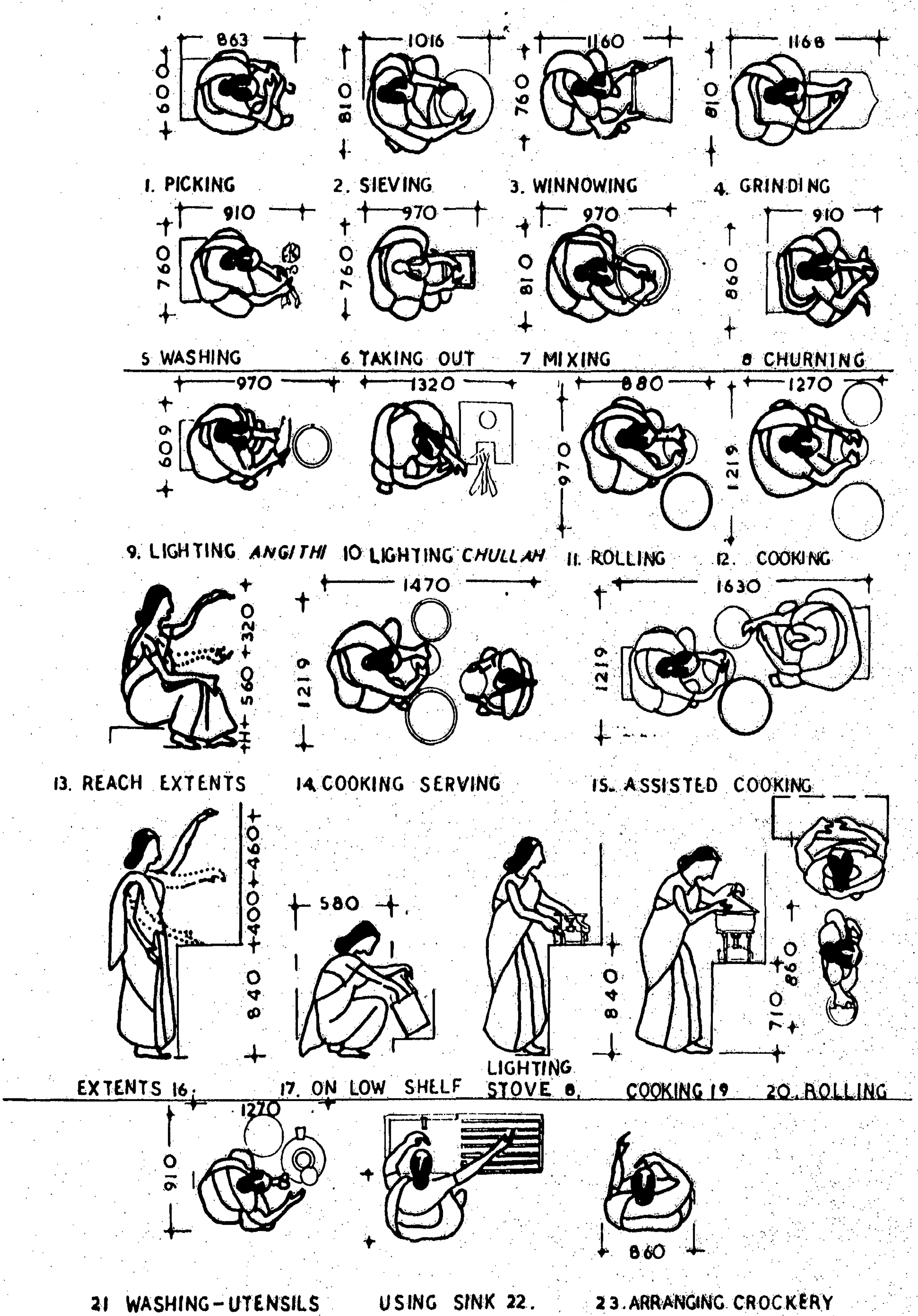
Source: CBRI Roorkee

ANTHROPOMETRIC STUDIES PERSONAL CARE



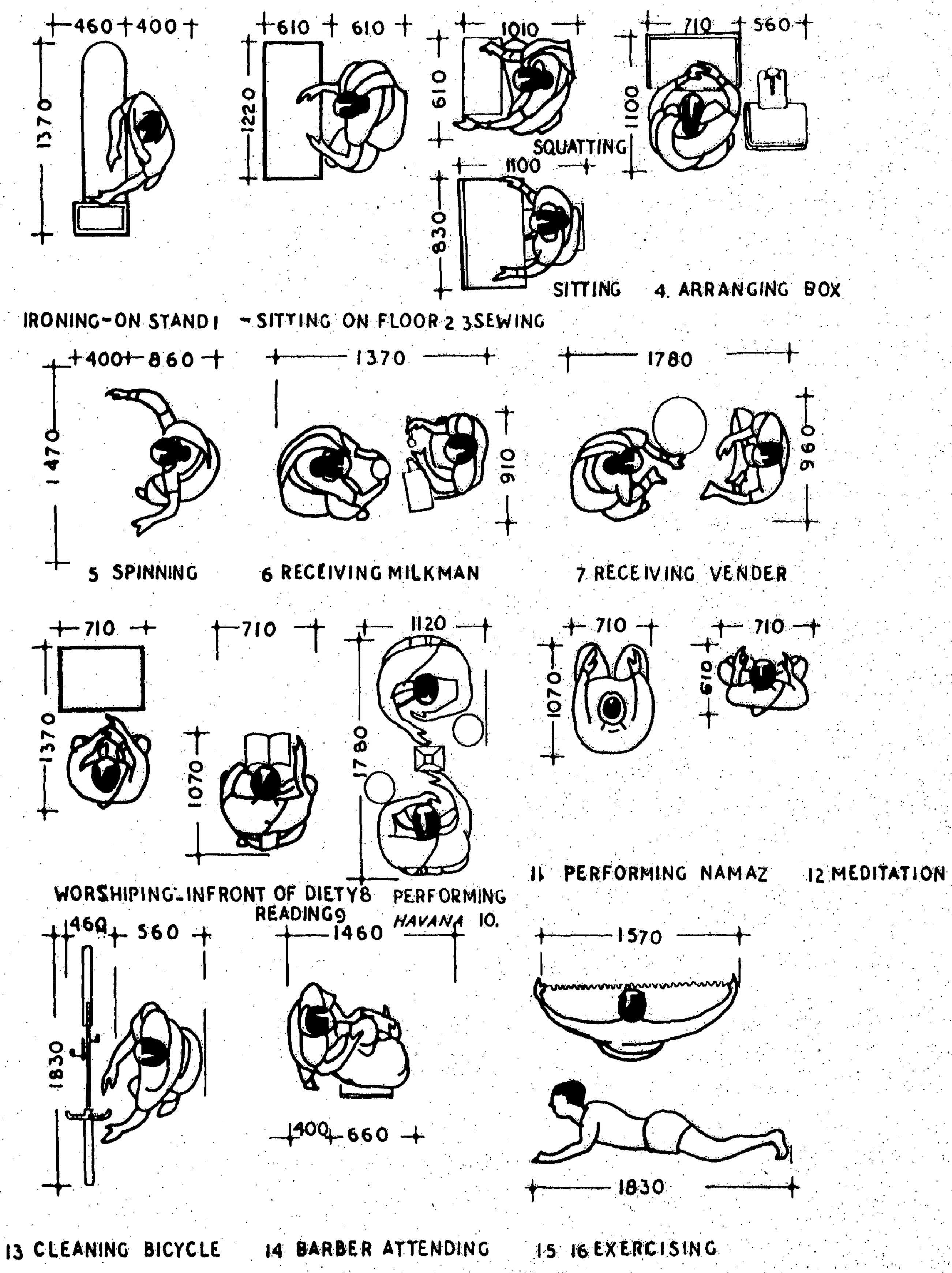
Source: CBRI Roorkee

ANTHROPOMETRIC STUDIES FOOD PREPARATION



Source: CBRI Roorkee

ANTHROPOMETRIC STUDIES AUXILIARY & MISCELLANY



Source: CBRI Roorkee

Development of Plans

Various plan proposals are developed in the institute and then area statements, planning efficiency standards etc. are worked out. A lot of space studies are conducted to achieve the best possible solution. But on looking at the plans, one finds almost the same approach in the design of building as is generally found in the plans developed by the other agencies. The scientist/research scholars fail to convince how their plans are more economical than the one developed by the other architects or organisations.

Use of Anthro Pometeric Study

Anthro pometeric studies are conducted or advocated by the research organisations but these studies are hardly applied in actual buildings. With the result common man is unable to realise its application. But are we really suggesting some economy with its use, is still a question and needs a thorough examination.

Economical Specifications

Many low cost specifications have been suggested by the institute and are being used by the different agencies. But the discussions reveal that for various reasons such as less exposure and quality control, many of these specifications are not being accepted by the users. For example, for frames and shutters secondary wood species are recommended in the case of E.W.S. and L.I.G. housing. But these secondary species of wood require seasoning to avoid warping but unfortunately it is never done. In some of the cases, it has been found that residents have themselves replaced the door panels after occupation where secondary species of wood have been used.

Estimates

On the basis of plan proposals and specifications, preliminary estimates and then final estimates are prepared as usual on the basis of final drawings.

Finalization of Specifications

After the rough estimate, adjustment is required to bring down the estimate within the budget.

Working Details

With the finalization of specifications, working details (Architectural as well as structural) are prepared as per plan.

Site supervision and quality control

It is one aspect which is advocated by the institute as it minimizes the wastage of material at the site, thus saving in cost especially when there is mass housing programme with prefabricated components. This aspect plays very important role in saving the cost.

5.3 OBSERVATIONS ON THE ABOVE METHODOLOGY

Outlines of some of the observations in the methodology being adopted by the different agencies are as followed:

TYPICAL SPECIFICATIONS FOR LOW COST HOUSING

URBAN

1. Foundation and Plinth :

1.1 Base Concrete

The base concrete may be 100 to 150 mm thick consisting of

a) Lime concrete 1:2:6 (1 lime : 2 fine aggregate i.e. surkhi, sand : 6 coarse aggregate i.e. stone or brick aggregate)

b) Cement concrete 1:5:10 (1 cement : fine aggregate : 10 coarse aggregate - stone or brick)

1.2 Masonry :

a) Brick masonry in cement mortar 1:6
cement lime mortar 1:1:8
Lime mortar 1:2:3

b) Coused rubble stone masonry/precast stone masonry blocks/Random rubble masonry in
cement mortar 1:6,
cement lime mortar 1:1:8
Lime mortar 1:2-3

2. Damp Proof Coarse

a) 2 cm thick cement lime plaster (1 cement : 1 lime : 5 coarse sand) with one or two coats of Bitumen.

b) $2\frac{1}{2}$ to 4 cm thick coat of cement concrete 1:2:4 with two coats of bitumen.

c) 4 cm thick coat of cement concrete $1:1\frac{1}{2}:3$ with integral waterproofing compound.

3. Walls

a) Brick masonry

b) Coursed stone masonry/precast stone masonry blocks/random rubble stone masonry

Cement mortar 1:6

Cement lime mortar 1:1:6-9/1:2:9-12/1:3:12-15

Lime mortar 1:2-3

Mud mortar with 2% lime.

4. Arches/Lintels

a) Flat or segmental arch in brick work upto 1.2 metre span.

b) Precast RCC thin lintels in M-150 concrete upto 1.8 metre span ensuring composite action between lintel and brickwork above.

c) Stone patties of suitable size (where available for small spans)

d) RCC lintels suitably designed for any span length.

5. Structural floor/roof

a) Brick tiles on precast RCC or timber battens/floor.

b) Jack arch roof with precast RCC joists.

c) Madras terrace floor/roof

d) Timber joists and planking

e) Trusses in Timber/RCC/Steel with AC/CGI sheets/ Corrugaced asphaltic sheets/tiles

f) Reinforced brick on Reinforced brick concrete slabs.

g) Stone patties of required thickness for spans upto 3.2 m where available at reasonable cost.

h) Precast units like channel units, cored units, cellular units, doubly curved tiles, solid RCC planks, reinforced brick panels on precast RCC joists.

i) Reinforced cement concrete slab.

6. Doors and Windows

6.1 Frames

Secondary species of timbers locally available after proper seasoning and chemical treatment

Angle iron frames.

6.2 Shutters

Secondary species of locally available timbers after proper seasoning and chemical treatment, of thickness around 3.5 cms.

6.3 Fittings

M.S. Black Ja paned fittings.

7. Flooring

7.1 Base for ground floor

Rammed earth followed by 10 to 15 cm of sand filling and 10 cm of lean cement of lime concrete.

7.2 Wearing course

a) 2.5 to 3.5 cm thick cement concrete 1:2:4

b) Brick/brick tile flooring laid in cement/lime mortar.

c) Stone slabs.

8. Finishing

8.1 External rendering on walls

Cement lime mortar 1:1:6-8

Cement mortar 1:6

Rough cast cement plaster in two coats

8.2 Internal rendering on walls

Cement lime mortar 1:1:8

Lime surkhi mortar 1:1:2 (1 lime: 1 surkhi : 2 sand)

Cement mortar 1:6

8.3 Finish on walls

Internal	White wash
External	Colour wash

8.4 Finish on wood work and iron work

One coat of primer plus two coats of painting.

9. Water Proofing

Bitumen coating at 17 kg per 10 m^2 impregnated with a coat of coarse sand at 60 dm^3 per 10 m^2 with

a) residual type petroleum bitumen of penetration 80/100 or

b) with hot cutback bitumen followed by

1. Mudphuska with tiles if the terrace is used or

2. Mudphuska finished with mud plaster and gobri leaping if the terrace is not to be used or

3. Lime concrete.

10 Plumbing and drainage

10.1 External plumbing G.I. pipes

Internal plumbing : plastic pipes for cold water supply

10.2 Drainage

Single stack system of plumbing subject to Municipal bye laws.

11 Electrical Installations

Wiring on wood batten with PVC insulated PVC sheathed aluminium conductor cable.

1. It is a traditionally years old system being followed by the construction agencies which conveys more about the details required during construction.

2. No doubt planning and constructional management is an important aspect at the site, but more important is the analysis of this aspect which is being given less weightage.

3. There is a very little attempt on the analysis of various economical parameters during the stage of development of plans itself.

4. Almost every architect expresses the efficiency in planning through broad items like plinth area, floor area, wall area and internal circulation. But if one analyses, it is much more.

5. It is observed from the plans received from different agencies that there is no standardization of elements like room sizes, kitchen sizes, plot sizes, building form, plinth height, ceiling height, wall thickness, number of doors and windows, sizes of the windows, location of the windows and doors, foundation size and so on.

5.4 STUDY OF THE OPTIMUM COST REDUCTION PARAMETERS

To study the cost reduction parameters, it is very essential to analyse the building at the planning stage itself.

Right from the space and functional activity study of the house, one is also required to study the other building components such as land, foundation, walls, roofs, floors, doors/windows, plastering, configuration of the building, combination of dwelling units, layout in detail because all these components will provide to user the cost analysis of the elements at various stages.

To determine the optimum values further analytical break up is required such as size of the foundation, length of the wall, thickness of the wall, plinth height, ceiling height, type of roofing, span of roofing, numbers of doors and windows, sizes and types of doors and windows design, location, plan form, number of common walls, location of services, combination of dwelling units layout, plot sizes and so on.

OPTIMIZATION AND ITS SIGNIFICANCE

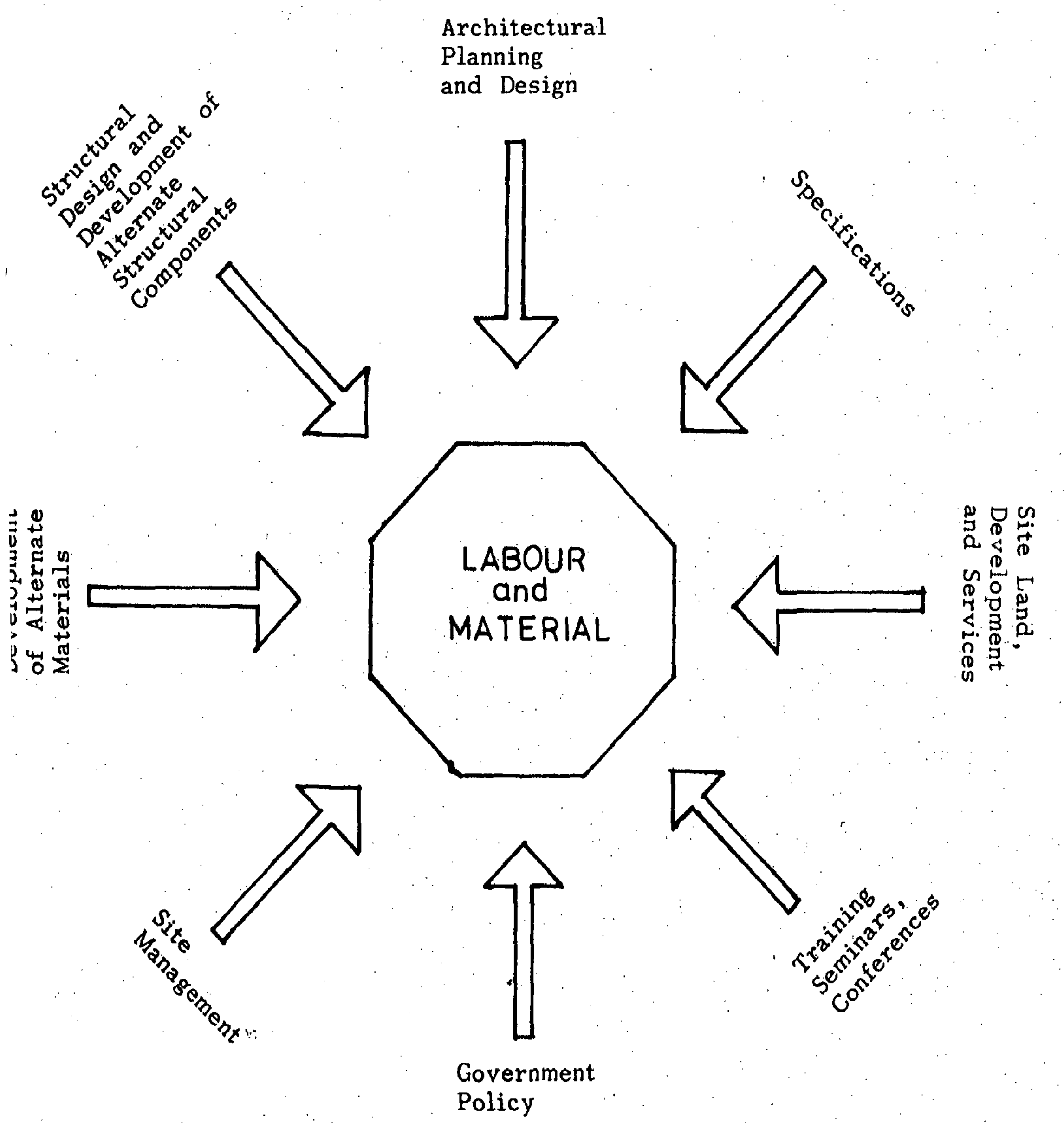
Concept of optimization and significance has already been explained in chapter 1.1.7. However some more definitions are being described for better understanding.

The term optimization

The optimum solution lies in choosing a set of values for the design variables such that the function gives its optimum value subjected to one or more constraints or no constraints at all.

Unconstrained Optimization

When there are no constraints imposed upon design problem to arrive at an optimum result, the problem is known as an unconstrained optimization.



Above flow diagram illustrates that what ever measures are adopted through Architectural planning and design, structural design, development of alternate structural components, development of alternate materials, site management, Govt. Policy, training/seminars/ conferences, site/land development/ services and specifications these will ultimately affects the cost of labour and material. So emphasis should be laid to reduce the cost of this component.

FLOW DIAGRAM

Constrained Optimization

To arrive at an optimum result, when one or more constraints are present which are to be satisfied then the problem is known as constrained optimization.

Ideal Optimization

The best optimization that can be aspired is one based upon cost, material, configuration synthesis while cost, material configuration synthesis is most desirable, in practice for any given problem, absolute optimum synthesis involves huge amount of work. Such an optimization is very complexed in nature and a solution may be difficult. The optimization problem has to solved in a restricted sense.

NEED FOR OPTIMIZATION

Labour and material are basic tools which govern the cost of any building. So like any other building, cost in housing is also influenced by labour and material. It is very clear from the enclosed flow diagram.

The diagram clearly shows that all type of saving through various fields finally leads to saving in labour and material. It is obvious from the field survey of various houses under construction, discussion with house owners, private architects/engineers, observations on work done by various agencies such as housing boards, development authorities, N.B.O., HUDCO and research organisations that there is a urgent need to analyse the problem from the grass root level. Case studies of houses being developed by different organisations show that no defined criteria is being followed by them to reduce the cost of building. It seems that seminars, conferences concentrate more on govt. policy and evolution of alternate cheap materials rather than common man's specific problem. People are wasting the costly building material like brick, cement and steel by using them with their own consciousness and for want of proper guidelines, wastage in material is not only affecting the individual economy but also country economy. This wastage is also helping a lot for the shortage of housing in the country to a large extent.

To check all this there is a need to develop the optimum parameters for all housing elements. These optimum parameters will not only help the common man to construct his own house according to his budget but also affects the overall national economy.

5.5 CRITERION FOR OPTIMIZATION OF HOUSING ELEMENTS

It is obvious from the evaluation of the procedures being followed by the various agencies and the feedback of the survey report that there is an urgent need for the effective approach to the problems of the users.

The study of field survey clearly shows that there is a wide gap of understanding between users and planners. Thus there is a lack of awareness about the importance of optimum use of housing elements.

So keeping the above factors into mind, I would like to suggest the following criterion :

1. Identification of housing elements
2. Critical analysis of elements for optimum use.

IDENTIFICATION OF ELEMENTS

It is well known fact that the user would always like to opt for the best despite financial constraints. He is never ready to accept the solutions which affects the basic functions structural stability and comfort.

Due to lack of knowledge, many undesirable elements which have nothing to do with the primary functions of the building can be found in most of the buildings which not only increase the cost unnecessarily but also obstructs many ways.

So in this dissertation, I have tried to list out the various housing elements and have then made an attempt to analyse them for the optimum use.

Housing elements have been put under following broad categories and subcategories for analysis :

Land

a. Type of soil
b. Topography
c. Location

Building Elements

(A) Structural

a) Foundation

b) Plinth height

c) Damp proof coarse

i) Type of DPC

ii) Thickness

d) Walling

i) Thickness of wall

ii) No. of internal wall.

Roofing

i) Type of roof

ii) System in roofing

iii) Span

Plastering

i) Type of plaster

ii) Thickness of plaster

iii) Ratio in plaster

Flooring

i) Type of floor finish

ii) Design of floor

(B) Architectural

1. Building plan form
2. Planning and design elements

i) Space planning

ii) Combination of dwelling units

iii) Layout plan

3. Door/window design

i) Location

ii) Size and design

4. Miscellaneous

a) Wall projections

b) Roof projections

c) Parapet wall/Railing design

d) Internal and external finishing on wall

e) Design, size of cupboards in roof

f) Painting on wood work and iron work

g) Length and design of compound wall

(C) Material

a) Type of material

b) Locally available material or transported one

c) Alternate material or traditional one.

3) Services

a) Sanitary and water supply

i) Centralisation of services

ii) Use of low cost material

iii) Use of alternate material and technology

b) Electrical

i) Type of fitting

ii) Minimization of no. of circuits

4) Managerial Aspect

a) Quality control

b) Check on wastage of material

ANALYSIS OF ELEMENTS

Analysis of elements is nothing but a critical study of housing components. Housing is a vast field and can not be analysed in one chapter. So my study of elements is confined to dwelling unit and cluster planning as I am of the belief that once the critical study is carried out on these two areas, it can easily be extended to other larger one also.

As described earlier approach to the design should be from analysis to planning rather than planning to analysis as is being adopted by various housing agencies. For analysis one requires a cot of calculations, so for an architect/planner it becomes difficult to do both the things simultaneously. To avoid this difficulty, some easy tables as enclosed have been developed. This will enable the architect or planner in analysing the problem well in advance and thus arriving at optimum solutions more convincingly.

These tables will be of great help to young architects in practice who can not afford engineers for estimation due to lack of funds.

CONCRETE IN FOUNDATION

Table OCF-1

Ratio	Length	Width	Thickness 7.5 cm CEM	7.5 cm SAND	7.5 cm BALLAST	15 cm CEM	15 cm SAND	15 cm BALLAST	Remarks
1 : 5 : 10	1 M	45 cm	0.096			0.192			
	1 M	60 cm	0.128			0.296			
	1 M	75 cm	0.16			0.32			
	1 M	90 cm	0.192			0.384			

MASONRY WORK

Table OMW-1

	Length	Thickness	Height	Value Cem.	Value Conc.	Bks.
Ratio 1:6	1 M	11.5 cm	15 cm	0.23	8.6	
	1 M	23 cm	15 cm	0.46	17.2	
	1 M	34.5 cm	15 cm	0.69	29.8	
	1 M	46 cm	15 cm	0.96	34.4	

R.C.C. SLABS/SUNSHADES

Table ORSS-1

Ratio	R.C.C.Slab length	Thickness	Width 45 cm			60 cm
			Cem	Sand	Ballast	
1 : 2 : 4	0.19 M	5 cm	0.022			0.022
	0.15 M	7.5 cm	0.033			0.044
	0.19 M	10 cm	0.44			0.048

R.C.C. BEAMS /LINTELS

Table ORBL-1

Ratio	Length	Width	Thickness	Consumption Cem	Sand	Ballast
1 : 2 : 4	1 M	23 cm	7.5 cm	0.1138		
	1 M	23 cm	15 cm	0.2277		
	1 M	23 cm	22.5 cm	0.341		
	1 M	23 cm	30 cm	0.455		

PLASTERING

Table OPL-1

Ratio	Length	Thickness Plaster	Height	Cement Consumption One Side	Cement Consumption Bot. Sides	Sand
1:6	1 M	12 mm	0.15 m	0.0135	0.0270	
	1 M	20 mm	0.15 m	ADD 35 %	ADD 35 %	
				0.018	0.036	

WOODEN FRAMES

Table OWF-1

Length	Size Sect.	Quantity of Wood required	Unit
1'-0''	$5''\times2\frac{1}{2}''$	0.086	Cu ft
(1 M)	(12.5x6.25)	(0.0078)	(Cu m)
1'-0''	$4''\times2\frac{1}{2}''$	0.069	''
(1 M)	(10x6.25)	(0.00625)	(Cu.m)
1'-0''	3''x4''	0.083	''
(1 M)	7.5x10	(0.0075)	(Cu m)

Sleeper 5''x10''x10' - 3.25 cu.ft.
12.5 cm x 25 cm x 3.0 - 0.0737 cu.m.

Table OWP-1 WOODEN PANELS

Length	Width	Thickness	Wooden quantity	Unit
1'-0''	1''	$1\frac{1}{2}$''	0.01	W.FT
(1 M)	(2.5)	(4.0)	(0.001)	(M^3)
1'-0''	2''	$1\frac{1}{2}$''	0.02	-do-
(1 M)	(5.0)	(4.0)	(0.002)	-do-
1'-0''	3''	$1\frac{1}{2}$''	0.03	-do-
(1 M)	(7.5)	(4.0)	(0.003)	
1'-0''	4''	$1\frac{1}{2}$''	0.04	-do-
(1 M)	(10.0)	(4.0)	(0.004)	

Sleeper 5''x10''x10' = 3.25 cu.ft.

12.5cm x 25 cm x 3.0 cm = 0.0937 cu.m.

CHAPTER-6

CRITICAL ANALYSIS OF ELEMENTS

6.1 LAND

Land is a first and foremost element in housing as it serves as a base for entire process. In urban areas, the availability of land is getting scarce day by day due to population explosion so analysis for optimum use is required to be studied.

The cost of land depends upon following factors :

1. Type of soil
2. Topography
3. Location

Type of soil

Cost of building greatly depends upon the physical behaviour of the soil. The sandy soil or loose soil will add to the cost more than the hard soil. Similarly buildings on black cotton soil will be costly than that on the ordinary alluvial soil due to expansive behaviour of the soil. So while selecting the site for the low cost housing utmost care is required to be taken regarding the physical behaviour of the soil.

Topography of land

The land with more undulations will make the building more costly due to additional cost in development. So as far as possible, site selected for low cost housing should have minimum ups and downs and the area should not be low lying. The undulations on the site need levelling thus affecting the cost.

The low lying area increases the cost due to followin factors :

1. More earth filling
2. Increase in cost of foundation
3. Increase in land development and services cost.

Location of land

Land or site should be well approachable through trans portation means. Its further distance will make the transportation of material and labour costly, thus affecting the cost. So location aspect of the site is very important where as cost of the building is concerned.

6.2 FOUNDATION

Foundations are considered to be the footing for a building. Study of the houses under construction reveals that more than required amount is spent on foundation due to lack of knowledge. In private sector where individuals construct their houses under own supervision invest a lot on foundation.

There are two main factors which should be considered while designing the foundation :

1. Soil condition
2. Total load on the wall

FOUNDATION

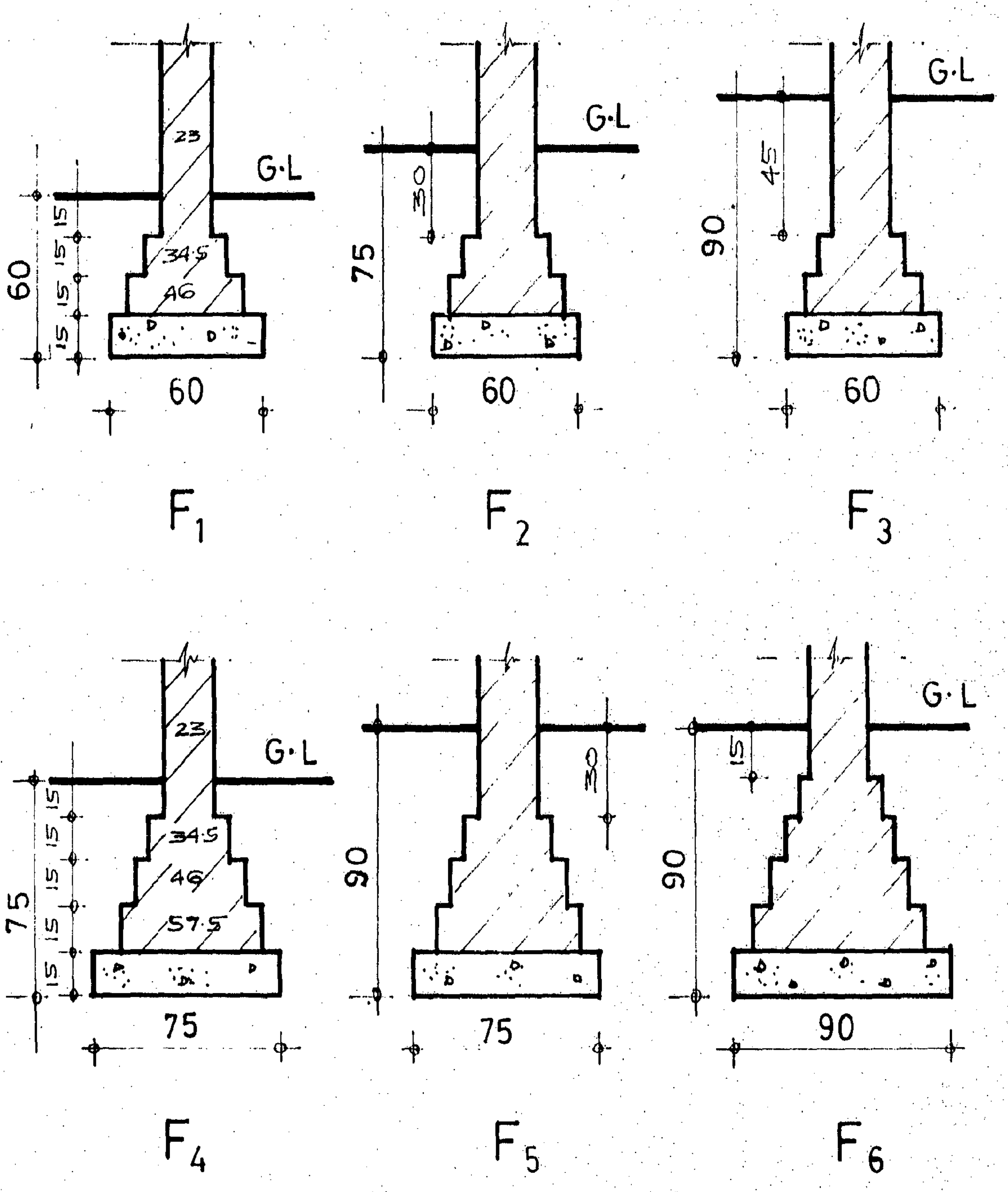


Fig -1

The soil condition factor will determine the depth of the foundation where as total load on the wall will lead to the size of foundation. Though the CBRI has recommended the minimum depth of foundation as 60 cm for single storeyed houses under normal type of soil yet above said parameters must be considered while calculating the depth of foundation.

So it will not be wise to suggest the optimum size of the foundation but at the same time, it will be more useful to bring into light the comparative saving in cost for different types of foundation.

The table F-1 suggest the comparative cost difference. For analysis purpose, length of the foundation has been assumed as 10 m with mortar ratio 1:6 (1 cem, 6 sand).

Table F-1

Sl. No.	Type	Size (cm)	Length (m)	Mortar Ratio	Quantity Brick	Cement in bags	% incre over F_1
1	F_1	60x60	10	1:6	774	20.7	
2	F_2	60x75	10	1:6	1032	25.3	18.18
3	F_3	60x90	10	1:6	1118	29.9	30.76
4	F_4	75x75	10	1:6	1204	32.2	24.70
5	F_5	75x90	10	1:6	1376	36.8	43.75
6	F_6	90x90	10	1:6	1720	46	55.0

The table F_1 clearly shows that size of the foundation chosen without design can affect the cost of foundation upto 37%. So keeping this factor into mind, foundation should always be properly designed.

This will ultimately help in optimising the cost of the house.

6.3 PLINTH HEIGHT

Function of raised plinth is :

1) To avoid the entry of rainwater into building
2) To prevent the building from getting damped
3) To provide suitable slope for drainage of ground water
4) To prevent the outside creatures like snakes, frogs from entering into the building.

Out of above four functions (1) and (3) are the primary functions. It has been observed through study of different residential buildings, that minimum plinth height should be 15 cm and optimum plinth height should be 30 cm. Any height above 30 cm will simply increase the cost of the house as is also clear from the Table PH-1

Table PH-1

Sl. No.	Plinth height (cm)	Size of plan	Quantity (m^3)	Saving (%)	Saving % over 2
1	15	5x10	1.035	± 0	-50%
2	30	5x10	2.07	50%	± 0
3	45	5x10	3.105	66%	+ 33
4	60	5x10	4.14	75%	+ 50
5	75	5x10	5.175	80%	+ 60

For the houses meant for economically weaker sections 15 cms plinth height is enough for cost consideration.

It is obvious from the table that saving upto 75 % can be done in the case of E.W.S. and upto 50 % in the case of L.I.G. and M.I.G. if optimum plinth height is adopted.

Damp Proof Course

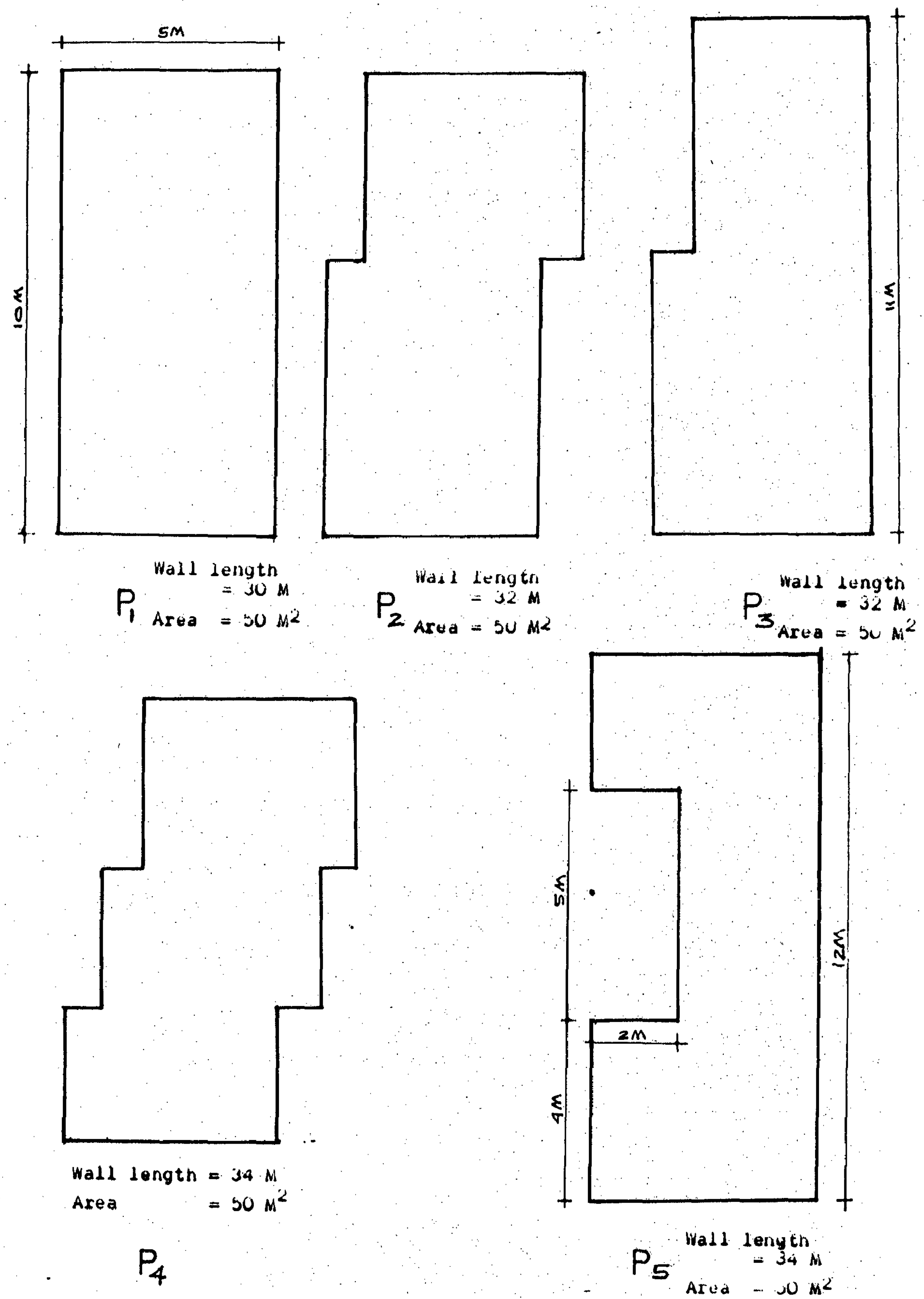
Damp proof course is provided in the building at plinth level.

The main function of damp proof course is to check the dampness from rising into the wall above plinth level.

It has been observed through survey that thickness of D.P.C. course varies from 15 mm to 40 mm. The material used in the D.P.C. is either cem. sand plaster with water proof compound and bitumen layer or cem. concrete alongwith two coats of hot bitumen. Different specifications have been suggested by various construction agencies with substantial cost difference.

Cost analysis has been done for 5x10 m plain size with different thickness of D.P.C. to find out the percentage saving over one another.

It is very much evident from the table that there is considerable saving variation for different D.P.C. thickness. Behaviour of different thickness has shown that 25 mm thick cem. concrete D.P.C. can equally serve good purpose in preventing the moisture from rising into the wall. D.P.C.



This shows that there is increase in wall length from 4% to 12% resulting in more consumption of bricks and cement.

FIG PF-1

Table DPC-1

Sl. No.	Thickness of DPC in mm	Size of plan	Thickness of wall	Ratio	Quantity cement in bags	Saving % over 1	Saving % over 2
1	15	5x10	23	1:6	0.68	± 0	- 40.2
2	25	5x10	23	1:2:4	1.138	+40.2	+ 0
3	30	5x10	23	1:2:4	1.36	+90	+16.32
4	40	5x10	23	1:2:4	1.82	+62.6	+37.47

in 15 mm thick cem. sand plaster has shown some problems of wear and tear. So 25 mm thickness of cem. concrete D.P.C. is considered to be optimum for all areas where there is no stagnation of water. As is clear from the table DPC-1 also that saving upto 37.47 can be achieved by using optimum thickness of D.P.C.

6.4 WALLING

Walls in superstructure consumes substantial quantity of material. So efforts should be made to minimise the cost of walling. Cost of walling depends upon following parameters :

1. Thickness of wall
2. Total wall length
3. Height
4. Ratio and type of mortar used
5. Percentage of shared wall.

Analysis of Material required for different proportion

Mortar for 10 cu.m.

Type of mortar	Material	1:1	1:2	1:3	1:4	1:5	1:6	Unit
				Proportion				
Lime Mortar	White lime (slabed)	7.00	4.75	3.57	-	-	-	Cu.m.
	Surkhi or sand or cinder	7.00	9.5	10.7	-	-	-	Cu.m.
Cement mortar	Cement	-	4.5	3.57	2.68	2.14	1.78	Cu.m.
			(135)	(107)	80.4	64.2	45.9	Bags
	Sand	-	9.5	10.7	10.7	10.7	10.7	Cu.m.

This shows that 10% to 55% saving in cem. can be achieved by using proper proportion.

Some of the plans collected from different housing agencies cost reduction parameters in walling. Type of plans collected as shown in figure are

1. One room dwelling unit
2. Two room dwelling unit
3. Three room dwelling unit.

External and internal wall length with respect to its thickness, and percentage of shared wall length has been indicated in Table TW_1, TW_2 and TW_3

One Room Dwelling Unit

Table TW-1

Sl. No.	Plan No.	Plinth area m2	External Wall 11.5	Length 23	Internal Wall 11.5	Length 23	Total wall length	Length of wall to be shared	% external shared length
1	E_1	26.2	X	19.3	5.5	2.1M	26.9	9.72	49
2	E_2	28.5	X	20.17	3.6	4.5	28.27	8.12	40.25
3	E_3	25.0	X	24.5	7.56	X	32.06	12.62	48.48
4	E_4	23.0	X	21.17	2.1	2.58	25.85	9.17	32.31

Two Room Dwelling Unit

Table TW_2

Sl. No.	Plan No.	Plinth Area	External Wall Length 11.5	External Wall Length 23	Internal Wall Length 11.5	Internal Wall Length 23	Total wall length	Length of wall to be shared	% shared length
1	L_1	31.5	X	24.25	5.53	6.54	36.32	9.84	40.5
2	L_2	37.4	X	30.58	2.58	5.4	38.58	6.63	21.63
3	L_3	42.12	1.8	27.53	6.6	7.63	43.56	8.9	32.32
4	L_4	32.86		24.82	6.54	6.63	37.99	10.9	43.9
5	L_5	30.8	X	28.52	2.5	8.44	39.46	11.04	38.7

Three Room Dwelling Unit

Table TW_3

Sl. No.	Plan No.	Plinth Area	External wall Length 11.5	External wall Length 23	Internal wall Length 11.5	Internal wall Length 23	Total wall length	Length of wall to be shared	% shared length
1	M_1	47.6	X	29.44	10.07	6.56	46.07	12.5	42.45
2	M_2	49.12	X	32.6	6.6	5.4	44.6	X	0.0
3	M_3	71.85	X	35.63	16.79	2.61	55.03	10.58	29.64
4	M_4	70.144		35.30	6.0	10.47	51.77	3.5	9.9

Inferences

1. 49% of the total external wall length can be shared in one room dwelling unit, 40% in two room dwelling unit and 30% to 35% in case of three room dwelling units.

2. In the case of one room dwelling units, clubbing of 4 units result in maximum saving of wall while in the case of two room dwelling units clubbing of two units and sharing atleast two side walls can give the maximum saving.

3. It is obvious from the table T-Wl_3 that it is possible to share the wall in three room dwelling units also and can result in saving upto 30% to 40%.

4. Staggered 11.5 cm thick wall can be adopted as internal walls or even structural wall inside the building it properly designed thus affecting the cost.

Recommendations

1. For one room dwelling unit two to three walls should be shared.

2. For two room dwelling unit, minimum two wall must be shared.

3. For three room accomodation, minimum one and half wall should be shared.

4. In the case of one room dwelling units as far as possibl staggered walls should be adopted in internal walling.

6.5 CEILING HEIGHT

Height of ceiling is guided by two parameters :

1. Distance between bottom of fan and ceiling
2. Distance between bottom of ceiling fan and the upper portion of man in a upward stretched position.

In the first case, some gap is desirable for the fan to extract the air 30 cm to 45 cm air gap has been suggested by the CBRI, for proper sucking.

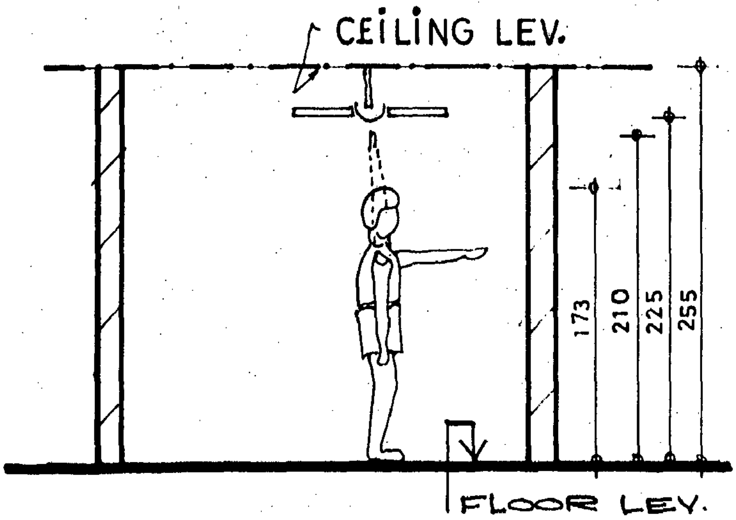
In the second case, some gap is required between bottom of ceiling fan and the hand of a man in the upward stretched position.

As shown in the Fig. C_1 height of a person in a stretched position is 210 cm Minimum 30 cm gap is desirable from the bottom of the fan to avoid any accident.

So minimum height of the ceiling should be 270 cm and optimum 285 cm where ceiling fan is proposed. But in houses where no ceiling fans are required, optimum height may be kept as 240 cm. Cost analysis has been done considering the various ceiling height which are generally adopted by the people while constructing their houses as indicated in the table C-1. For the sake of analysis 5x10 m size of the plan has been considered.

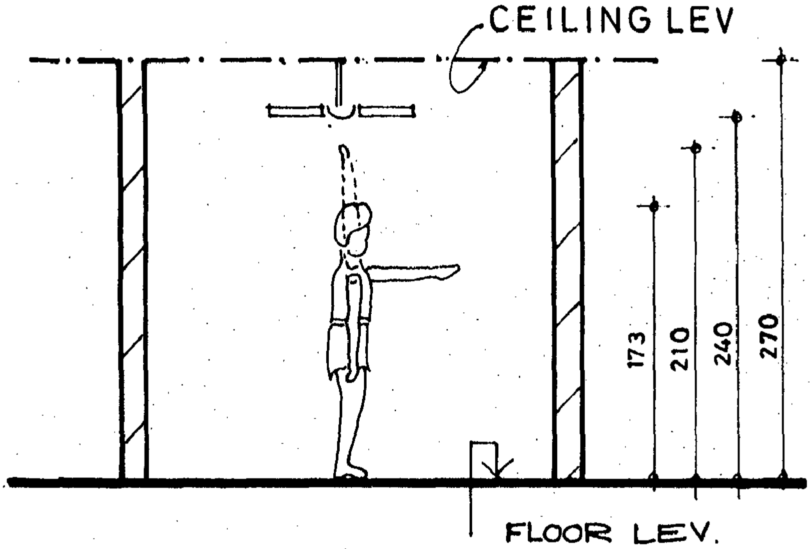
CEILING HEIGHT

MINIMUM



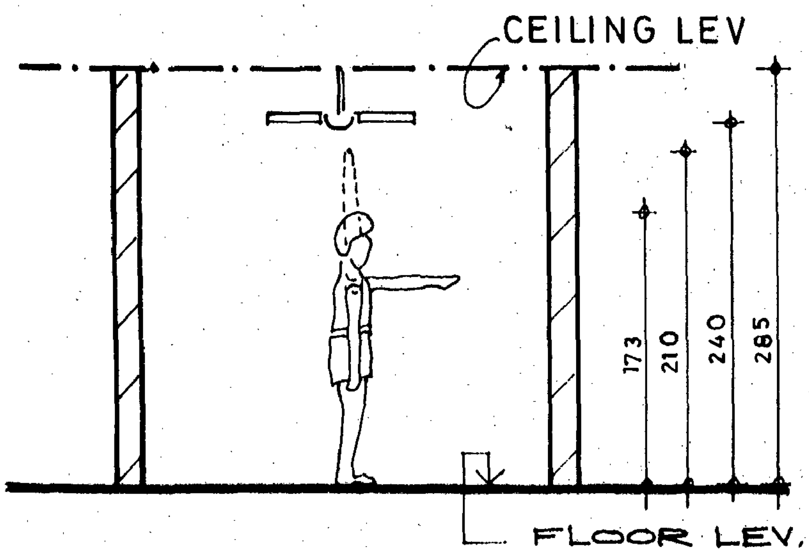
C_1

OPTIMUM



C_2

IDEAL



C_3

FIG C-1

Table C-1

Sl. No.	Ceiling height in M	Plan size in M	Quantity Ratio 1:6 Brick	Cement in bags	Saving over (2)
1	2.4	5x10		220.8	-10.95
2	2.7	-do-		248.4	± 0
3	2.85	-do-	9804	262.2	+ 5.26
4	3.00	-do-	10320	276.0	+ 10%
5	3.15	-do-	10836	289.8	+ 14.18
6	3.30	-do-	11352	303.6	+ 18.18

It clearly shows that there is wide variation in the cost and saving upto 18.18 % can be achieved by adopting optimum height.

6.6 ROOFING

Roof consumes about 20 % of the building cost.

Cost of roof depends upon three main parameters :

1. Type
2. Span
3. System

Type

For plain areas of this region, basically three types of roof are used :

1. R.C.C.

2. R.B.C.

3. R.B.

Cost saving wise analysis is given in the table TR-1.

Table TR-1

Item		R.C.C. slab	R.B.C. slab	Partially precast units R.C.C. plank	Ribbed slab	Channel unit	Brick panel
Material cem.kg		45.5	31.4	31.0	23.10	32.0	23.80
Bk.(No)		-	26.5	-	-	-	-
Steel kg		9.8	9.95	4.99	6.98	7.59	5.57
Labour cost/ M^2(Rs.)		150.2	142.36	98.34	100.02	114.13	98.12
Saving compared to conventional RCC slab	Cost	-	5.2	34.5	33.4	24.0	34.4
	Cem.	-	30.9	31.8	49.2	30.3	47.7
	Steel	-	-1.5	45.2	28.7	18.8	43.7

It is clear from the table that conventional RCC roof consumes 48.8 % more cement, 29 % to 49 % more steel than precast RCC planks and ribbed slab respectively. Where good quality bricks are available, R.B.C. slab is economical than conventional RCC slab. In case of large scale housing programmes, prefabricated roofing is very economical for many obvious reasons.

Span

In low cost housing, span of roof plays very important role. Minimum the span, minimum is the consumption of steel in the roof.

It has been observed that for span 2.4 m to 2.7 m there is not much difference in steel consumption but beyond 2.7 m substantial increase in steel is there. Spans more than 3.3 m are not economical in the low cost housing.

So the planning of low cost houses should be done in such a way that span does not exceed 3 M.

Structural economy wise, optimum span for one room and two room dwelling units are recommended as 2.4, 2.7m and for three room dwelling units as 2.7 m and 3.0 m.

System

Two roofing system are there

1. One way
2. Two way

One way is economical for sizes where ratio is 1:2 and two way is economical otherwise. In one room dwelling unit if planning of house is done in such a way that ratio 1:2 is achieved, then substantial saving in steel can be achieved. In this system, main walls are required to be load bearing while cross walls may be 11.5 cm thick non load bearing walls.

6.7 FLOORING

Flooring affects the cost in two ways :

1. Type of floor finish
2. Design of flooring

Type of floor finish

- Mosaic
- P.C.C.
- Brick
- Mud

Mud flooring is the cheapest but should be recommended to slum dwellers only. Brick flooring is cheaper than P.C.C. flooring while P.C.C. is cheaper than mosaic.

For one room and two room dwelling units, 40 mm P.C.C. flooring should be recommended being more durable than brick flooring. For three room dwelling units also, except w.c., bath and kitchen, P.C.C. flooring may be recommended.

This will help in optimizing the overall cost of the building.

Design of Floor

General specification for the floor design are hard core of earth, 100 to 150 mm fine sand filling, 75 mm base concrete and 40 mm cement concrete. The function of sand is to check the moisture and aunts from rising into the floor, but this can be avoided in areas where water table or moisture in the soil is less. Even the glass strips to devide the floor can be avoided.

The study of private houses under construction reveals that substantial amount of money is spent by the house builders in evolving floor pattern through glass strips of different thickness. The optimum thickness of glass strips is recommended as 4 mm. Granular glass strips are cheaper than the plain glass, and at the same time, these provide better bond due to roughness.

6.8 PLASTERING

Cost of plastering depends upon three parameters :

1. Type of plaster
2. Thickness of plaster
3. Ratio in plaster

Material for mosaic layer for different proportion (100 sq.m.)

Type of flooring	Material	Proportion 1:1	Proportion $1:1\frac{1}{2}$	Proportion 1:2	Unit
Mosaic	Cement	0.50 15	0.4 12	0.36 10.8	Cu.m.
flooring	Marble chips	0.5	0.6	1.08	Cu.m.

Above table clearly shows that by proper proportion, economy upto 28 % can be achieved.

Analysis of Material required for pointing with different mortar of various proportion for 100 sq.m.

Type of mortar	Material	Proportion 1:2	1:3	Unit
Cement	Cement	0.20	0.16	Cu.m.
Mortar		6.00	4.8	Bags
	Sand	0.4	0.48	Cu.m.

1. Labour cost for pointing is 25 % more than the plastering
2. Cost of material for plastering is 65 % more than that of pointing.
3. Cost of plastering is 47 % more than that of pointing. Therefore in those areas where bricks are of good quality and rainfall is less, outside pointing will be more economical.

Analysis of material required for plastering with different mortars of various proportion for 100 sq.m.

Thickness of plaster	Material	Proportion 1:2	1:3	1:4	1:5	1:6	Unit
12 mm	Cement	18	13.5	12	10.5	9	Bags
	Sand	1.2	1.35	1.6	1.85	1.90	Cu.m.
20 mm	Cement	30	23.4	19.5	16.2	13.8	Bags
	Sand	2.0	2.34	2.6	2.7	2.76	Cu.m.

This shows that saving in cem. upto 55% can be achieved by adopting suitable thickness of plaster.

Typeof plaster

- Cement sand plaster
- Lime plaster
- Mud plaster

In areas where lime is available in plenty, lime plaster is recommended but in regions where lime is transported from outside, cem. sand plaster should be used.

Mud being locally available material in rural areas mud plastering on walls is the cheapest. Now stablized mud plaster is being recommended for outside wall as it is more stable and can withstand any climate.

Thickness of plaster

Thickness of plaster depends upon the surface conditi of wall. Analysis of 12 mm, 15 mm and 20 mm thick plaster shows that cost reduction upto 20 to 40% can be made using proper thickness of plaster. Table TRP_1 clearly indicates the comparative material consumptions.

Ratio in Plaster

1:4 to 1:8 ratio of mortar plastering is being used. Table TRP_2 obviously shows the substantial cost difference with different ratio in plastering mortar.

ARCHITECTURAL ELEMENTS

Building plan form

Wall length is governed by the plan form of building.

Analysis has been done considering five different shapes with same area as shown in figure no. PF-1

Following are the inferences :

1. 6.25 % increase of wall length in P_2 over P_1
2. 6.25% increase of wall length in P_3 over P_1
3. 11.76% increase of wall length in P_4 over P_1
4. 21.05% increase of wall length in P_5 over P_1

This clearly shows that plan with internal courtyard has maximum wall length as indicated in the table TPF_1. So if internal courtyard planning is suggested in low cost housing, maximum wall length should be shared.

For considering better ventilation and light, optimum number of shared wall has been recommended as two as is indicated in table TPF_2

Table TPF_1

Sl. No.	Plan No.	Area	Wall length	% increase over 1
1	P_1	50	30	-
2	P_2	50	32	6.25
3	P_3	50	32	6.25
4	P_4	50	34	11.76
5	P_5	50	38	21.05

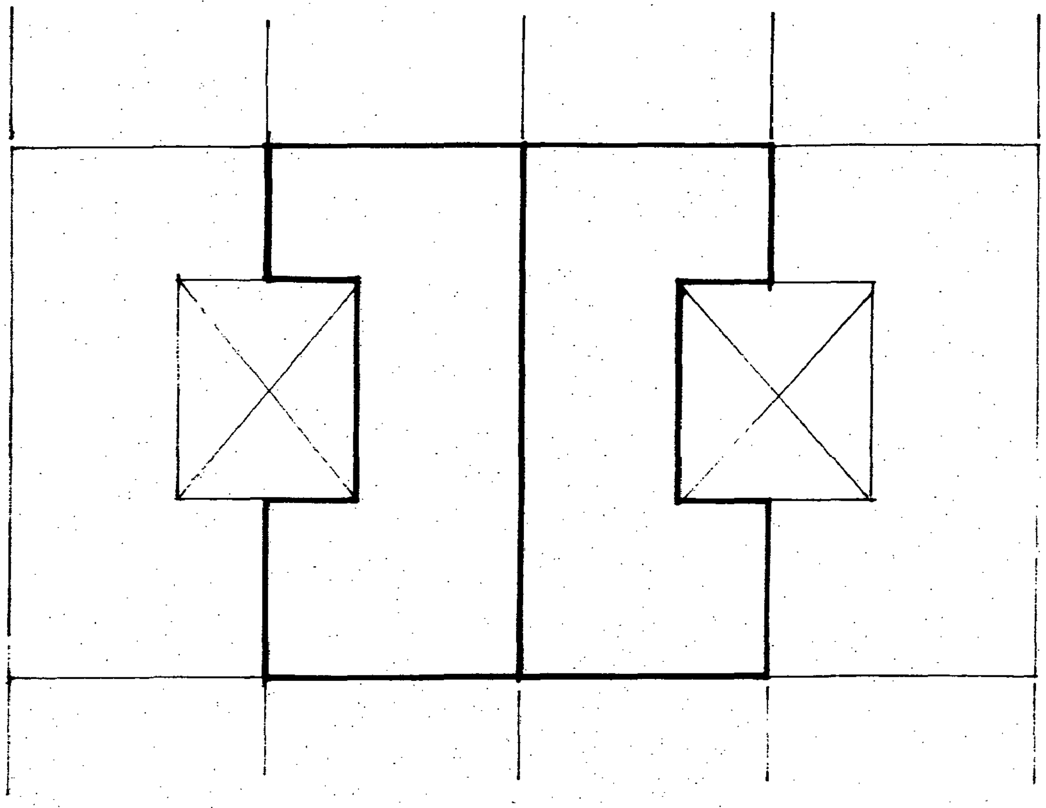


FIG. OP-1

% shared wall length 50

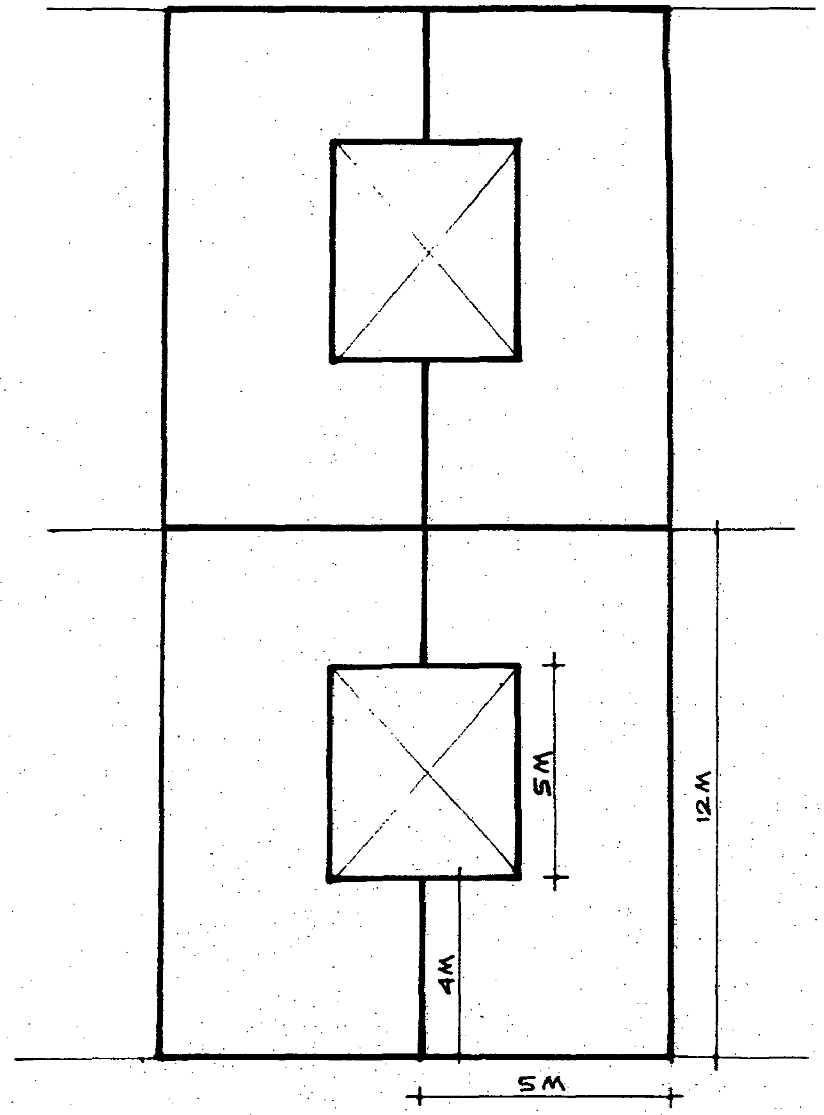


FIG. OP-2

% shared wall length 63·15

Table TPF_2

Sl. No.	Plan No.	Total wall length	Shared wall length	% shared wall length
1	OP_1	38	19	50
2	OP_2	38	24	63.15

6.10 PLANNING AND DESIGN ELEMENTS

Space Planning :

Space planning is governed by two factors

i) Internal circulation area

ii) Furniture layout

Internal circulation area is further influenced by movement pattern, location of cupboards, doors and windows.

Furniture layout is governed by the type of furniture depending upon the activity.

Internal circulation :

Two cases have been analysed to study the effect of cupboard and door location on internal circulation area in the room. In both the cases width of the room has been taken as 240, 270 and 300 cms.

CASE I

With two door opening

Sl. No.	Plan No.	Width of Room	R.A.	C.A.	% G.A.
1	E-1A	300	10.5	4.56	43.4
2	E-1B	270	10.5	4.56	43.4
3	E-1C	240	10.5	4.76	45.4

R.A. = Room area
C.A. = Circulation area

With one door opening

Sl. No.	Plan No.	Width of Room	R.A.	C.A.	%C.A.	Saving %
1	E-2A	300	10.5	2.4	22.85	20.55
2	E-2B	270	10.5	2.16	20.57	22.83
3	E-2C	240	10.5	1.92	18.28	22.57

CASE II

With two door opening

Sl. No.	Plan No.	Width of Room	R.A.	C.A.	% C.A.
1	E-3A	300	10.5	2.8	26.67
2	E-3B	270	10.5	3.04	28.95
3	E-3C	240	10.5	3.5	33.33

LOCATION OF CUPBOARD

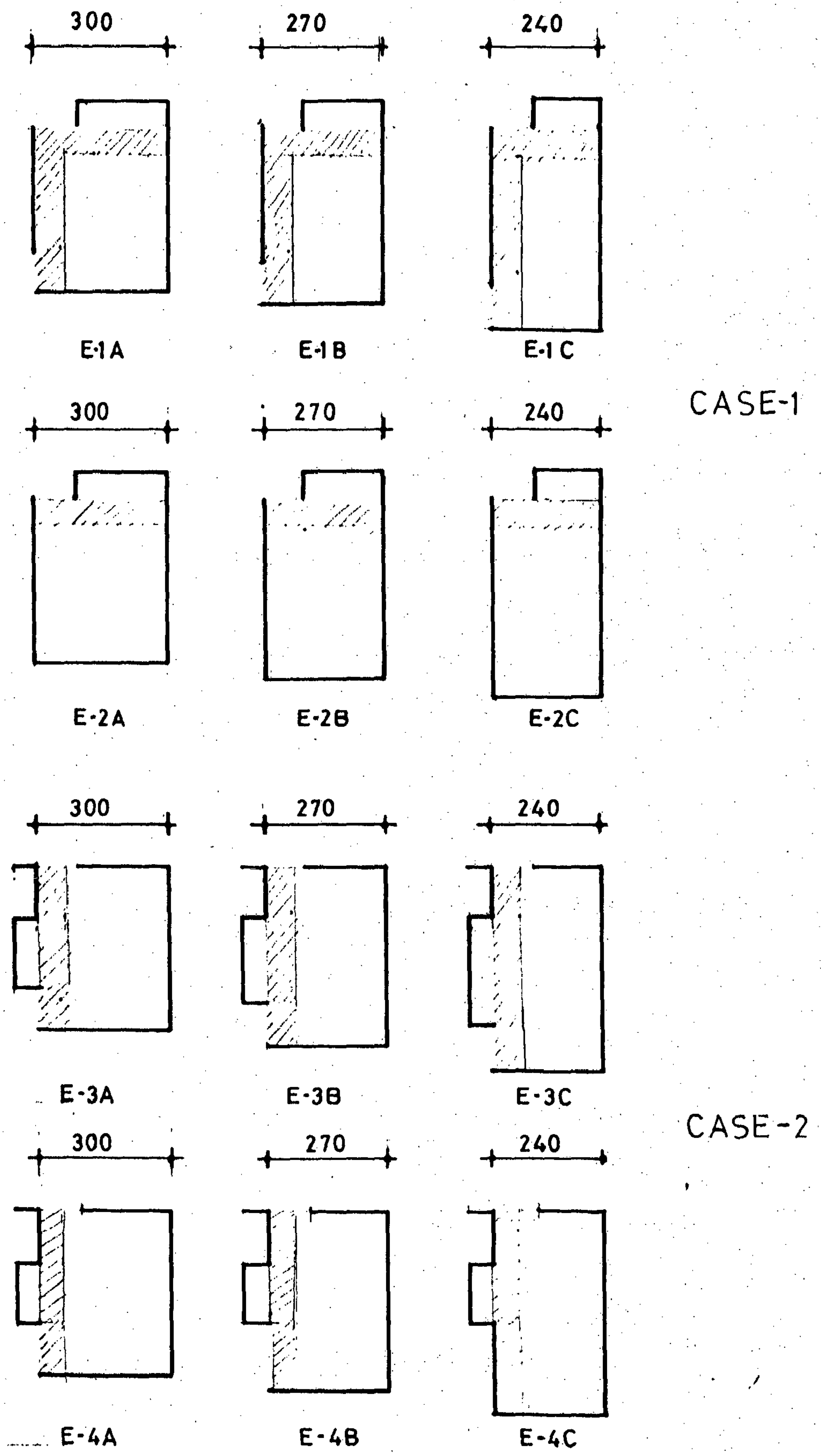


FIG. CB-1

With one door opening

Sl. No.	Plan No.	Room width	R.A.	C.A.	% C.A.	Saving %
1	E-4A	300	10.5	2.0	19	7.67
2	E-4B	270	10.5	2.24	21.33	7.62
3	E-4C	240	10.5	2.7	25.33	8.0

Inferences

Following inferences can be drawn from above study :

1. In the case of two door opening in the room, 26% to 43 % area is wasted in circulation.
2. By restricting the door opening to one, circulation area can further be reduced by 50 %.
3. Case II clearly indicates that locating the cupboard along the movement area between two doors circulation area can further be reduced by 24.4 %
4. Providing the cupboard along the movement area with one door opening, further saving upto 8 % can be done.

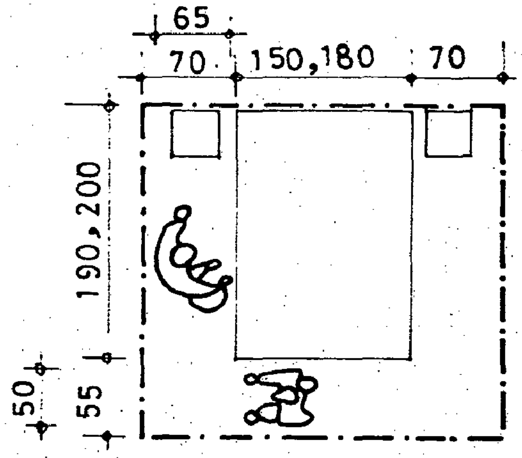
Recommendations

1. For one room and two room dwelling unit where cupboards are not lockable, cupboards should be located along the movement area between two door openings.
2. In case of two room andkthree dwelling units where cupboards with shutters are provided, cupboards should

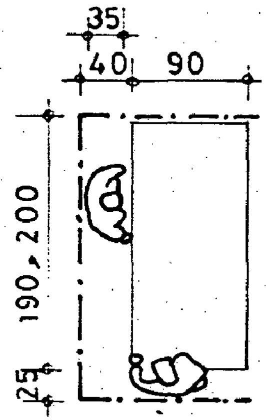
FIG. SA-1

SPACE REQUIREMENTS RELATED TO ACTIVITIES

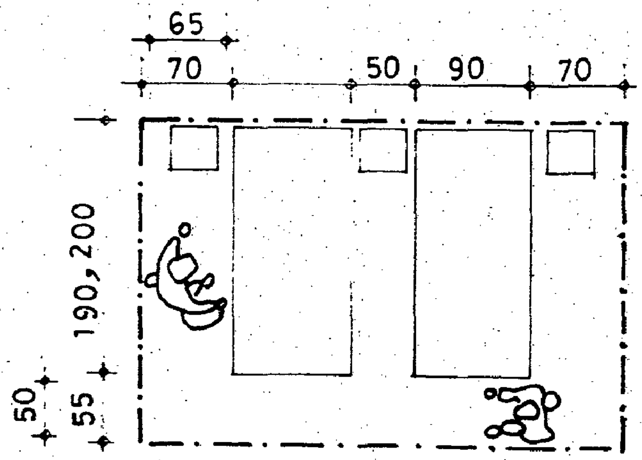
SLEEPING



Circulation around a Double bed

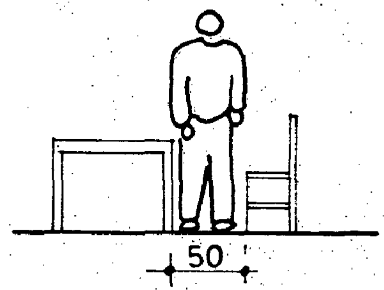


Making a bed

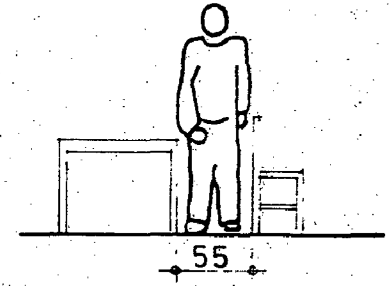


Circulation around Twin bed

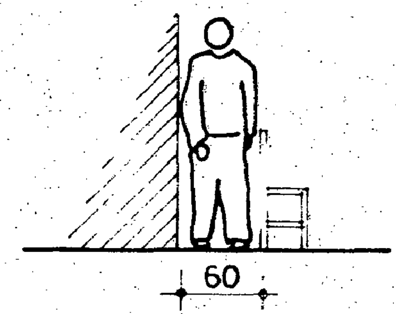
CIRCULATING



Passing between two pieces of furniture at or lower than table height.



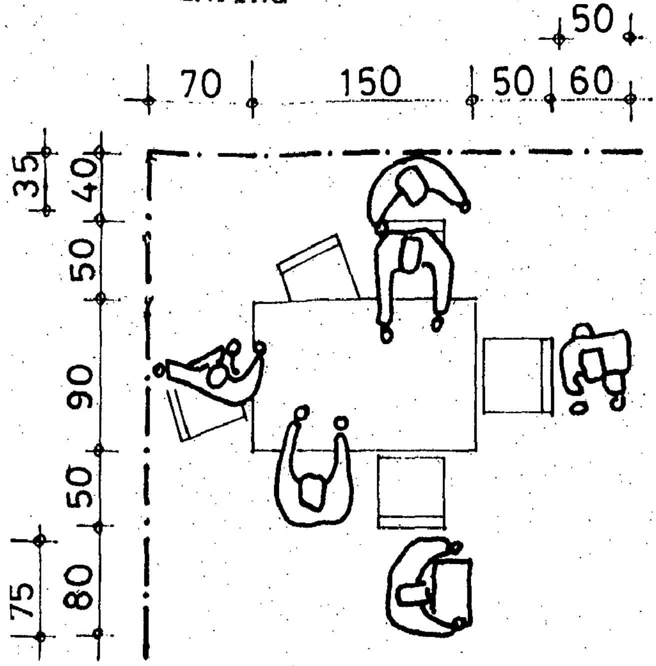
Passing between a piece of furniture at or lower than table height and a taller piece of furniture or wall.



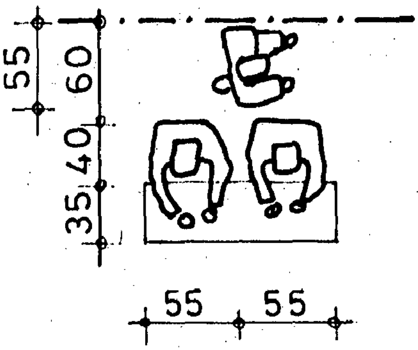
Passing between a tall piece of furniture and a wall.

FIG.SA-2

EATING

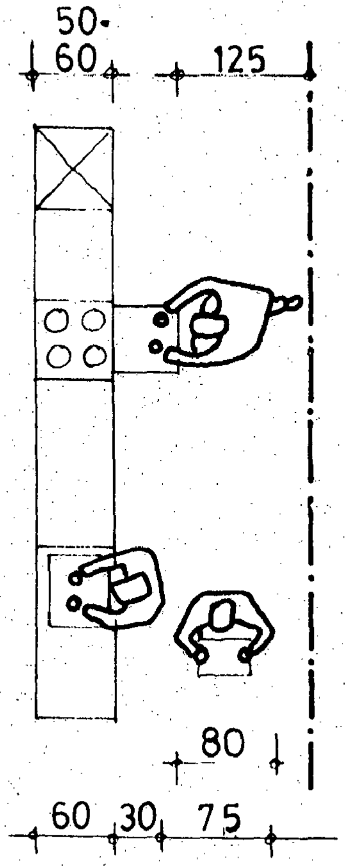


Sitting at table
and moving round.

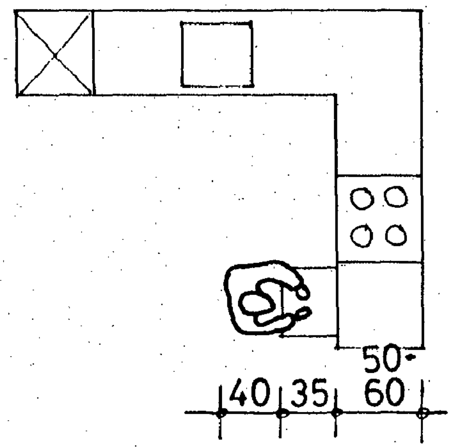


Sitting at a work top
with a person passing

FOOD PREPARATION



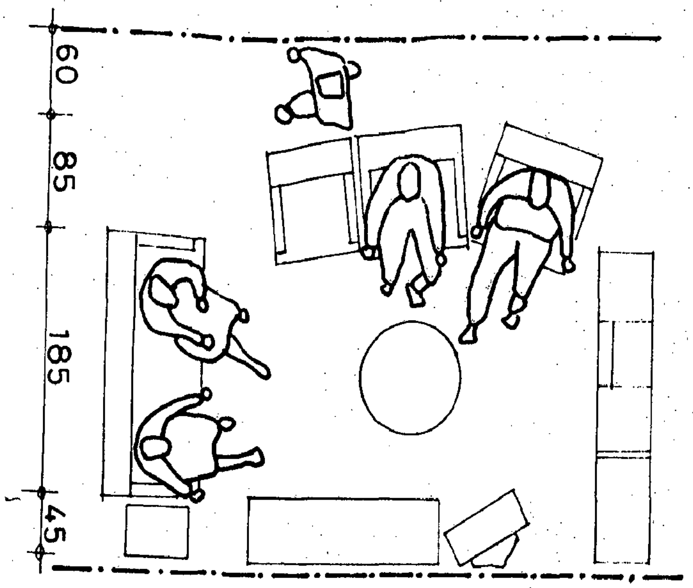
At the sink passing
with tray at the oven



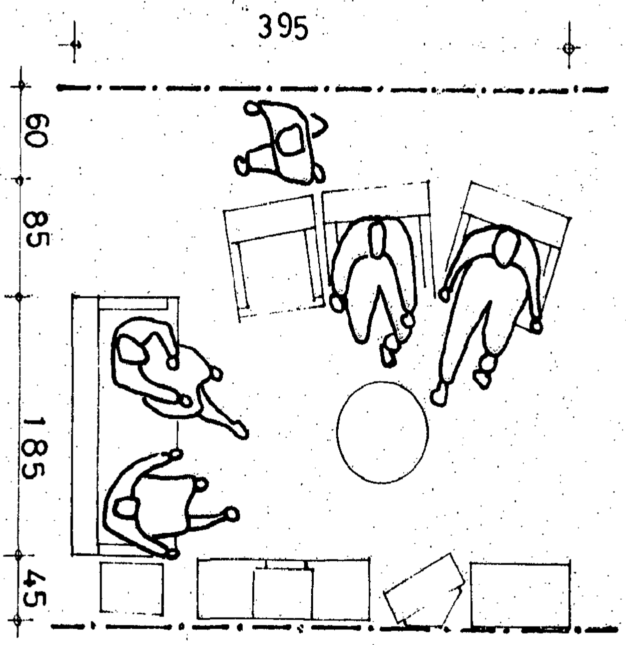
Sitting at pull out
work top (L-shape)

FIG.SA-3

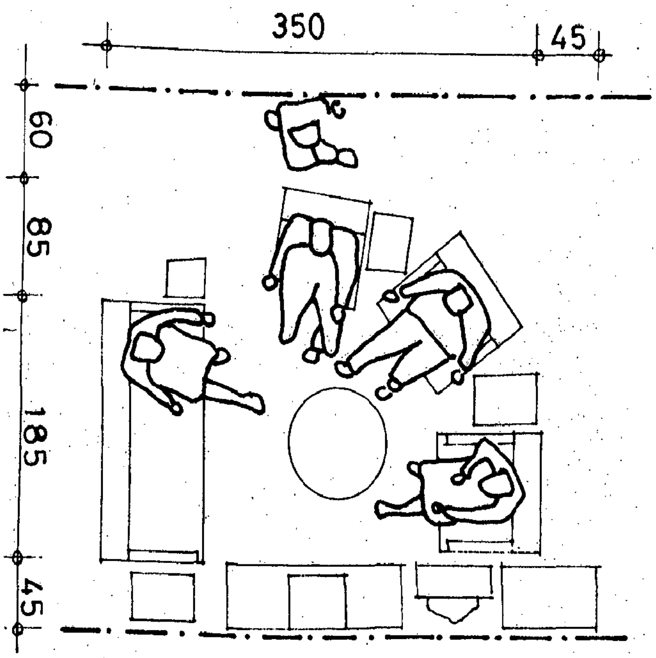
LEISURE ACTIVITY



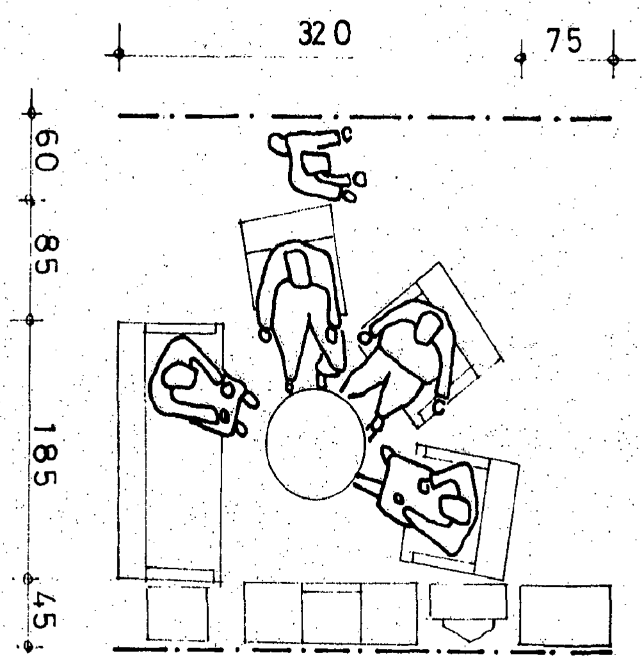
Looking at T.V.



Sitting around fire place
and looking at T.V.

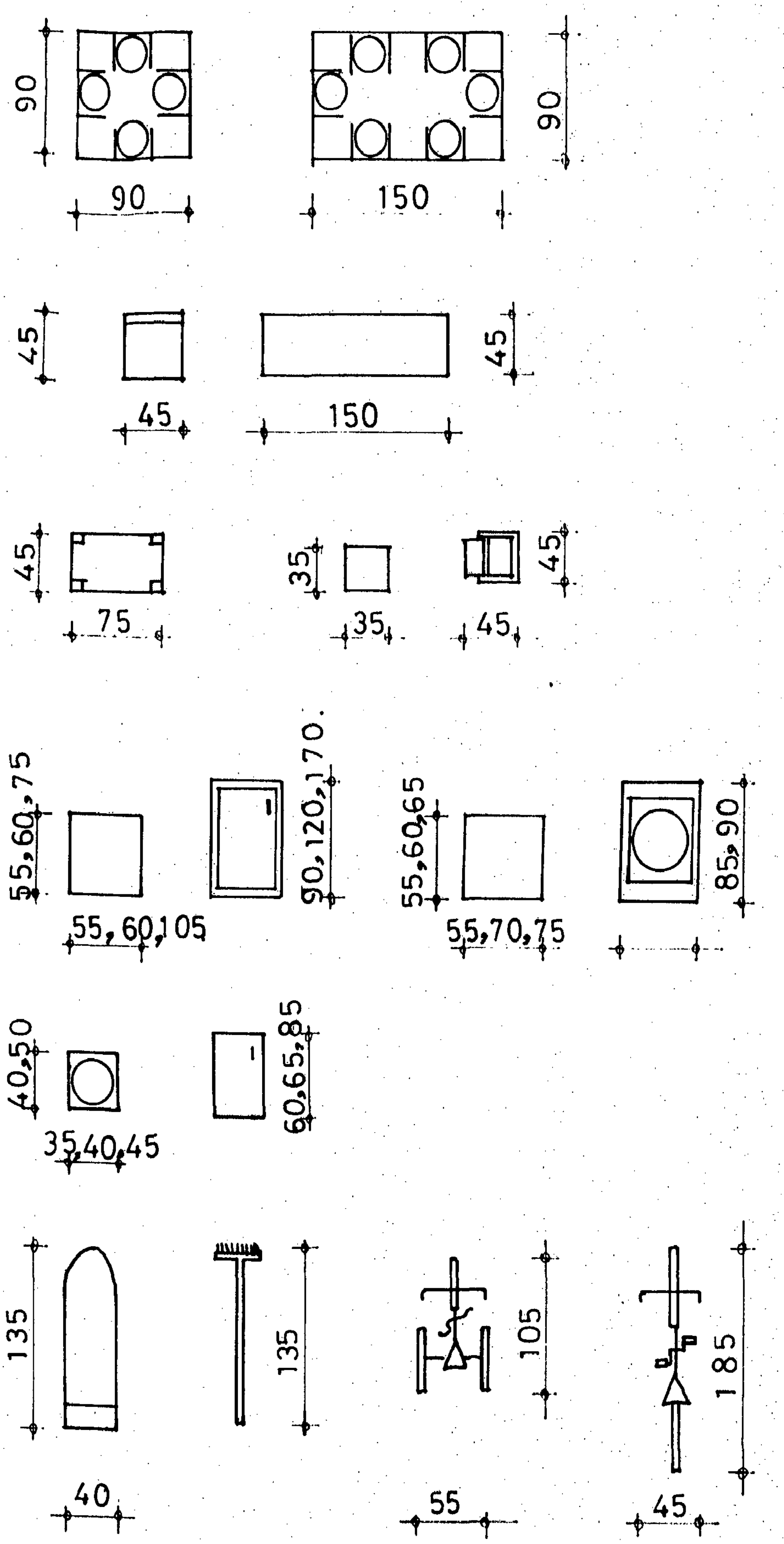


Talking and Reading



Eating at the Coffee table.

Furniture and Equipment Sizes



Dining Table for 4
Dining Table for 6

Dining Chair
Side Board

Trolley
Stool
High Chair

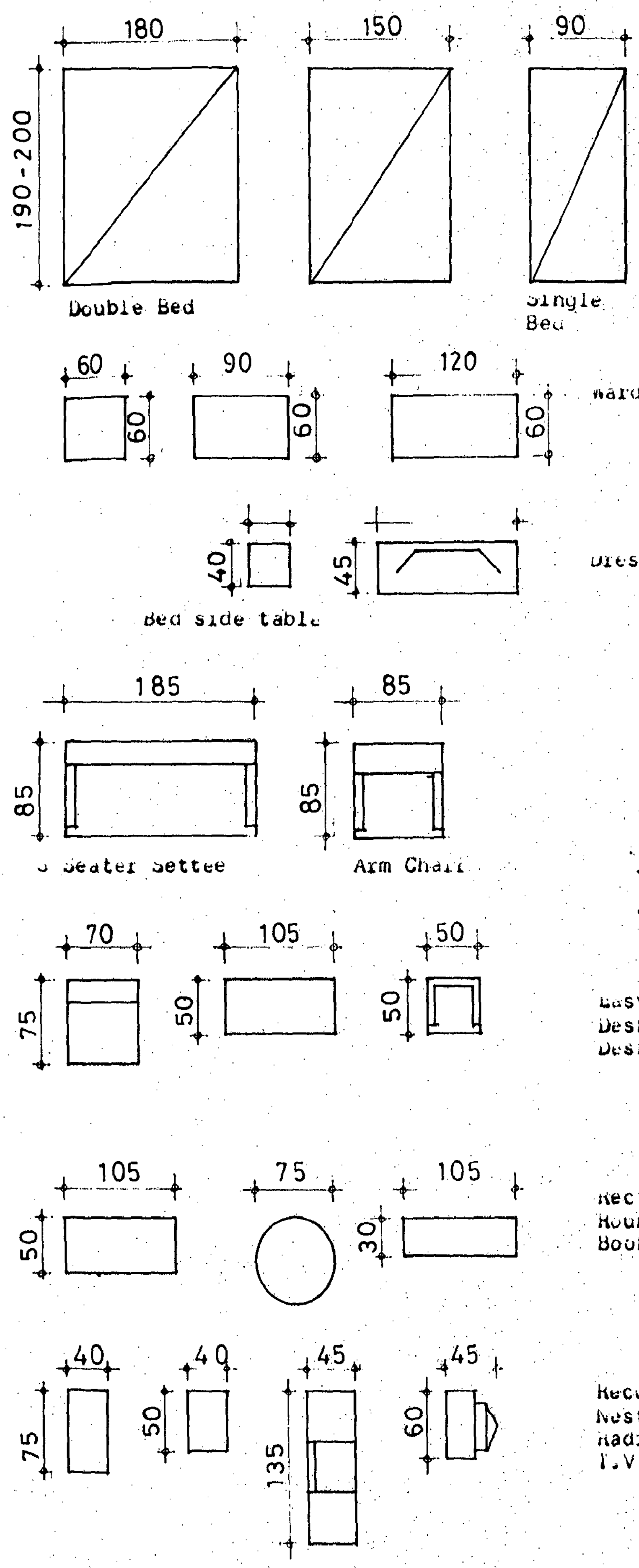
Refrigerator
Washing Machine

Spin Drier

Iron Board
Broom
Tricycle
Bicycle

FIG·FS-2

Furniture and Equipment Sizes



Wardrobe – 60, 90, 120 cms.

Dressing Table

Easy Chair
Desk
Desk Chair

Rectangular Coffee Table
Round Coffee Table
Book Case

Record Room
Nesting Table
Radio Gram
T.V.

FIG·FS-1

be located along the movement area between the door openings with 270 cm room width as indicated in case II This will give substantial saving in circulation area.

Furniture layout

Furniture layout is a main governing parameter for optimising the space within the house. Size of type of furniture and minimum space occupied by it for different activities have been described in figure SA-1, SA-2 and SA-3 respectively.

So utilizing this study optimum dimensions of different activity areas in a house such as bed room, drawing room, dining kitchen, toilet, bath and W.C. with different furniture layout can be found out.

STUDY

Bed Room

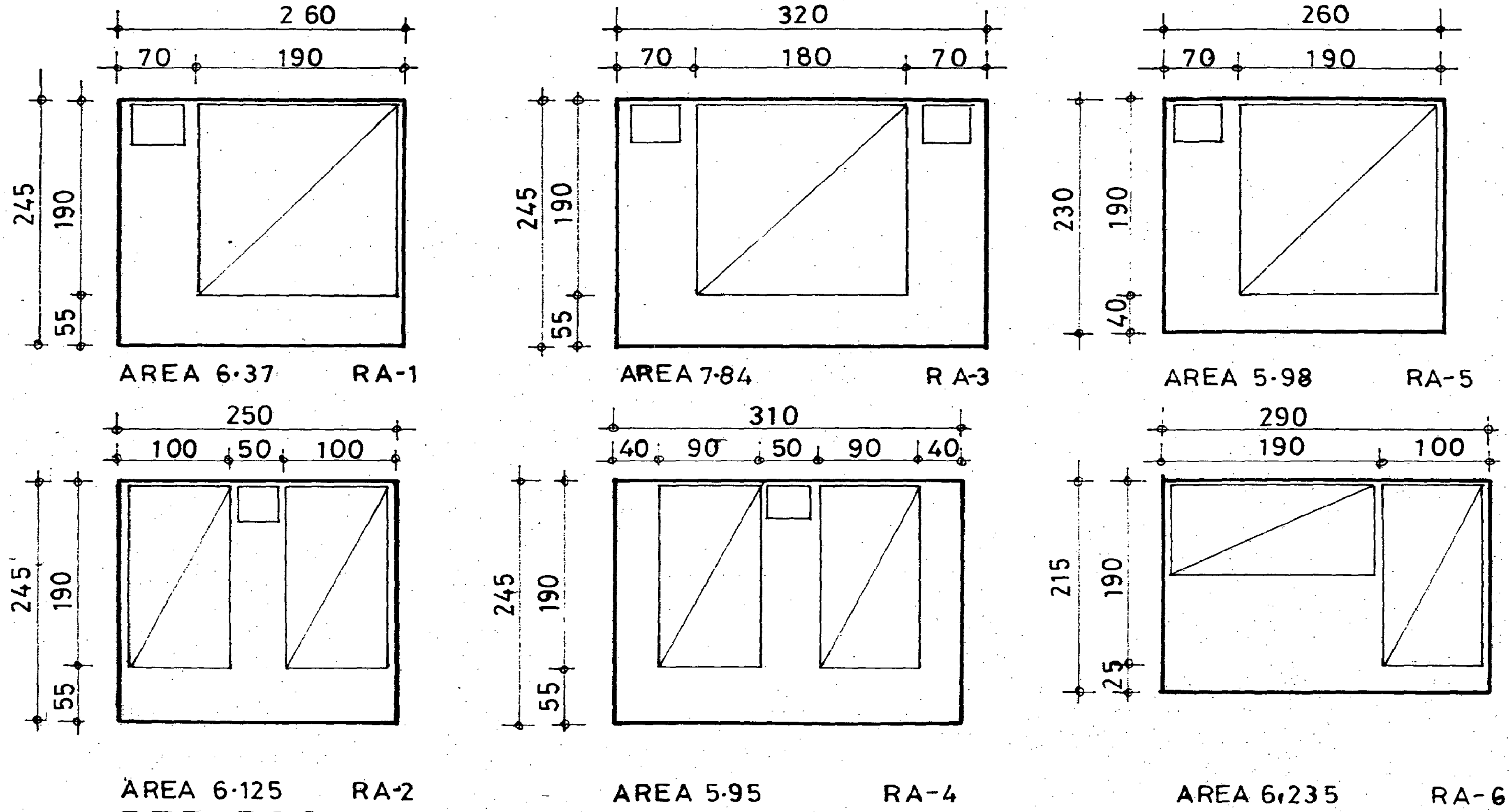
Activities performed in the bedroom are sleeping, studying, dressing and sitting. Furniture required are two beds, one side table one two chair, one small study table or rack.

Fig. SR-1 indicates the minimum dimensions for a room with minimum furniture i.e. two beds and one side table with six different layout.

Table TRB-1 alongwith fig. SR-1 suggests that saving upto 23% a space can be achieved by choosing proper dimensions with maximum furniture layout flexibility.

SPACE STUDY

FIG· SR-1

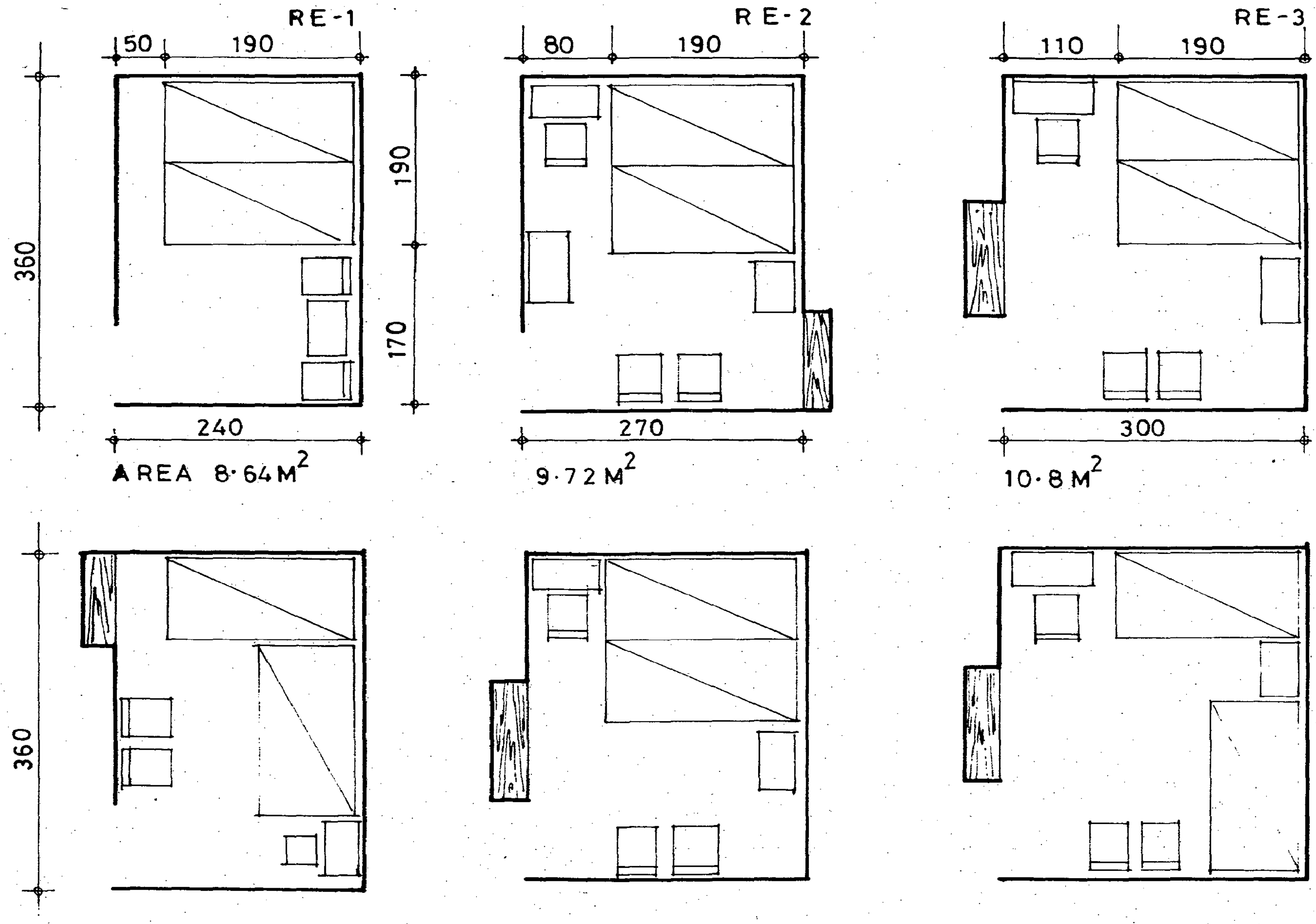


BED ROOM.

Minimum Room sizes with 2 beds and side table

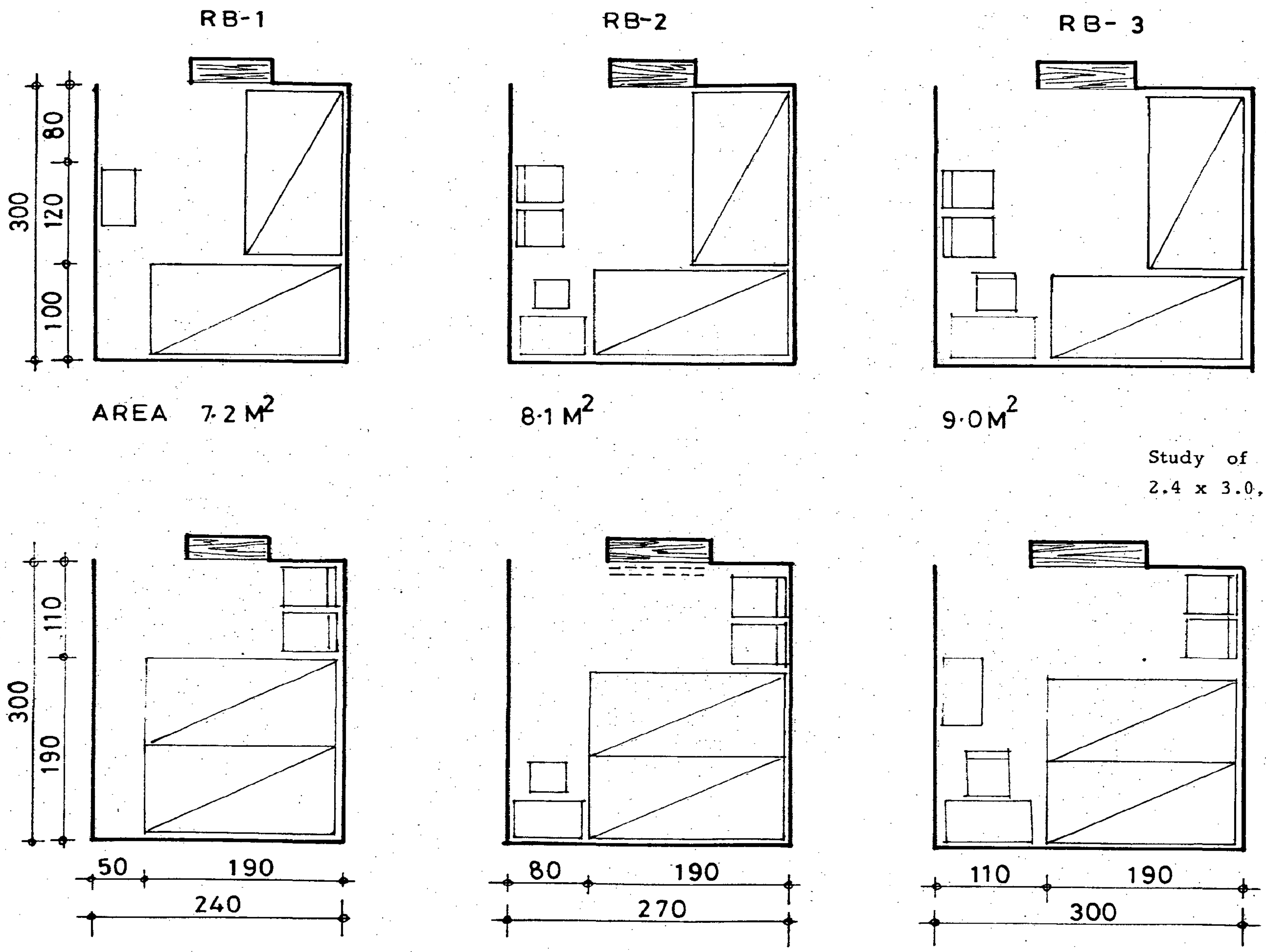
SPACE STUDY

FIG·SR-5



Space study of bed room with respect to door and cupboard location.

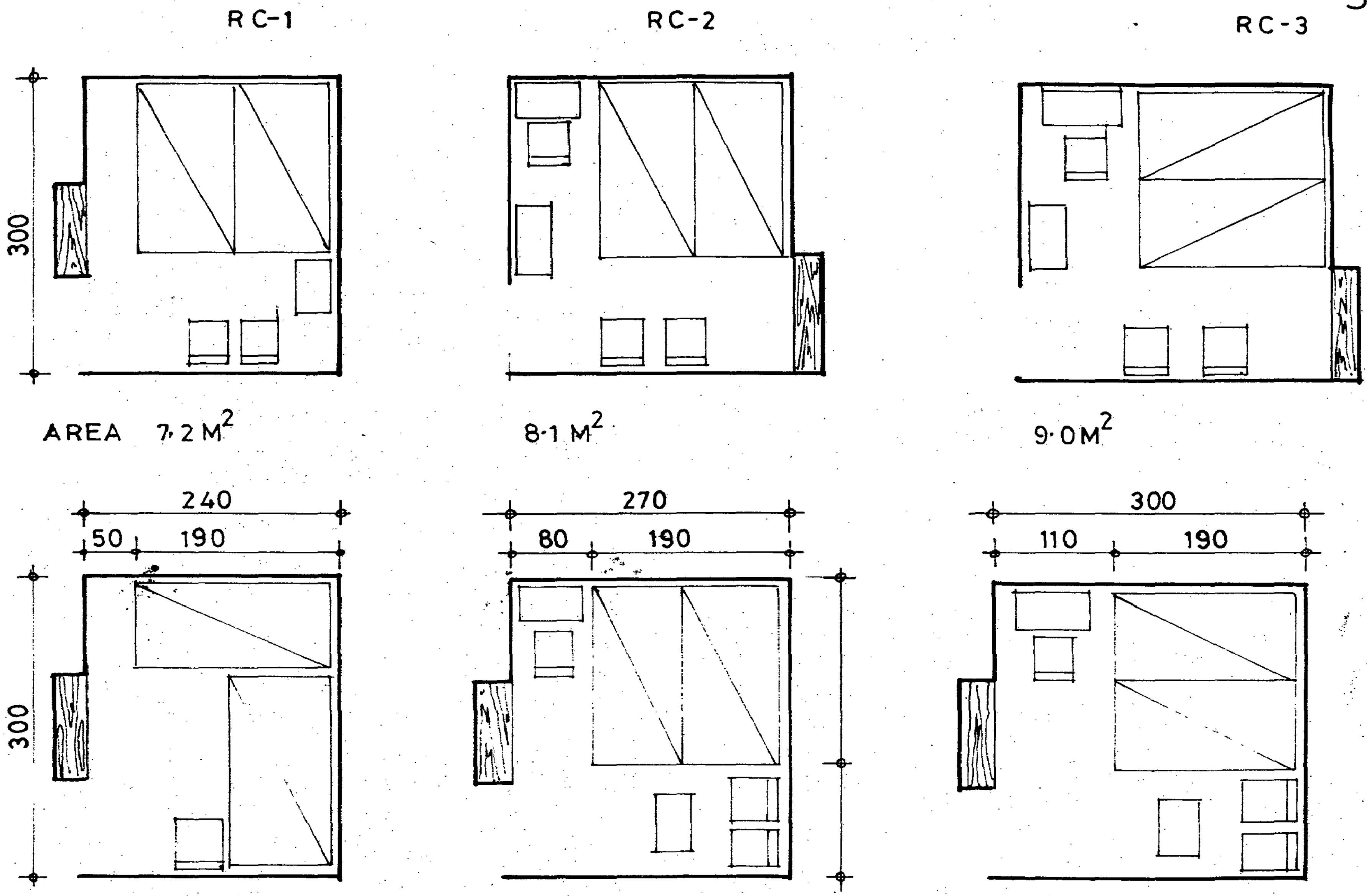
SPACE STUDY
FIG·SR-2



Study of bed room with sizes
2.4 x 3.0, 2.7 x 3.0, 3.0 x 3.0

SPACE STUDY.

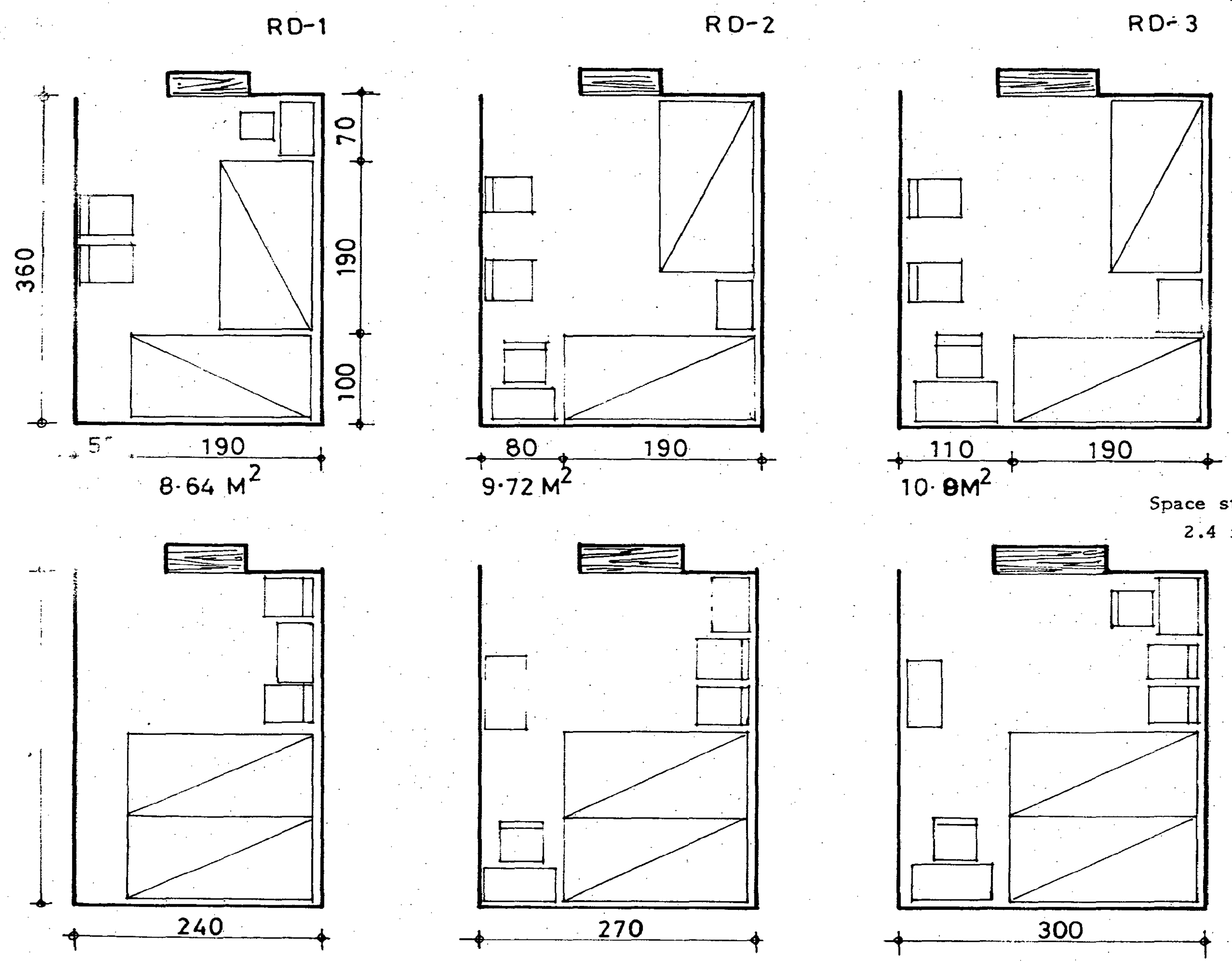
FIG·SR-3



Study of bed room with sizes
2.4 x 3.0, 2.7 x 3.0, 3.0 x 3.0

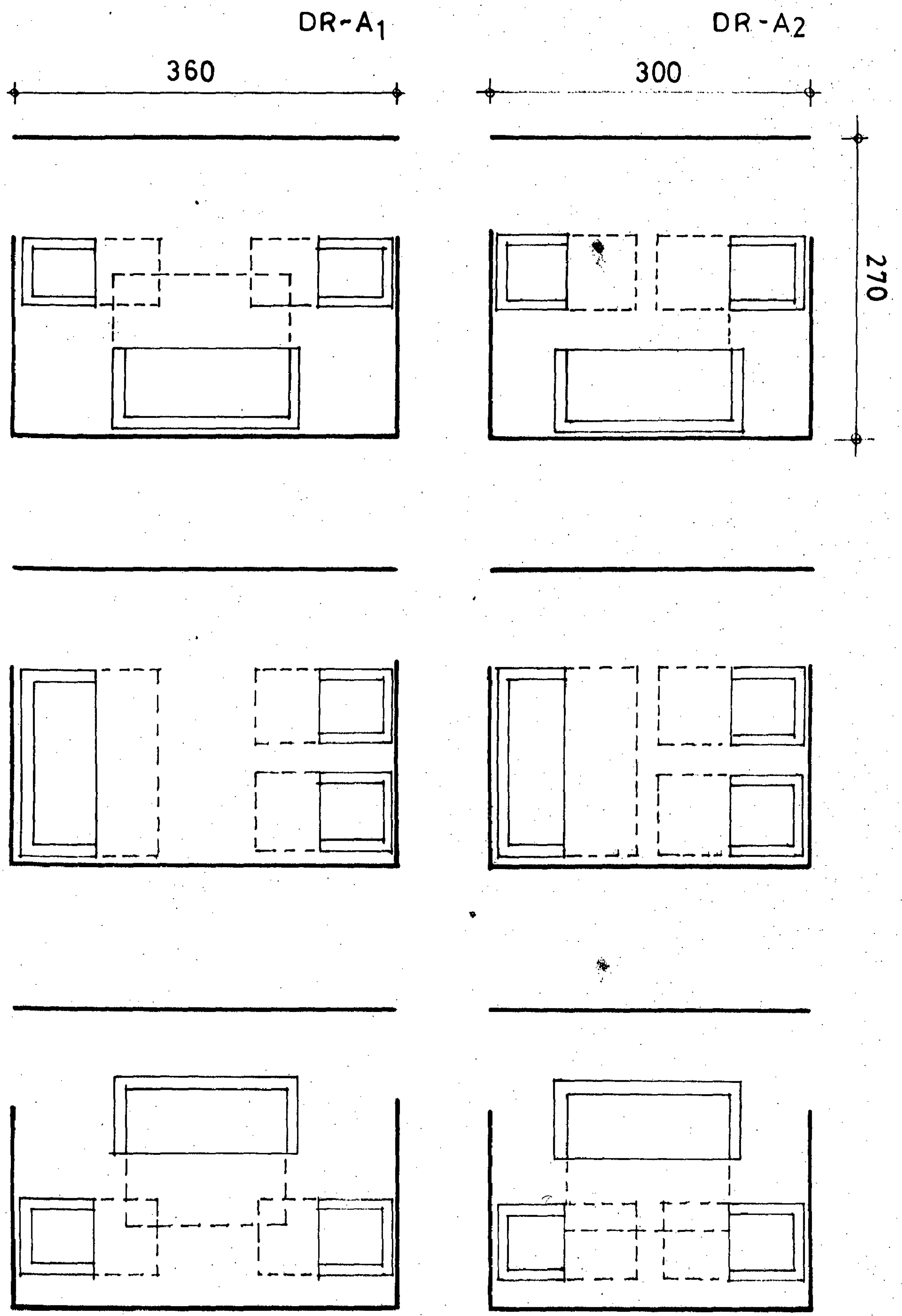
SPACE STUDY

FIG·SR-4



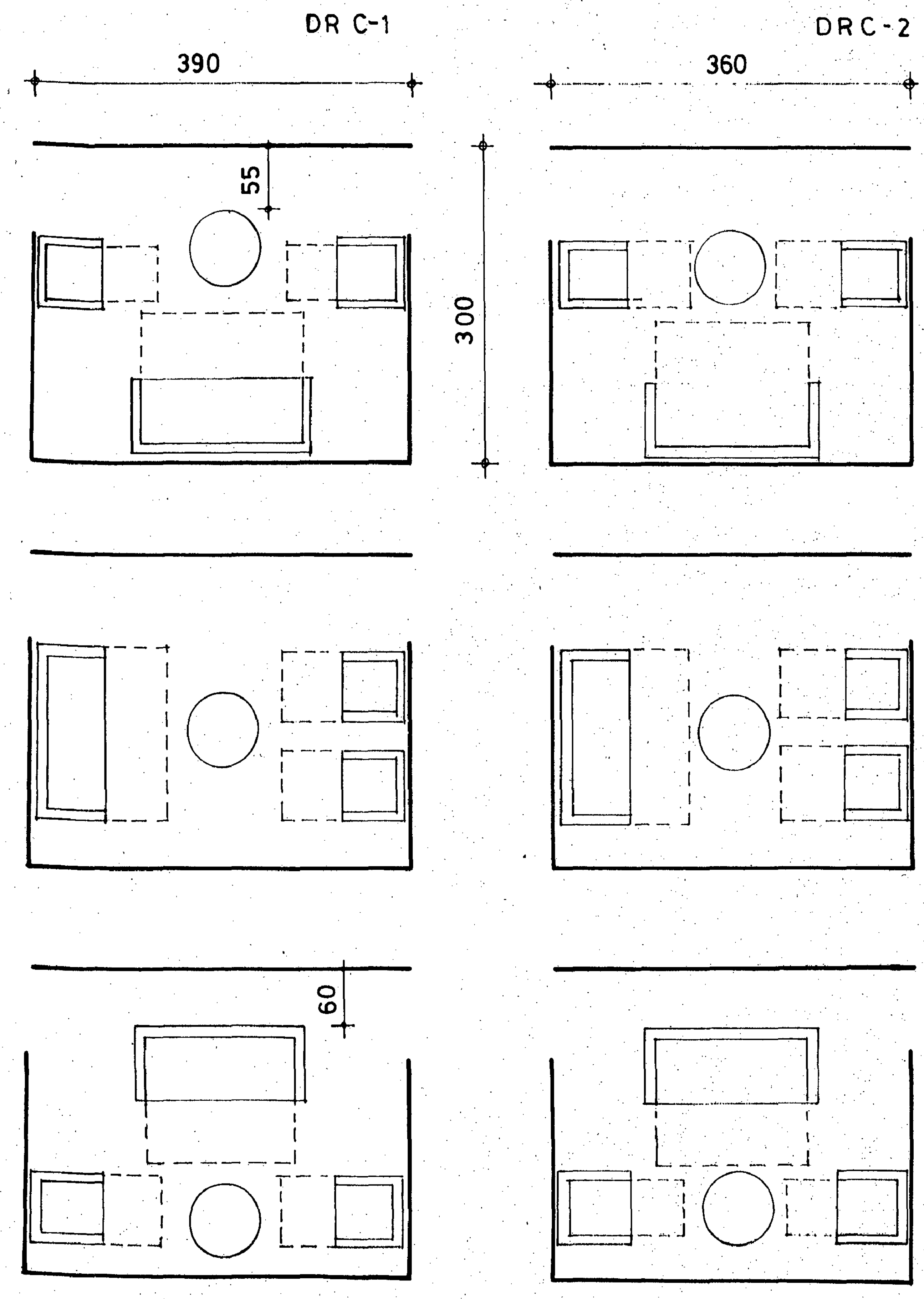
Space study [illegible] ed room with sizes
2.4 x 3.6, 2.7 x 3.6, 3.0 x 3.6

SPACE STUDY



DR-1
DRAWING ROOM.

SPACE STUDY



FIG· DR-3
DRAWING RM.

SPACE STUDY

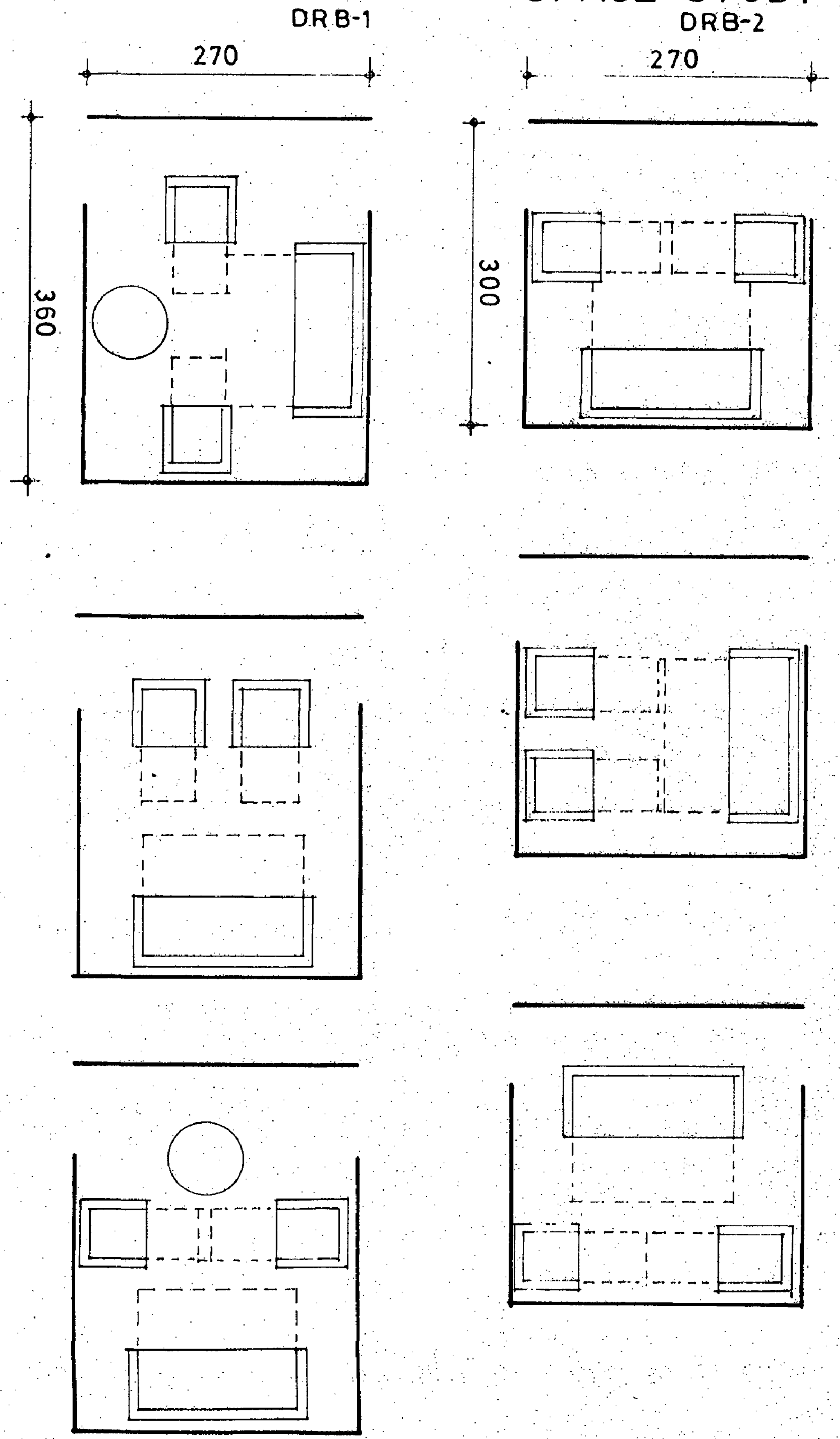
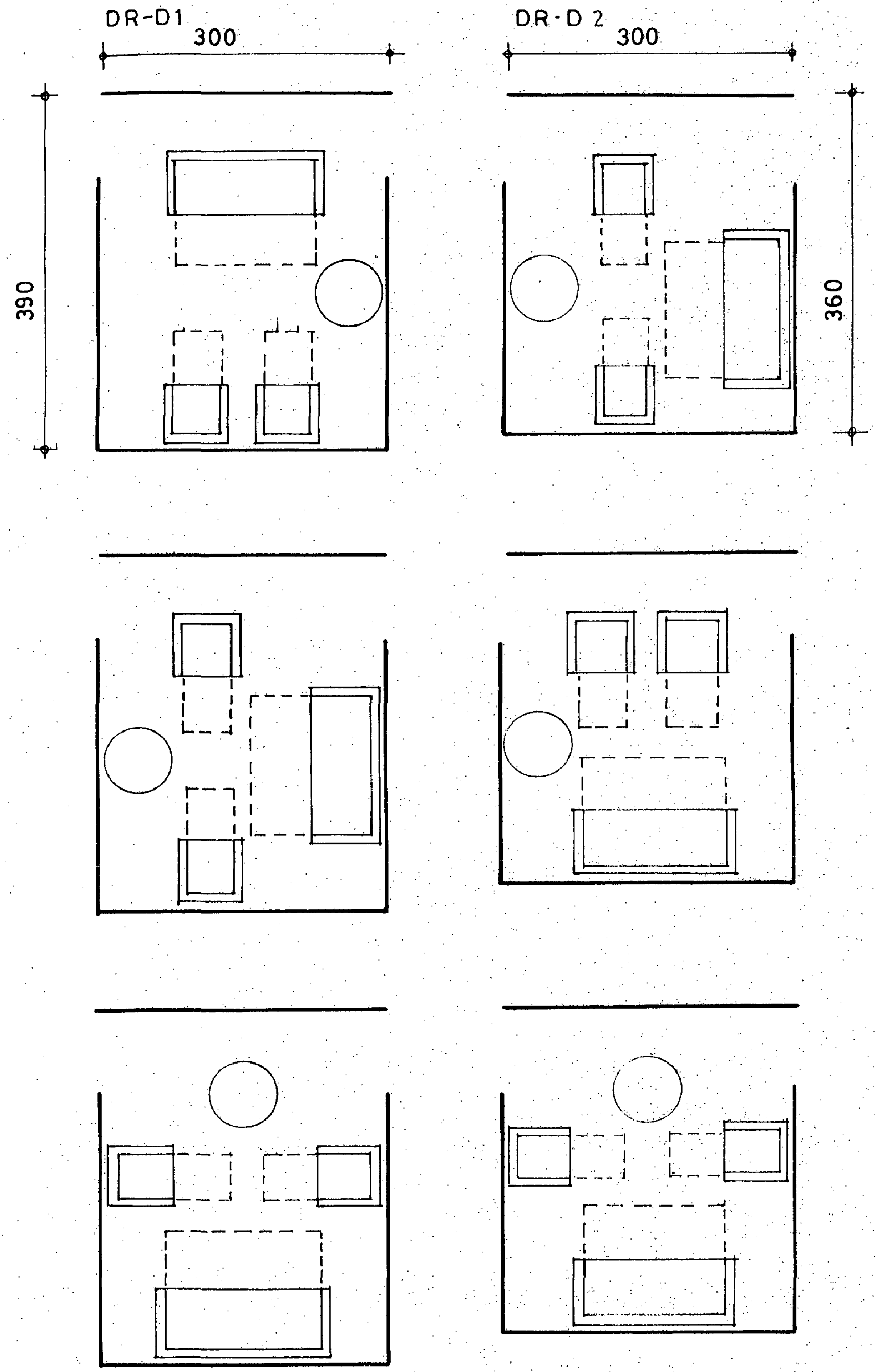


FIG DR-2
DRAWING RM.

SPACE STUDY



FIG·DR-4
DRAWING RM

DINING

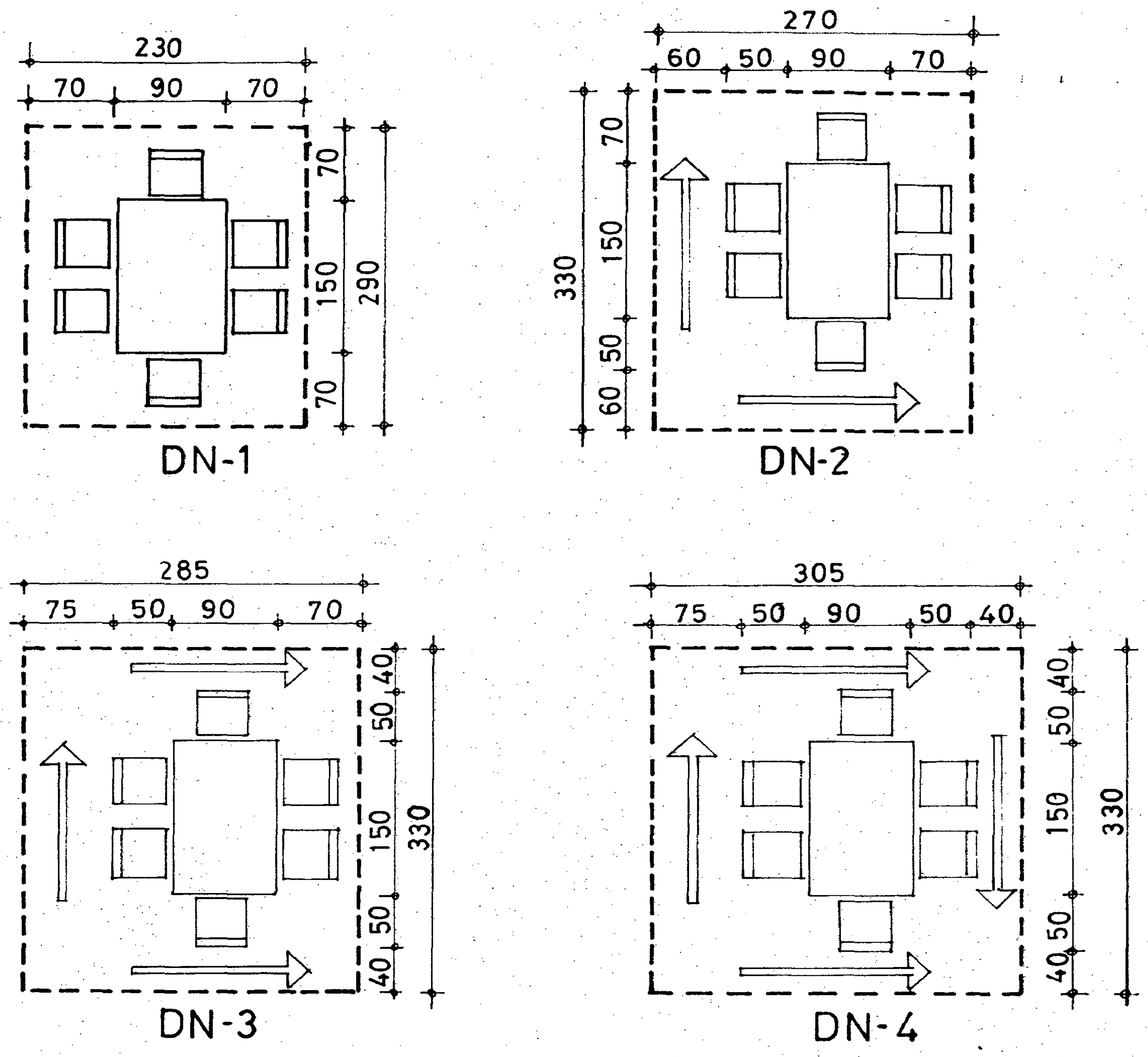


FIG. DNR-1

KITCHEN

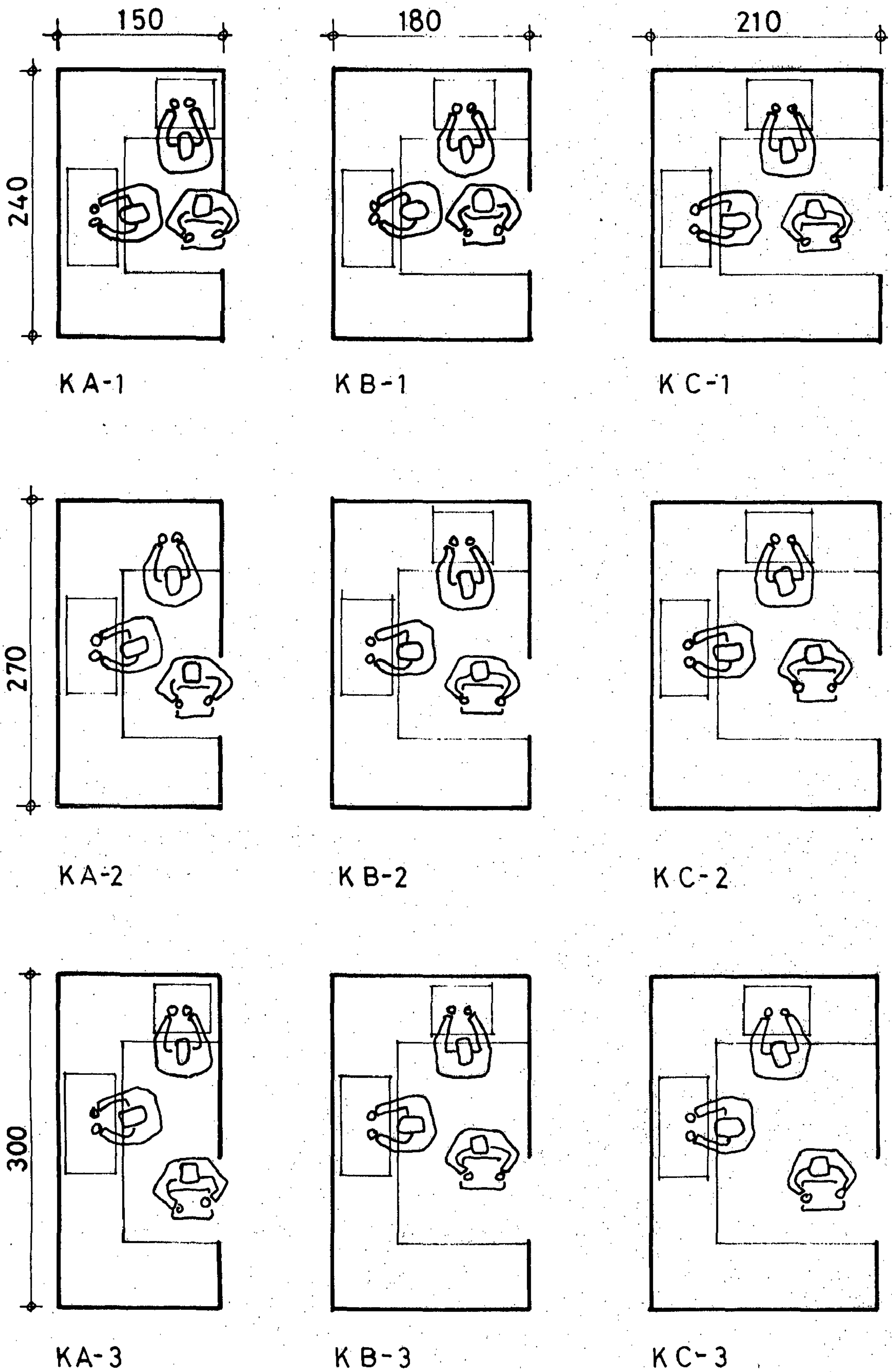
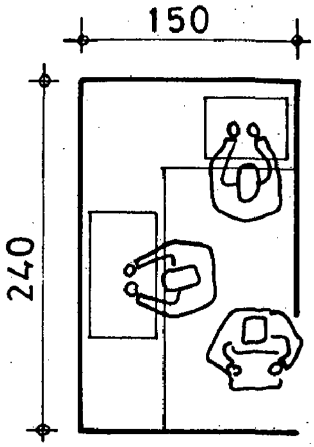
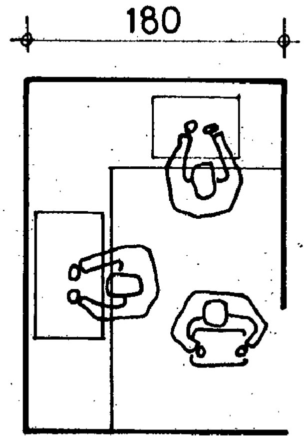


FIG. K-1

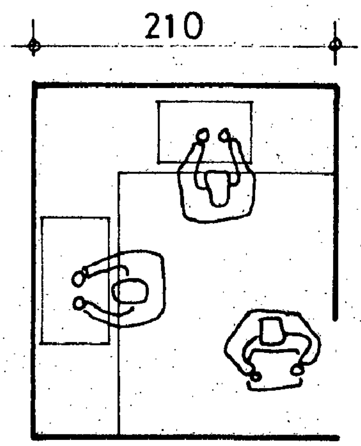
KITCHEN



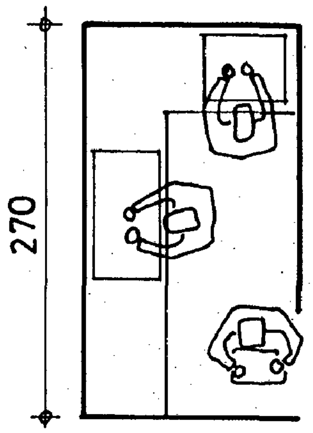
KA′1



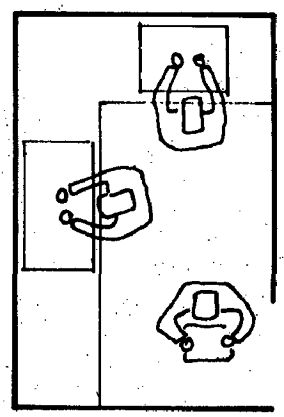
KB′1



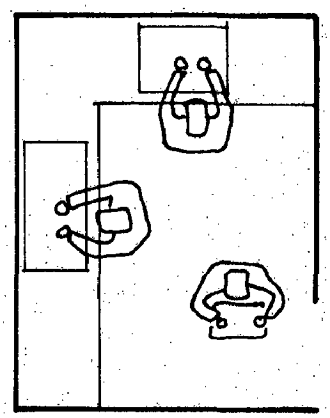
KC′1



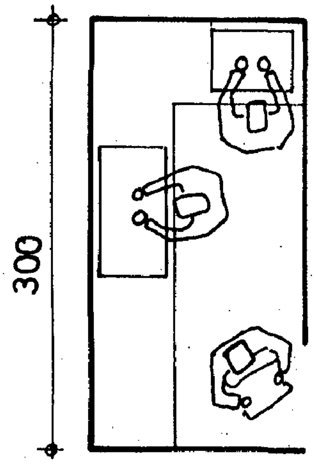
KA′ 2



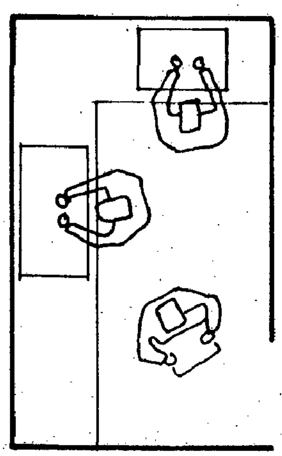
KB′2



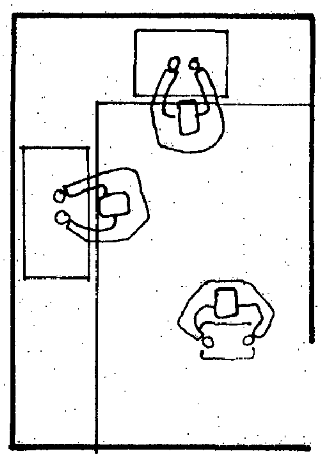
KB′ 2



KA′-3



KB′-3



KC′- 3

FIG. K-2

Table TBR-1

Sl.No.	Plan No.	Size	Area
1	RA_1	2.6x2.45	6.37
2	RA_2	2.5x2.45	6.125
3	RA_3	3.2x2.45	7.84
4	RA_4	3.1x2.45	7.595
5	RA_5	2.6x2.3	5.98
6	RA_6	2.9x2.15	6.235

Analytical study has been conducted to determine the optimum sizes for bed rooms with furniture provision of two beds, one or two chairs, one small study table.

Fig. SR-2, SR-3, SR-4, SR-5 alongwith analytical tables TBR-2, TBR-3, TBR-4 and TBR-5 clearly indicate that furniture layout flexibility is sufficient with room dimension 2.7x3.0m without sacrificing the a desired activity.

Any addition to above dimension increases the cost more, than the functional activity.

Table TBR-2

Sl. No.	Plan No.	Room size	Oneside room	Other side	Furniture layout efficiency	% saving over 2
1	RB_1	2.4x3.0	50+190	110+190	less sufficient	-11.1
2	RB_2	2.7x3.0	80+190	110+190	sufficient	± 0
3	RB_3	3.0x3.0	110+190	110+190	More than sufficient	+10

Table TBR-3

Sl. No.	Plan No.	Room size	Oneside Room	Other side	Furniture layout efficiency	% savin over 2
1	RC_1	2.4x3.0	50+190	110+190	Less sufficient	-11.1
2	RC_2	2.7x3.0	80+190	110+190	Sufficient	± 0
3	RC_3	3.0x3.0	110+190	110+190	More than sufficient	+ 10

Table TBR-4

Sl. No.	Plan No.	Room size	Oneside dim.	Other side dim	Efficiency	% saving over 2
1	RD_1	2.4x3.6	50+190	170+190	Less suffi- cient	-11.1
2	RD_2	2.7x3.6	80+190	170+190	Sufficient	± 0
3	RD_3	3.0x3.6	110+190	170+190	More than sufficient	+ 10

Table TBR-5

Sl. No.	Plan No.	Room size	Oneside dim.	Other side dim	Efficiency	% saving over 2
1	RE_1	2.4x3.6	50+190	170+190	Less suffi- cient	-11.1
2	RE_2	2.7x3.6	80+190	170+190	Sufficient	± 0
3	RE_3	3.0x3.6	110+190	170+190	More than sufficient	+ 10

Drawing Room

Activities performed in the drawing room are sitting leisurly, studying and emergency sleeping. Furniture required are one sofa set, one central table.

Space analysis has been conducted to define the optimum dimensions for drawing room by doing different furniture layout for rooms of dimension 270x300, 270x360, 300x360, 300x390 cm as shown in the figure DR-1, DR-2, DR-3, DR-4.

Inferences

1. 270x300 room can not function as drawing room as it indicates maximum circulation area as per table TDR_1, and TDR_2.
2. 300 cm as one side dimension can work as optimum dimension as per table
3. Optimum size of drawing room in low cost housing is recommended as 300x390 cm as indicated in the table TDR_2.
4. Entry along the longer side of drawing room results in more wastage of space in circulation.
5. Entry along the shorter side of room, results in maximum utilization of space as is clear from the table TDR_2.
6. In one room dwelling unit, 2.7x3.9 m size is sufficient for multipurpose uses is clear from Fig. DR-2

Table TDR_1

Sl. No.	Plan No.	Size	Area	C.A.	% utilization	% C.A.
1	DRA_1	3.6x2.7	9.72	2.16	77.7	22.3
2	DRA_2	300x2.7	11.7	1.8	77.7	22.3
3	DRC_1	3.9x3.0	11.7	2.34	80	20
4	DRC_2	3.6x3.0	10.8	2.16	80	20

Table TDR_2

Sl. No.	Plan No.	Size	Area	C.A.	% Utilization	% C.A.	% increase
1	DRB_1	2.7x3.6	9.72	1.62	83.33	16.67	5.63
2	DRB_2	2.7x3.0	8.1	1.62	80.00	2.3	20
3	DRD_1	3.0x3.9	11.7	1.8	84.6	4.6	15.4
4	DRD_2	3.0x3.6	10.8	1.8	83.33	3.33	16.67

Dining

Dining is a very important area in a house where three main activities are performed i.e. breakfast, lunch and dinner. In small dwelling units, it serves as study table also. Usually six chair dining table is preferred and also available in the market. So space should be provided accordingly. In addition some space should be left for refrigerator.

STUDY

To determine the optimum dining space, four plans have been analysed keeping the movement pattern into mind. Two main parameters which determine the dining and room size are :

1. Dinner movement
2. Service.

Figure DNR-1 indicates the furniture layout plan with different movement.

Table TDNR-1

Sl. No.	Plan No.	Size	Area	C.A.	% C.A.
1	DN_1	2.3x2.9	6.67	0	0
2	DN_2	2.7x3.3	8.91	2.24	25.1
3	DN_3	2.85x3.3	9.40	2.73	29.0
4	DN_4	3.05x3.3	10.05	3.31	32.93

Function analysis

DN-1 indicates no movement around the table

DN-2 indicates 2 sided movement

DN-3 represents three side movement

DN-4 represents four side movement

DN-2 plan showing two side movement serves equally good purpose than three or four side. It also indicates the minimum movement area.

So ON_2 serves as optimum plan for dining space. So optimum dimensions for 6 person dining room should be 2.7x3.3 m.

Kitchen

Kitchen space is governed by the shapes of working platform which are :

- U shape
- L shape

Analytical study has been conducted keeping the sizes as

150x240	150x270	150x300
180x240	180x270	180x300
210x240	210x270	210x300

for all the two shapes as shown in the figure K-1, K-2. Area wise analysis has been indicated in the table TK-1, TK-2, TK-3, TK-4, TK-5 and TK-6.

CASE-I

Table TK-1

Sl. No.	Plan No.	Area	Size	P.A.	C.A.	% P.A.	% C.A.
1	KA_1	3.6	1.5x2.4	2.2	1.4	61	39
2	KA_2	4.05	1.5x2.7	2.85	1.7	58	42
3	KA_3	4.5	1.5x3.0	2.0	55	45	

CASE-II

Table TK-2

Sl. No.	Plane No.	Area	Size	P.A.	C.A.	% P.A.	% C.A.
1	KB_1	4.32	1.8x2.4	2.5	1.82	57.8	42.1
2	KB_2	4.86	1.8x2.7	2.65	2.21	53.9	45.4
3	KB_3	5.4	1.8x3.0	2.68	2.72	49.6	50.3

CASE-III

Table TK-3

Sl. No.	Plan No.	Area	Size	P.A.	C.A.	% P.A.	% C.A.
1	KC_1	4.32	2.1x2.4	2.08	2.24	48.2	51.8
2	KC_2	5.67	2.1x2.7	2.95	2.72	52.1	47.9
3	KC_3	6.3	2.1x3.0	3.1	3.2	49.2	50.8

P.A. = Platform area

C.A. = Circulation area

CASE-IV

Table TK-4

Sl. No.	Plan No.	Area	Size	P.A.	C.A.	% P.A.	% C.A.
1	KA^1_1	3.6	1.5x2.4	1.7	1.9	47.3	52.7
2	KA^1_2	4.05	1.5x2.7	1.85	2.2	45.7	54.3
3	KA^1_3	4.5	1.5x3.0	2.0	2.5	44.5	55.5

CASE-V

Table TK-5

Sl. No.	Plan No.	Area	Size	P.A.	C.A.	% P.A.	% C.A.
1	KB^1_1	4.32	1.8x2.4	1.85	2.47		57.1
2	KB^1_2	4.86	1.8x2.7	2.0	2.86		58.8
3	KB^1_3	5.4	1.8x3.0	3.15	3.25		60.18

CASE-VI

Table TK-6

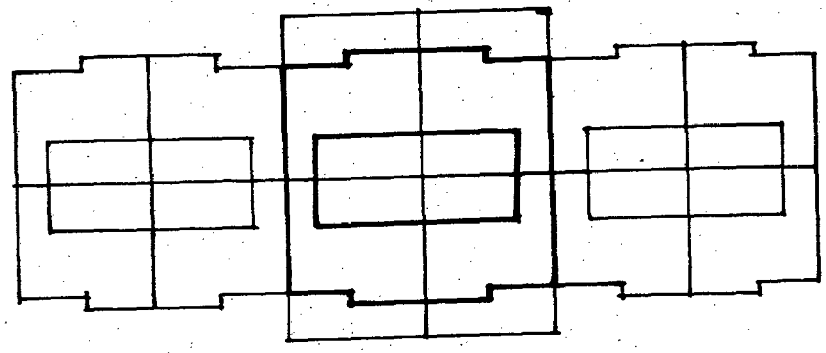
Sl. No.	Plan No.	Area	Size	P.A.	C.A.	% P.A.	% C.A.
1	KC^1_1	4.32	2.1x2.4	1.28	3.04	29.7	70.3
2	KC^1_2	5.67	2.1x2.7	2.15	3.52	37.9	62.08
3	KC^1_3	6.3	2.1x3.0	2.3	4.0	36.5	63.5

Inferences

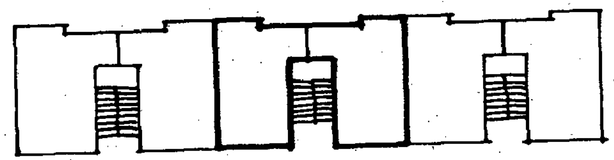
Following inferences have been drawn from the above study:

1. U shape kitchen provides more shelving area
2. Considering movement and cooking platform efficiency following optimum sizes are recommended :

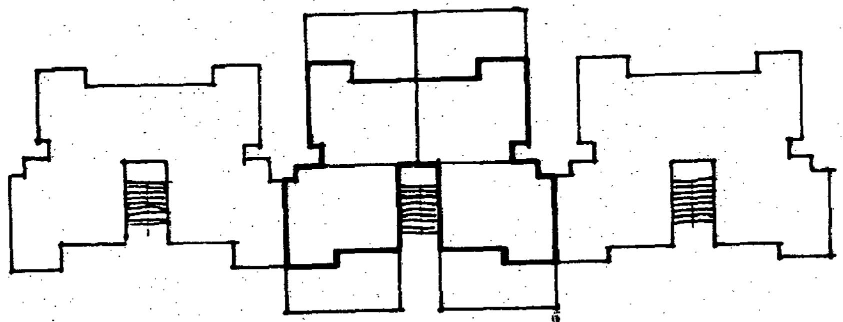
COMBINATION OF UNITS



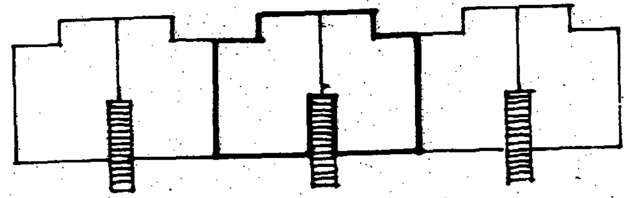
C1 % of outer common wall = 55.07



C3 % of outer common wall = 34.95



C2 % of outer common wall = 42.29



C4 % of outer common wall = 43.22

Fig CU-1

U-shape

Sl. No.	Width	Recommended optimum size	Area
1	1.5	1.5x3.0	4.5
2	1.8	1.8x2.7	4.86
3	2.1	2.1x2.4	5.04

L-shape

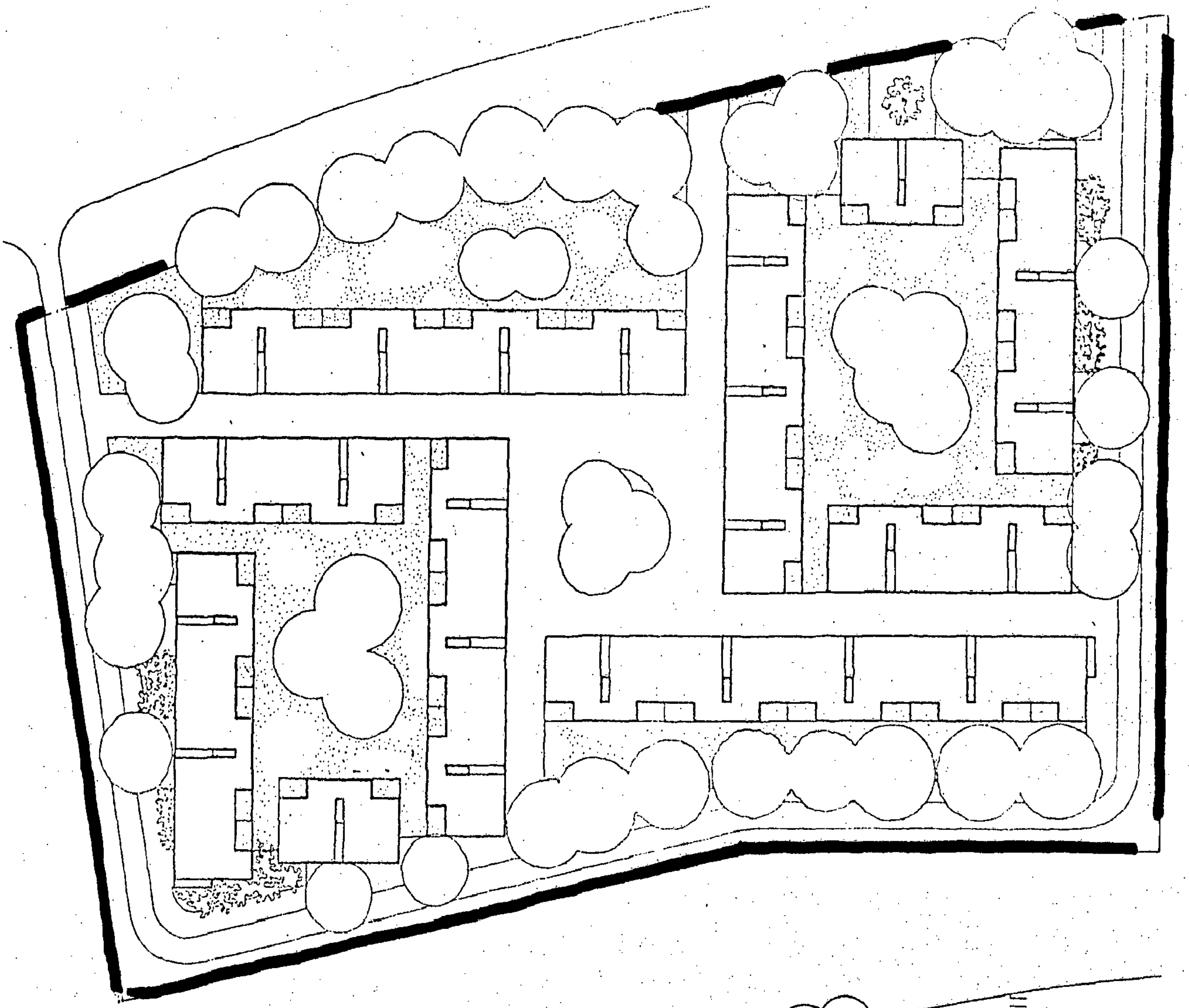
Sl. No.	Width	Recommended optimum size	Area
1	1.5	1.5x2.7	4.05
2	1.8	1.8x2.4	4.32

6.11 COMBINATION OF DWELLING UNITS

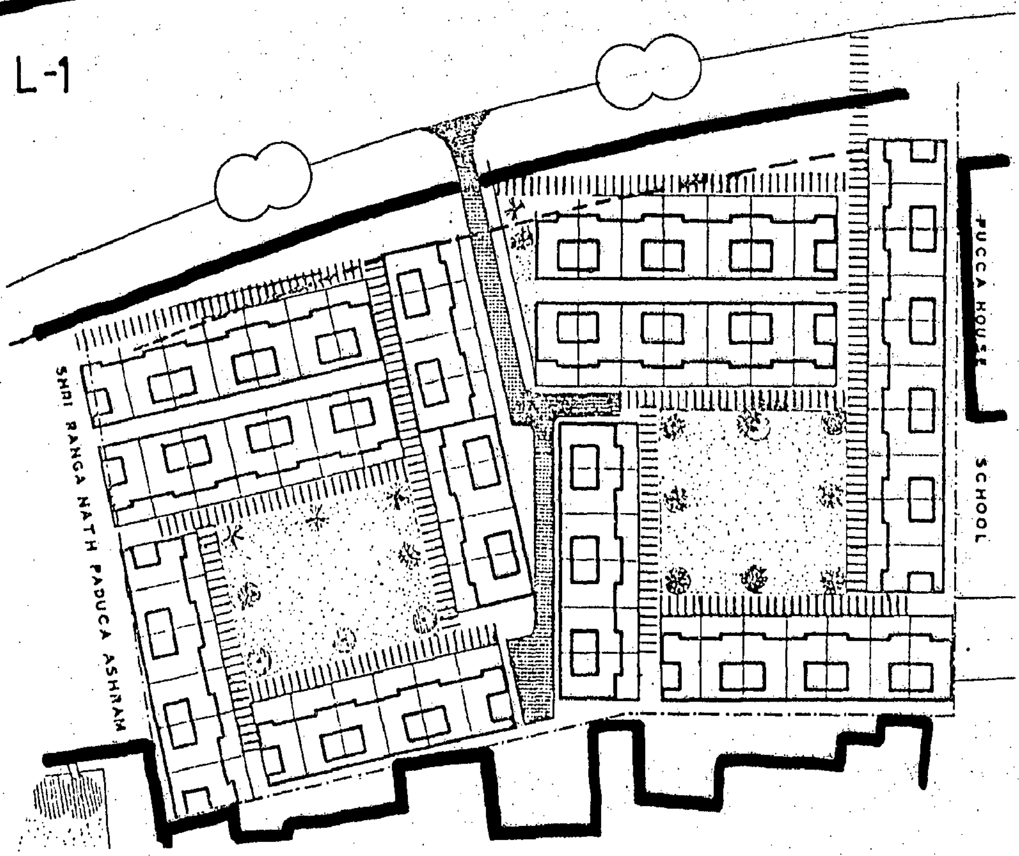
Substantial saving in material can be achieved by efficient clubbing of units as indicated in the figure (CU-1) Table TCU-1 indicates that 55 % of the total outer wall length can be commonly shared.

Table TCU-1

Sl. No.	Plan No.	Outer wall length	Common wall length	% common wall length
1	C_1	32.23	17.75	55.07
2	C_2	17.85	7.55	42.29
3	C_3	20.6	7.2	34.95
4	C_4	19.55	8.45	43.22



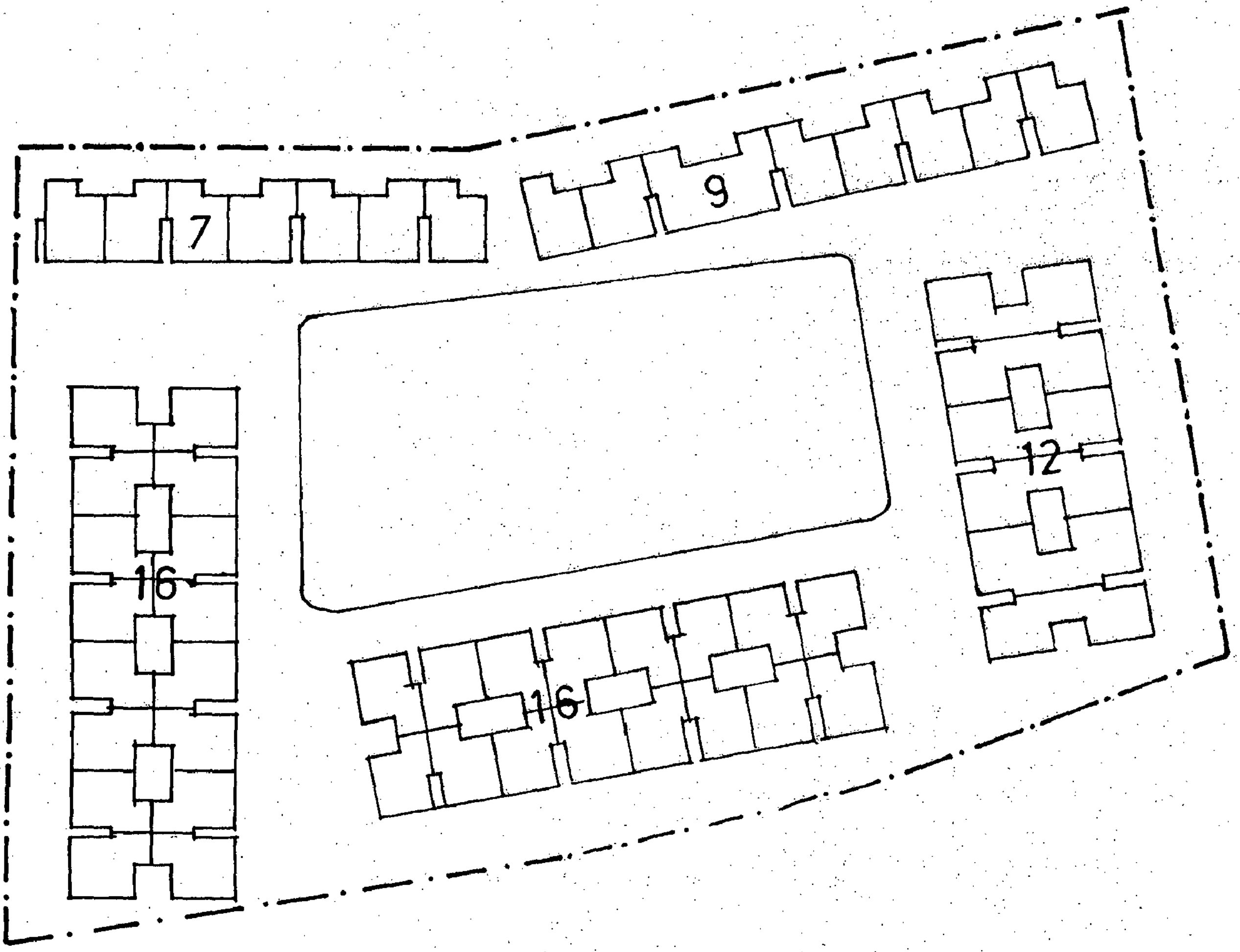
L-1



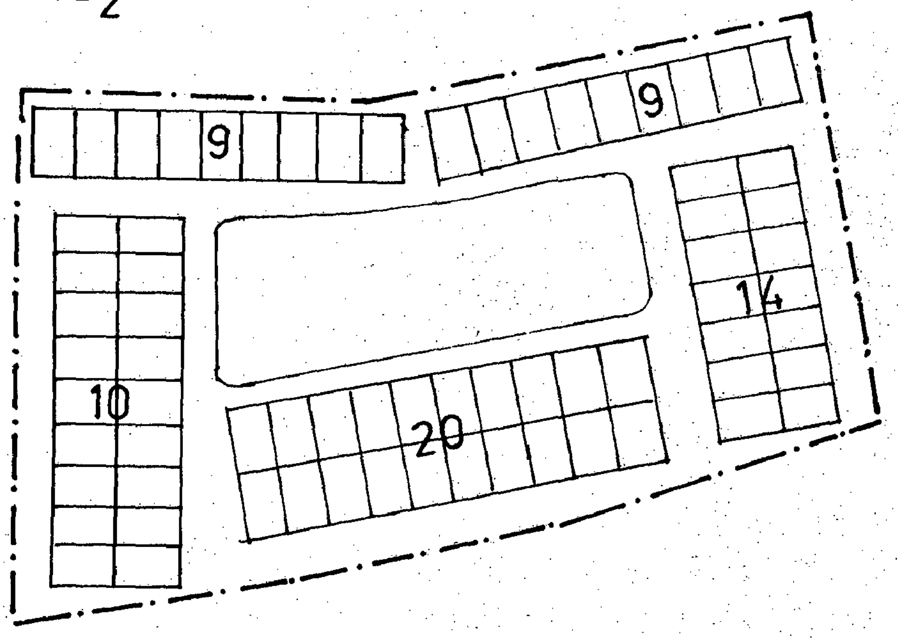
L-2

Fig L

LAY OUT PLAN



O-RL$_2$



O-RL$_1$

FIG. O-RL

6.12 LAYOUT PLANS

Two cases determined the optimum parameters for economical layout as shown in the figure L, ORL.

Table TLP-1

Sl. No.	Plan No.	No.of unshared side	Unshared length	Min. road length	No.of DU G.F.	% Road length(DU)
1	L_1	20	160	426	71	6
2	L_2	20	161	351	51	6.88

Table TLP-2

Sl. No.	Plan No.	No.of unshared side	Unshared length	Min. road length	No.of D U G.F.	% Road length(DU)	%savir wall lengtł
1	ORL_1	16	96	420	70	6	40%
2	ORL_2	16	128.8	414	60	6.9	20 %

Inferences

Following are the inferences drawn from table TLP-1 and TLP-2

1. Majority of layouts are cluster type.
2. Road length is more in cluster planning as roads are not shared.

3. Road length is more in cluster planning
3. No. of unshared sides are more resulting in more plastering, brick work.
4. As indicated in the table TLP-1 and TLP-2, 20% to 40% saving can be made by sharing walls.

6.13 DOORS AND WINDOWS

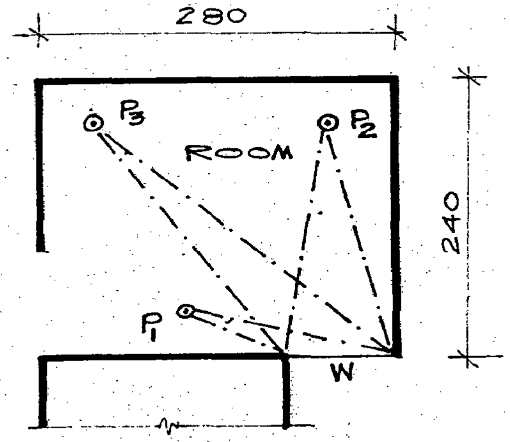
Doors and windows serve as media to distribute the light and ventilation into the building. More than 20% of the building cost is shared by this building element alone. By as much analysis has not been done in this direction, so a lot of wastage is terms of quality and quantity has been observed which is clear from the case studies. So special attention is needed on the following parameters :

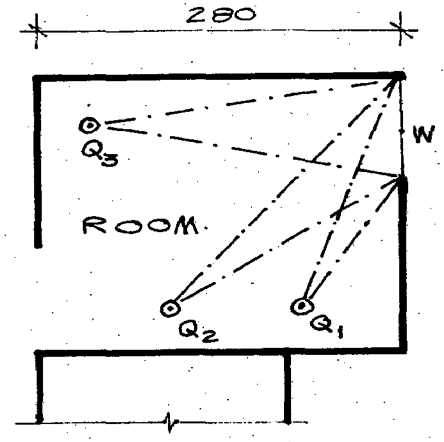
1. Opening size
2. Location
3. Frame design
4. Panel design
5. Frame section selection of material

6.13.1 Opening size and Location

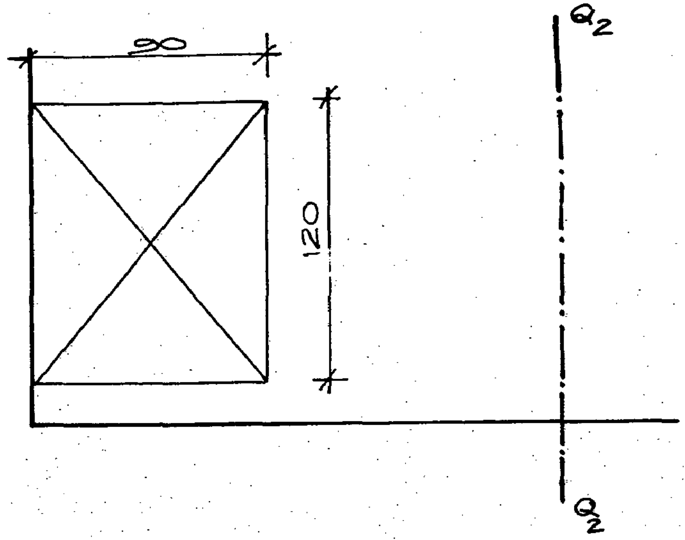
To determine the window opening size and its optimum location, lux grid method developed in the C.B.R.I., has been applied.

Analysis of the plans as shown in the figure WL_1, WL_2, WS-1 and OWS_1 alongwith tables TWS_1 and $TOWS_1$ indicate that if windows are designed as per desired illumination, saving in window area upto 20% to 40% can be achieved.



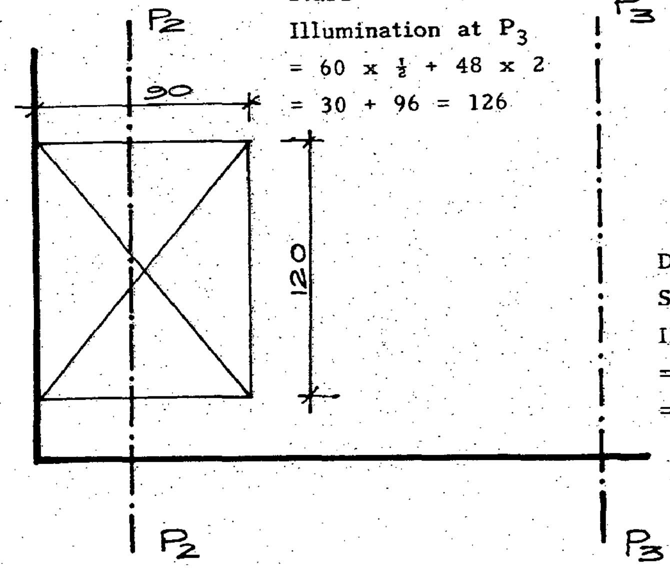


Illumination with 90 cm window

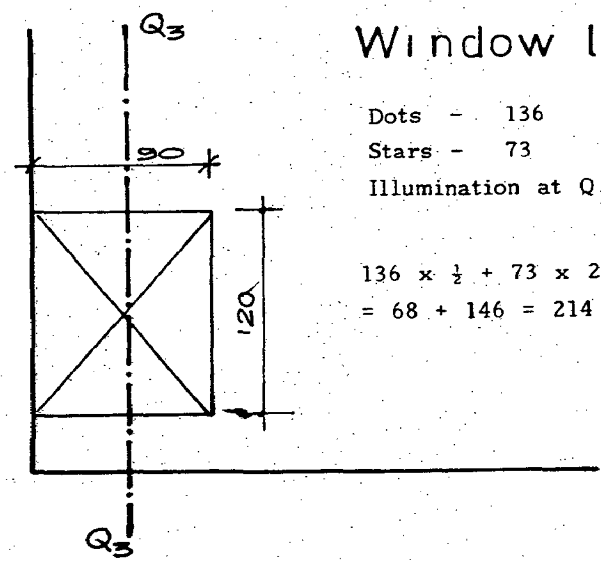


Window location.

Dots - 60
Stars - 48
Illumination at P_3
$= 60 \times \frac{1}{2} + 48 \times 2$
$= 30 + 96 = 126$



Dots - 128
Stars - 70
Illumination at P_2
$= 128 \times \frac{1}{2} + 70 \times 2$
$= 64 + 140 = 204$ Lux

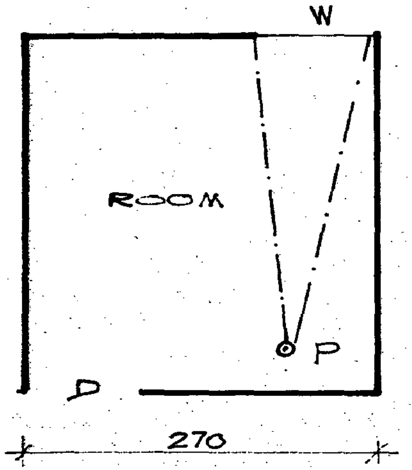


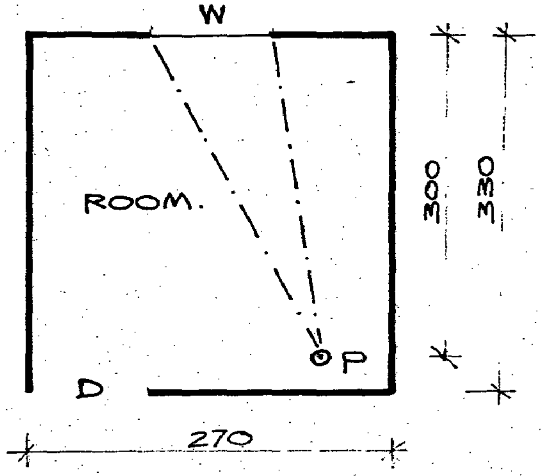
Dots - 136
Stars - 73
Illumination at Q_3

$136 \times \frac{1}{2} + 73 \times 2$
$= 68 + 146 = 214$ Lux

FIG. WL-1

Window Location.



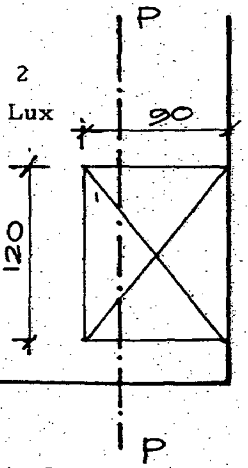


Dot - 84
Stars - 48

Illumination at p =
84 x ½ + 48 x 2
= 42 + 96 = 138 Lux

Dot - 84
Stars - 48

Illumination
= 84 x ½ + 48 x 2
= 42 + 96 = 138 Lux



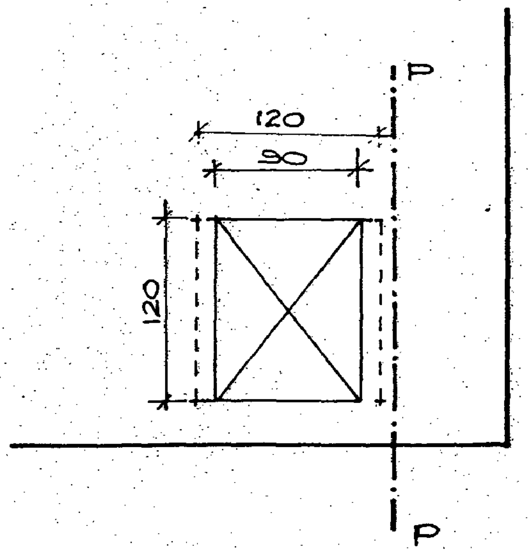


FIG.WL-2

Illumination with 120 cm window
138 + 46 = 184 Lux

Dots = 28
Stars = 16

Increase in illumination
28 x ½ + 16 x 2 = 14 + 32 = 46

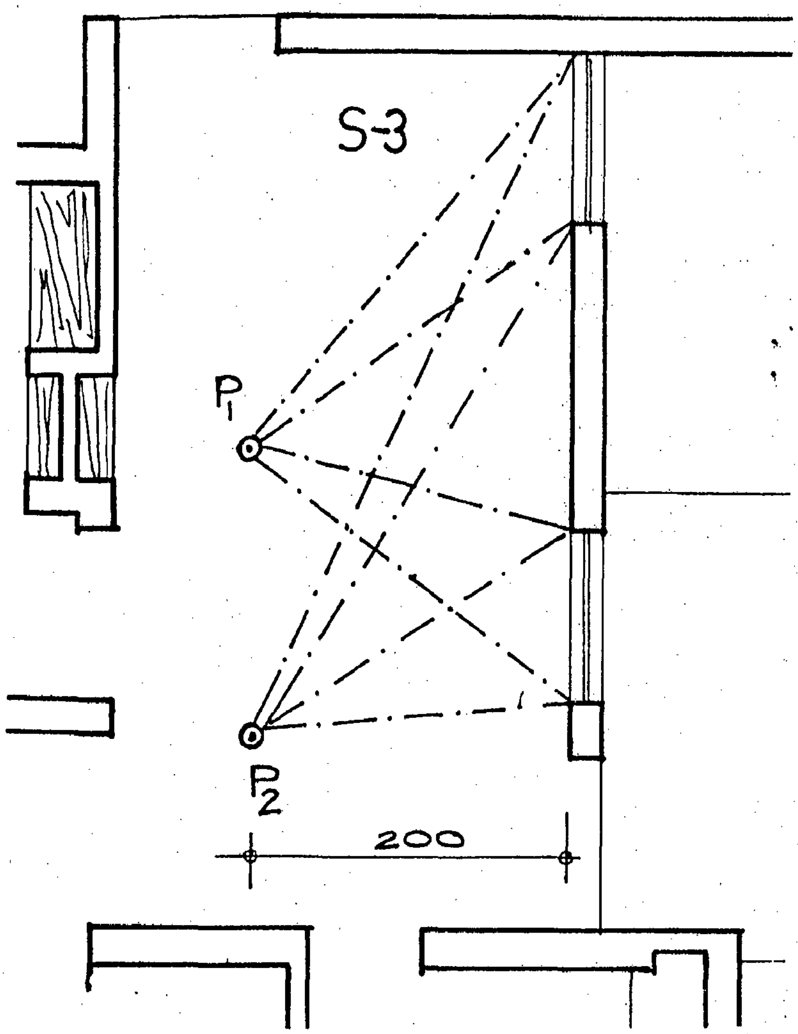
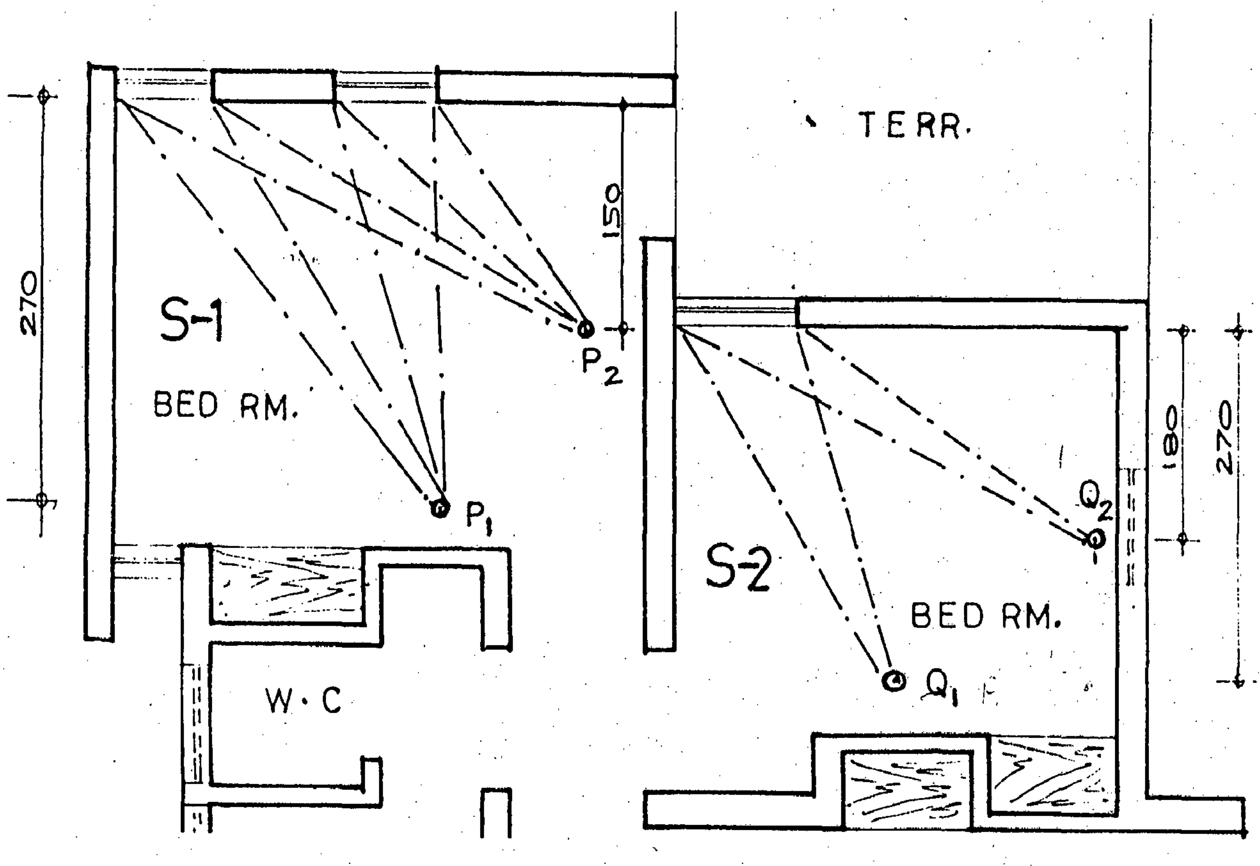
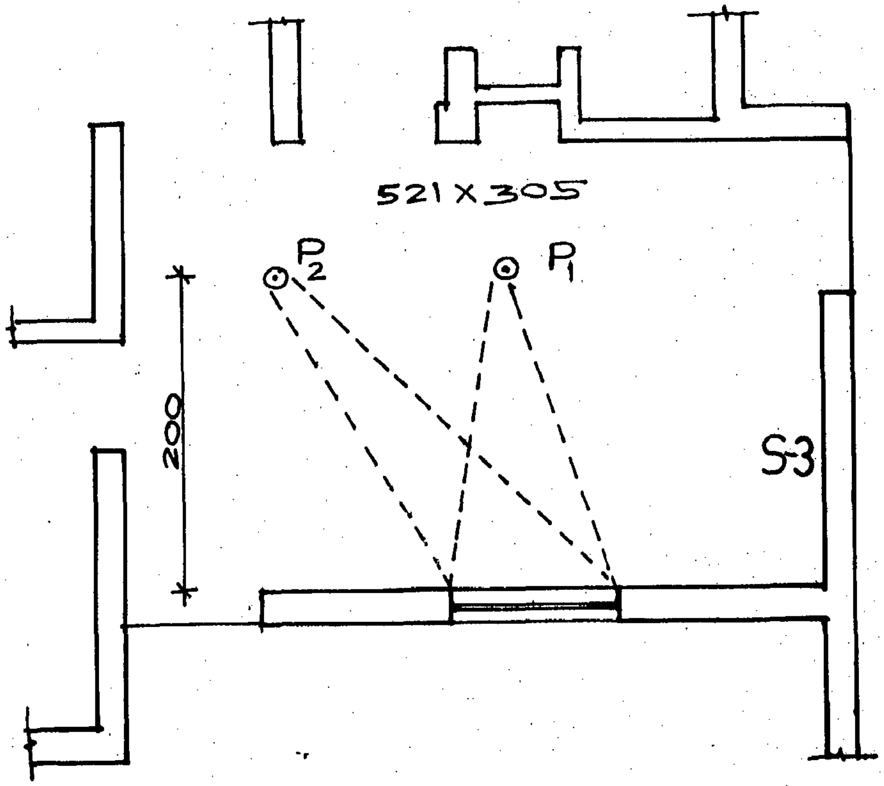


fig WS-1




521 X 305
P2
P1
200
S-3

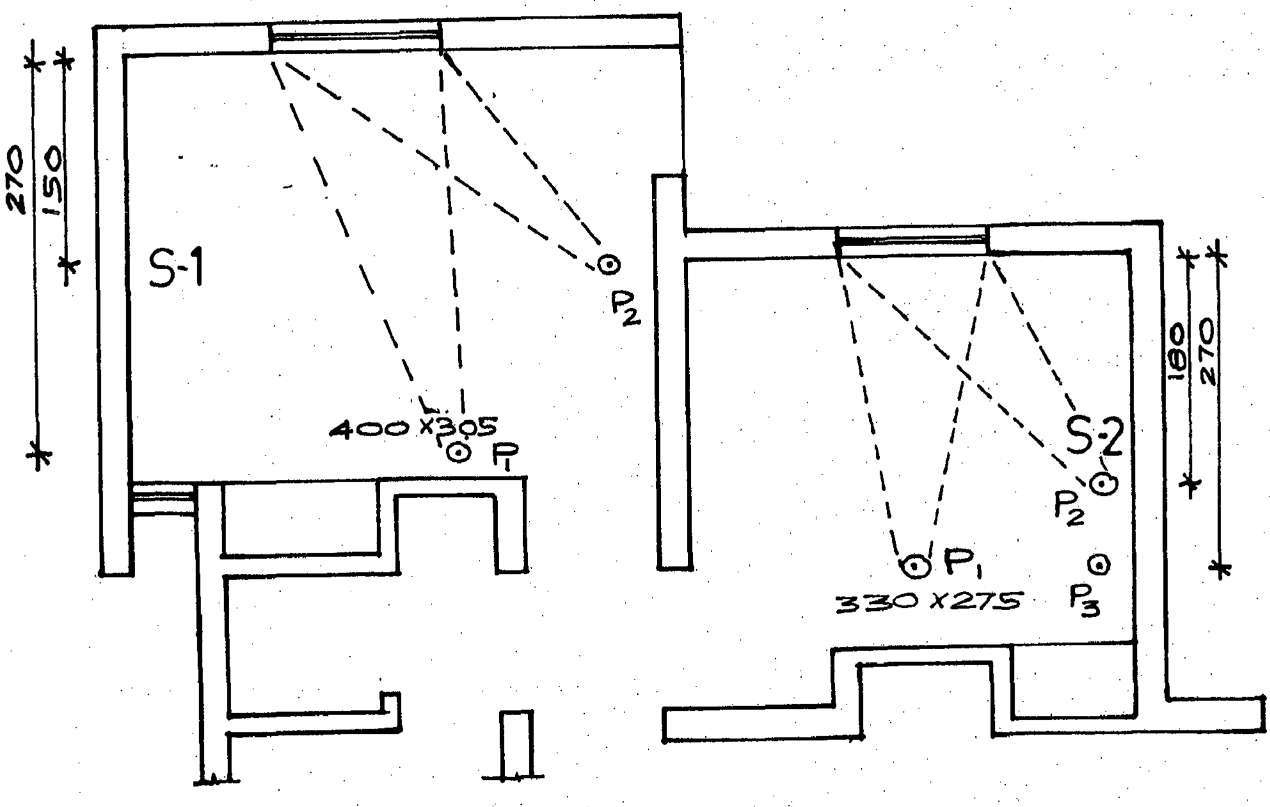
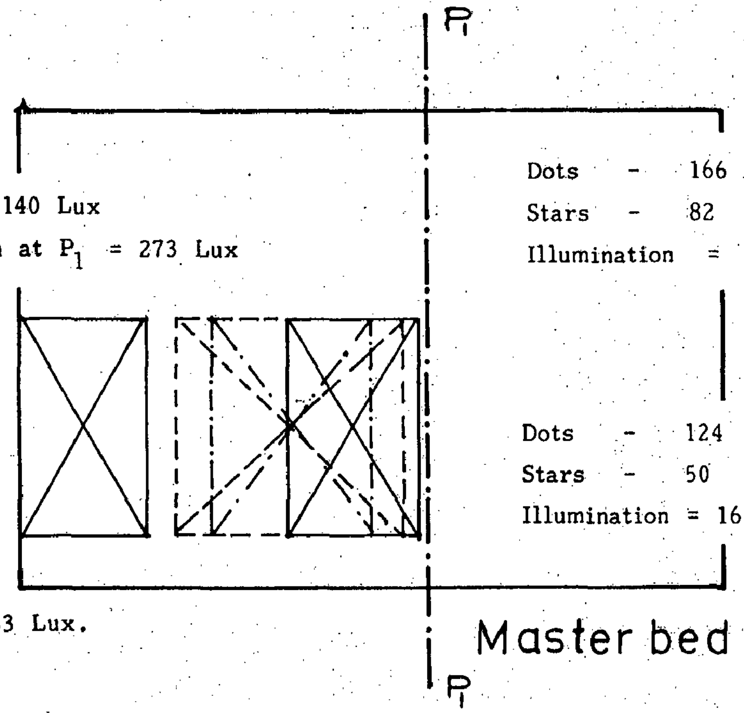

270
150
S-1
P2
400 X 305
P1
180
270
S-2
P2
P1
330 X 275
P3

fig - OWS-1

Dots - 101
Stars - 45
Illumination = 140 Lux
Total Illumination at P_1 = 273 Lux

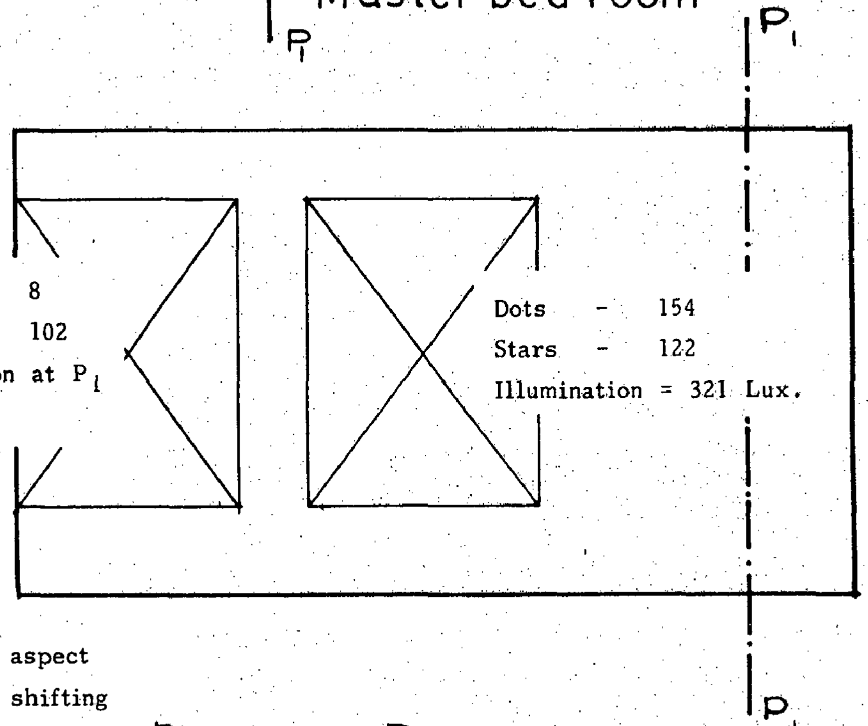
Dots - 166
Stars - 82
Illumination = 247 Lux



Dots - 124
Stars - 50
Illumination = 162 Lux

Dots - 50
Stars - 54
Illumination = 133 Lux.

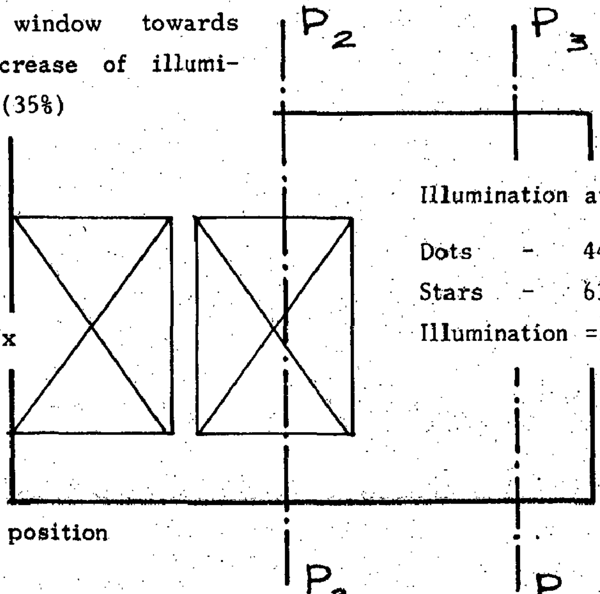
Master bed room



Dots - 8
Stars - 102
Illumination at P_1
208 Lux.

Dots - 154
Stars - 122
Illumination = 321 Lux.

This shows that locational aspect is very important. Simply by shifting the location of window towards centre there is increase of illumination by 113 Lux. (35%)



Small bed room
Fig WS-1

Illumination at P_2
Dots - 102
Stars - 63
Illumination = 171 Lux

Illumination at P_3
Dots - 44
Stars - 63
Illumination = 148 Lux

Illumination at P_2
with shifted window position
Dots - 122
Stars - 63
Illumination = 187 Lux

WINDOW SIZE

Table TWS_1

Sl. No.	Plan No.	Window Size	No.	Total opening area m^2	Location	Illumination at P_1	Desirable for study	Excess
1	S_1	75x120	2	1.8	Per plan	273 lux	150	123
2	S_2	90x120	1	1.08	''	208	150	58
3	S_3	105x120	2	2.52	''	658	150	508

Table $TOWS_1$

Sl. No.	Plan No.	Size	No.	Total opening area m^2	Location	Illumination at P_1	Desirable for study	Saving
1	S_1	120x120	1	1.44	per plan	162 lux	150	20 %
2	S_2	90x120	1	1.08	''	321	150	-
3	S_3	120x120	1	1.44	''	192	150	42.85 %

6.13.2 Frame Design

To determine the optimum frame design, following factors have been considered :

1. Length of the frame
2. Wooden section adopted.

DOOR FRAME

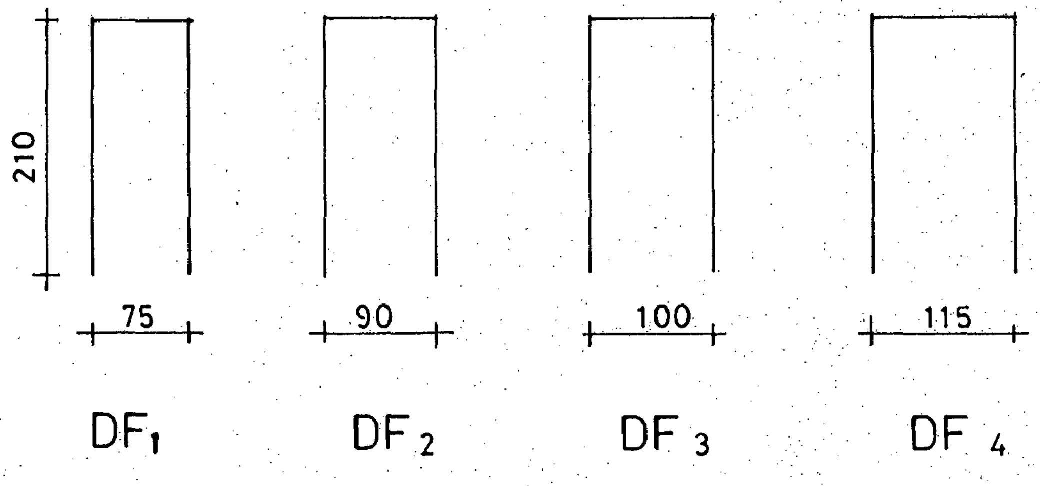


FIG. DF_1

WINDOW FRAME

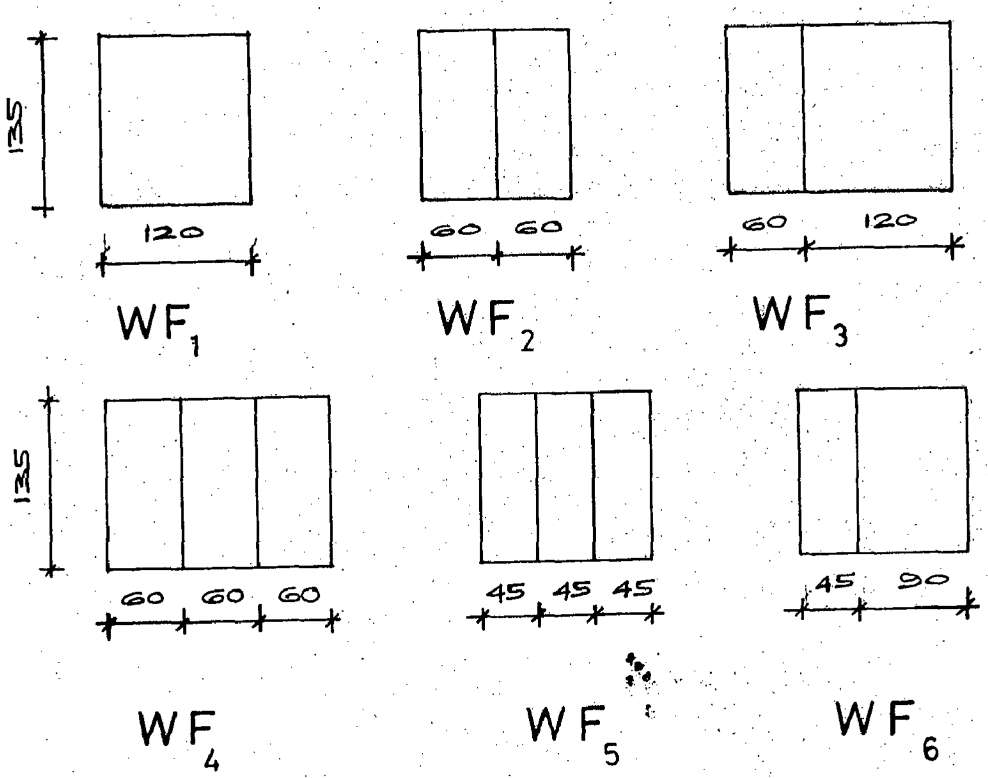
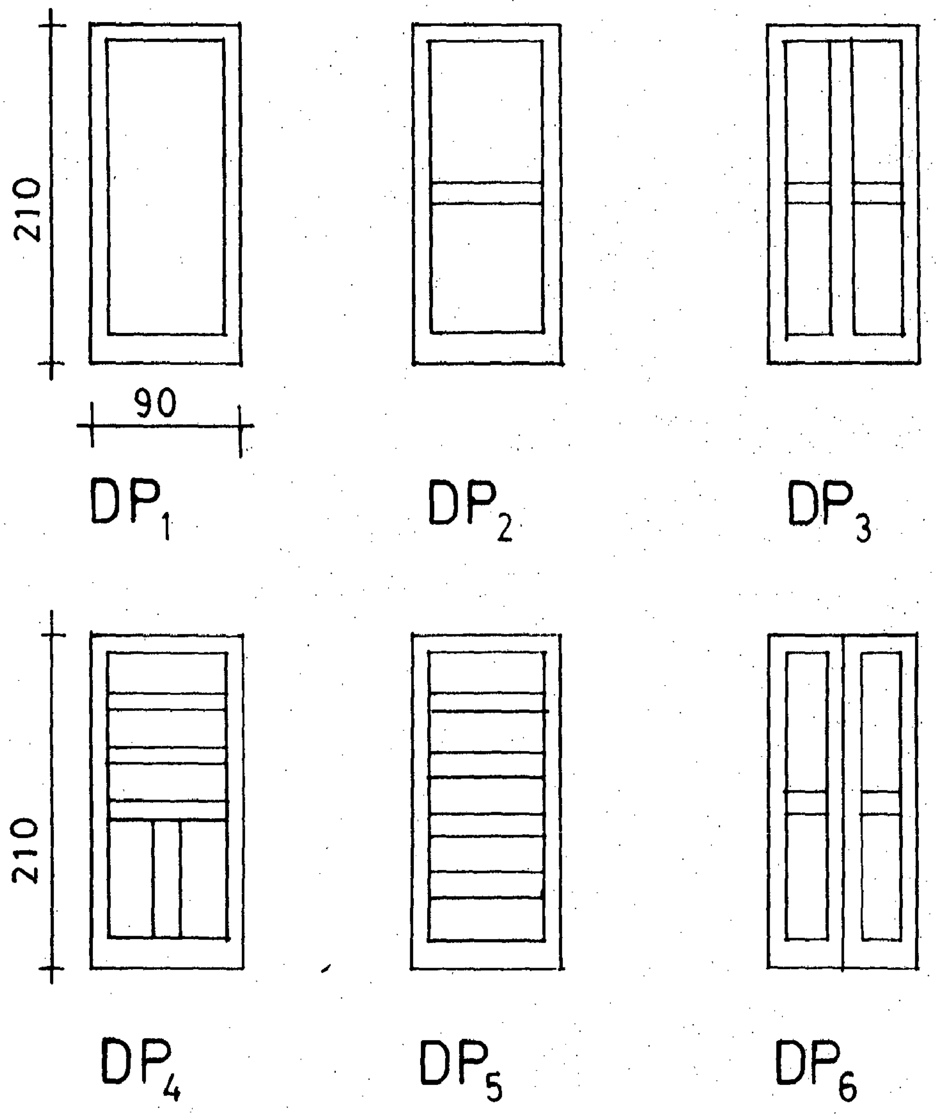


FIG. WF

DOOR PANEL DESIGN



WOOD SEC. 10 x 4cm.

FIG. DP-1

WINDOW PANEL DESIGN

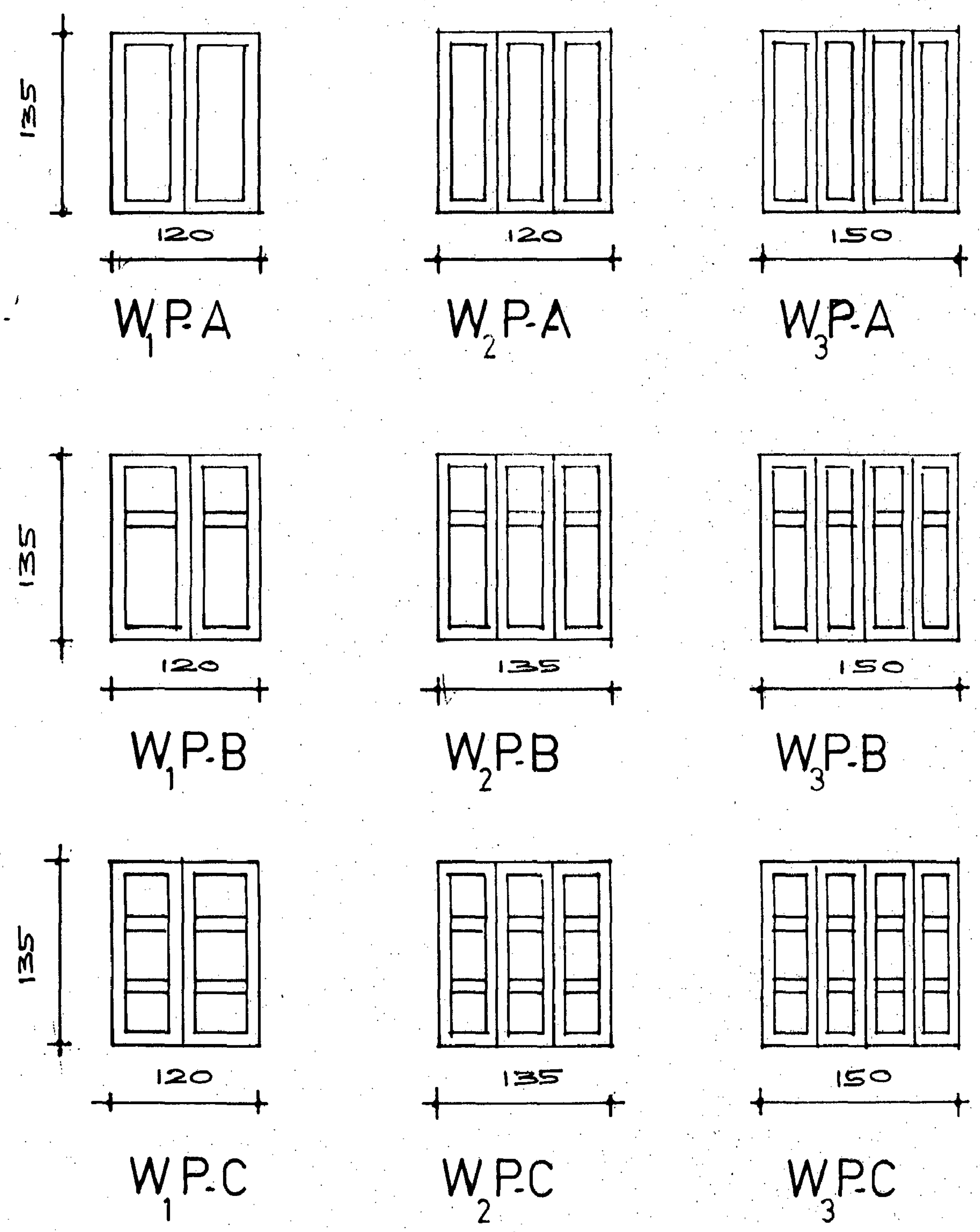


FIG. WP-1

WINDOW PANEL SIZE

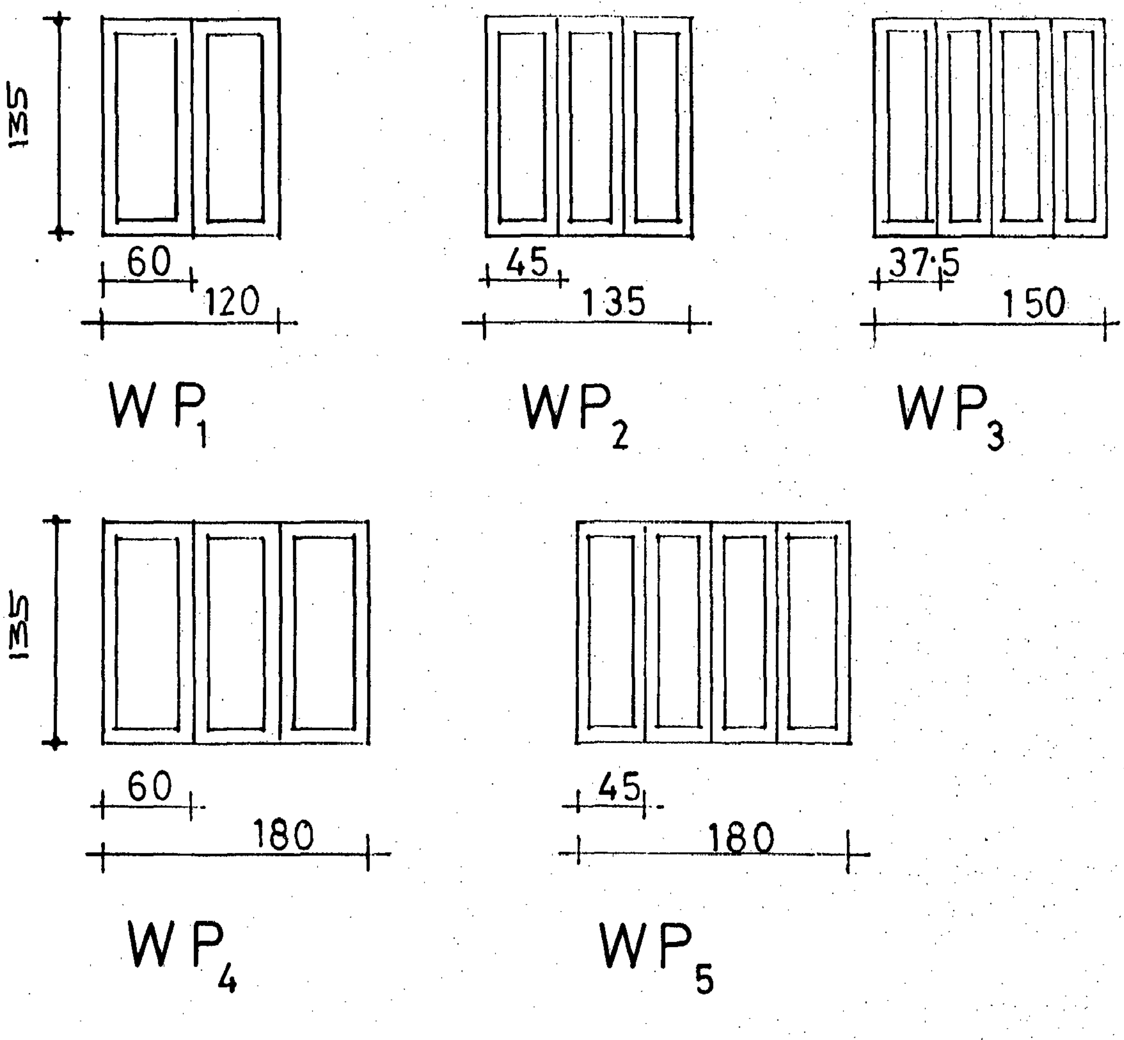
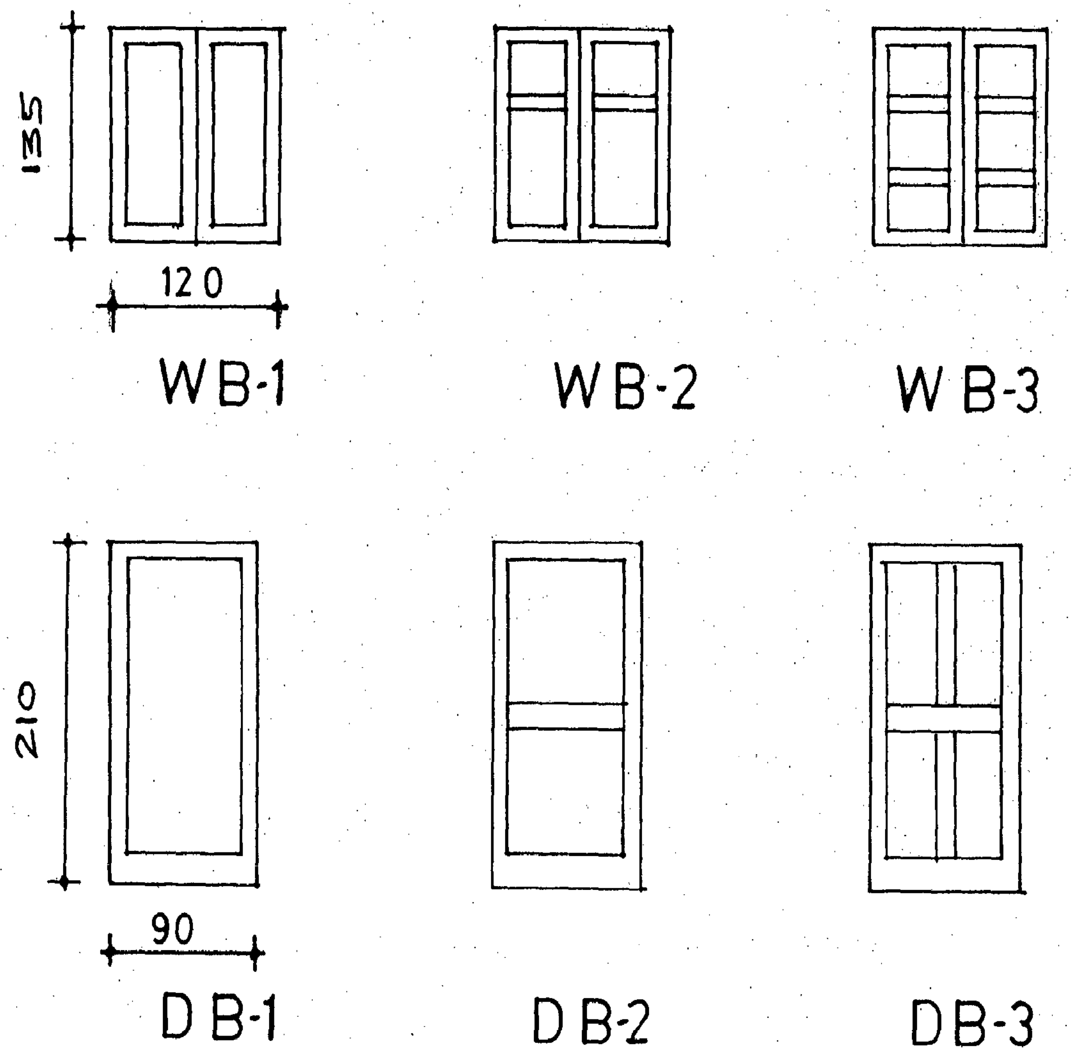


FIG. WP-2

DOOR-WINDOW BEADING



FIG· DWB-1

SEC· SIZE
7.5 ×4.0

Analysis has been done with different sizes of frames for doors and windows as shown in the figure DF and fig WF.

Length of frame and wooden quantity calculated as indicated in the table TDF_1 and TWF_1 clearly shows that saving upto 40 % to 58 % can be achieved by adopting suitable design without sacrificing the function of door.

The study shows that 90 cms width of the door does not obstructs the entry of scooter, furniture resulting in substantial saving. More than 90 cms width in low cost houses is undesirable as it will simply increase the cost.

Similarly adopting the frame design for window with minimum frame length, saving upto 40% can be done. For one room and two room dwelling units, 45 cms width module with no intermediate division upto 90 cms window width is recommended dwelling units, 60 cms module with no intermediate division upto 120 cms is recommended.

Table TDF-1

Sl. No.	Frame No.	Size	Design	Frame length	Wood Consumption	% increase over (1)
1	DF_1	0.075x2.1	as/fig	4.95	0.0386	-
2	DF_2	0.9x2.1	''	5.1	0.0397	2.9
3	DF_3	1.0x2.1	''	5.2	0.0405	4.8
4	DF_4	1.15x2.1	''	5.35	0.0417	7.4

Sect. 12.5x6.25

Table TWF-1

Sl. No.	Frame No.	Size	Window Area	Design	Frame length	Wood consump-tion	% incre. over (1.
1	WF_1	1.2x1.35	1.62	as/fig	5.1	0.0397	-
2	WF_2	1.2x1.35	1.62	''	6.45	0.053	20.9
3	WF_3	1.8x1.35	2.43	''	7.65	0.0596	33.3
4	WF_4	1.8x1.35	2.43	''	9	0.0702	43.3
5	WF_5	1.35x1.35	1.75	''	8.1	0.0631	58.8
6	WF_6	1.35x1.35	1.75	''	6.75	0.0526	24.4

6.13.2 Panel Design

The panel design of door and window depends upon following factors :

1. No. of leaf in the sutter
2. No. of divisions in the panel
3. Section size.

Analysis has been carried out to determine the optimum design of panel keeping the light, ventilation and cost factor into mind, as shown in the figure DP_1 and fig. WP_1, WP_2.

Table TDP-1, TWP-1, TWP-2, TWP-3, TWP-4, TWP-5 gives following inferences :

1. Post of panel is directly proportional to the no. of division in the window width.

2. Cost of door panel varies from size to size and saving in wood upto 30% can be achieved by adopting proper size.

3. Minimum the no. of leaf in the door/window, less will be the cost and substantial saving can be derived.

4. If single leaf window is to be provided, optimum width shall be 60 cm, for double leaf 90 cms with no middle member.

5. Single leaf door panel is economical than double leaf panel.

6. Design of door and window panel with one horizontal member is recommended as optimum one from cost consideration.

7. Door with many intermediate members is the costliest.

8. No. of intermediate members not only increases the quantity of wood but also increases the length of beading thus making it further costly as shown in table TDWB-1.

Window panel

Table TDP-1

Sl. No.	Panel No.	Size	Design	Wood Consumption	% increase over (1)
1	DP_1	90x210	as per fig.	0.072	
2	DP_2	''	''	0.0828	13
3	DP_3	''	''	0.0936	23
4	DP_4	''	''	0.1044	31
5	DP_5	''	''	0.108	33
6	DP_6	''	''	0.084	143

Window panel

Table TWP-1

Sl. No.	Panel No.	Size	Design	Wood Consumption	% increase over (1)
1	W_1PA	1.2x1.35	as/fig	0.0216	-
2	W_1PB	''	''	0.0243	11.1
3	W_1PC	''	''	0.027	20

Table TWP-2

Sl. No.	Panel No.	Size	Design	Wood Consumption	% increase over (1)
1	W_2PA	1.5x1.35	as/fig	0.0288	-
2	W_2PB	''	''	0.0310	7.24
3	W_2PC	''	''	0.0333	13.5

Table TWP-3

Sl. No.	Panel No.	Size	Design	Wood Consumption	% increase over (1)
1	W_3PA	1.5x1.35	as/fig	0.0366	-
2	W_3PB	''	''	0.0387	5.4
3	W_3PC	''	''	0.0408	10.29

Window Panel

Table TWP-4

Sl. No.	Panel No.	Size	Design	Wood Consumption	% increase over (1)
1	W_1PA	1.2x1.35	as/fig	0.0216	-
2	W_2PA	1.35x1.35	''	0.0288	25
3	W_3PA	1.5x1.35	''	0.0366	40.9

Table TWP-5

Sl. No.	Panel No.	Size	Area M^2	Design	Wood Consumption	% increase over (1)
1	WP_1	1.2x1.35	1.6	as/ design	0.0216	-
2	WP_2	1.35x1.35	1.8	''	0.0288	25
3	WP_3	1.5x1.35	2.02	''	0.0366	40.9
4	WP_4	1.8x1.35	2.4	''	0.0324	33.3
5	WP_5	1.8x1.35	2.4	''	0.0396	45.45

6.14 MISCELLANEOUS ELEMENTS

There are many miscellaneous elements which has substantial bearing on cost especially in low cost housing where cost reduction through each parameter matters.

Some of the elements are :

1. Wall projections
2. Roof projections
3. Parapet wall/railing design
4. Size of sun projection and facia on it
5. Design and size of cupboard
6. Internal and external finishing on wall
7. Grill design
8. Length and design of compound wall
9. Painting work on wood and iron work.

Survey of houses constructed by different agencies shows that substantial amount of money is spent on these elements for aesthetic reasons. So there is a need for check on it.

General analysis of these elements indicate that sufficient economy can be achieved by deleting undesirable elements. The figure WPN-1, RJN-1, SSN-1, CN-1, BW-1 clearly demonstrqte the possibility of optimisation of these elements.

Following inferences can be drawn from this.

1. Wall projections outside the building increase the wall length, thus affect the cost.

2. Cantilever roof projections and double projections should be avoided.

3. Simple brick parapet is economical than R.C.C. railing or steel railing.

4. Facia width in the case of one room and two room dwelling units should be restricted to 45 cm.

5. Brick facia over the sun shade should be avoided as it will not only increase cost but can also invite dampness inside the building due to water blockade.

6.15 SERVICES

About 15 % of total cost of building goes in services. This percentage can be brought down if the elements affecting the cost are optimized.

Services are of two types :

1. Sanitary and water supply
2. Electrical.

Sanitary and Water supply

About 8 to 9 % cost is consumed by this. Cost of sanitary and water supply is governed by two factors :

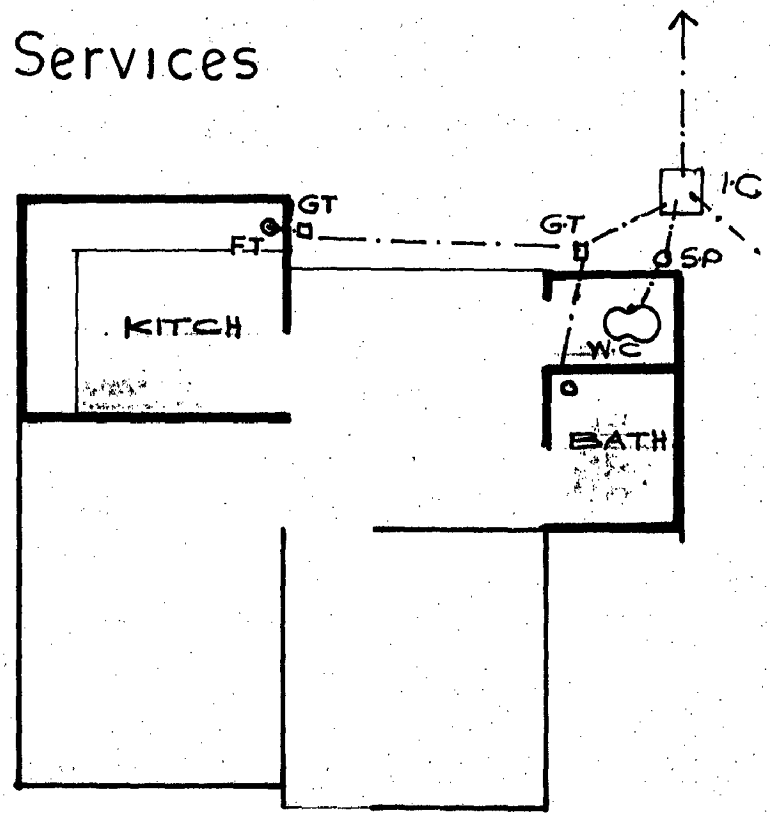
1. Centralisation of internal and external services.
2. Length of pipe length.

To determine the optimum parameters for sanitation and water supply four plans PS_1, PS_2, PS_3, PS_4 have been analysed.

From the table TS_1 following inferences can be drawn :

1. Centralisation of external services reduces the no. of inspection chamber.
2. Centralization of internal services reduces the length of S.P. and waster water pipe and no. of gulley traps.

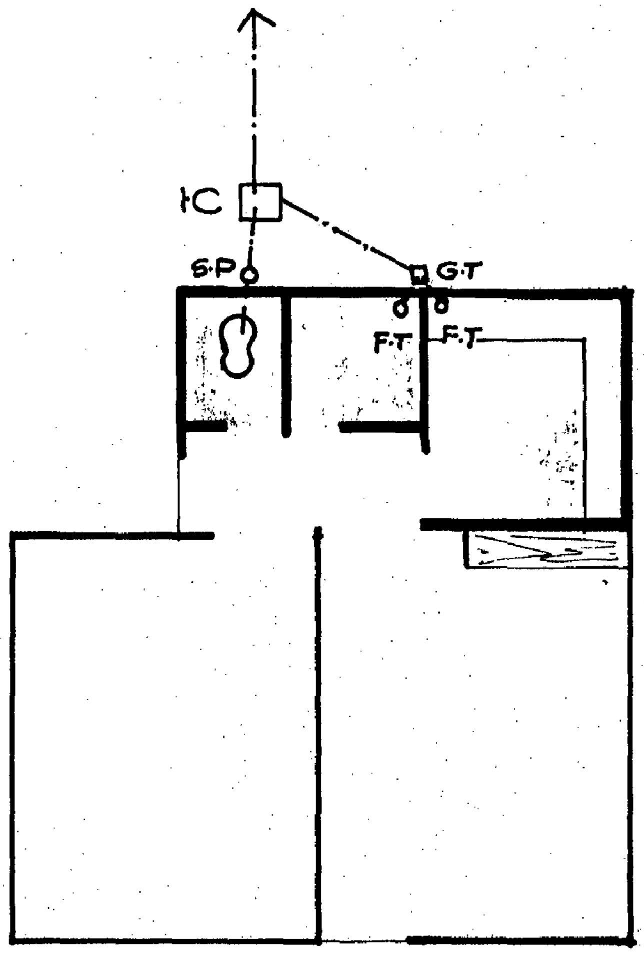
Services



PS-1

ANALYSIS

- No. of floor traps - 2
- No. of G.T. - 1
- Length of waste pipe - more
- 2 W.C. can be connected with one S.P. and one I.C.
- Requires more G.I. waste water pipe length due to distant location of bath and kitchen.

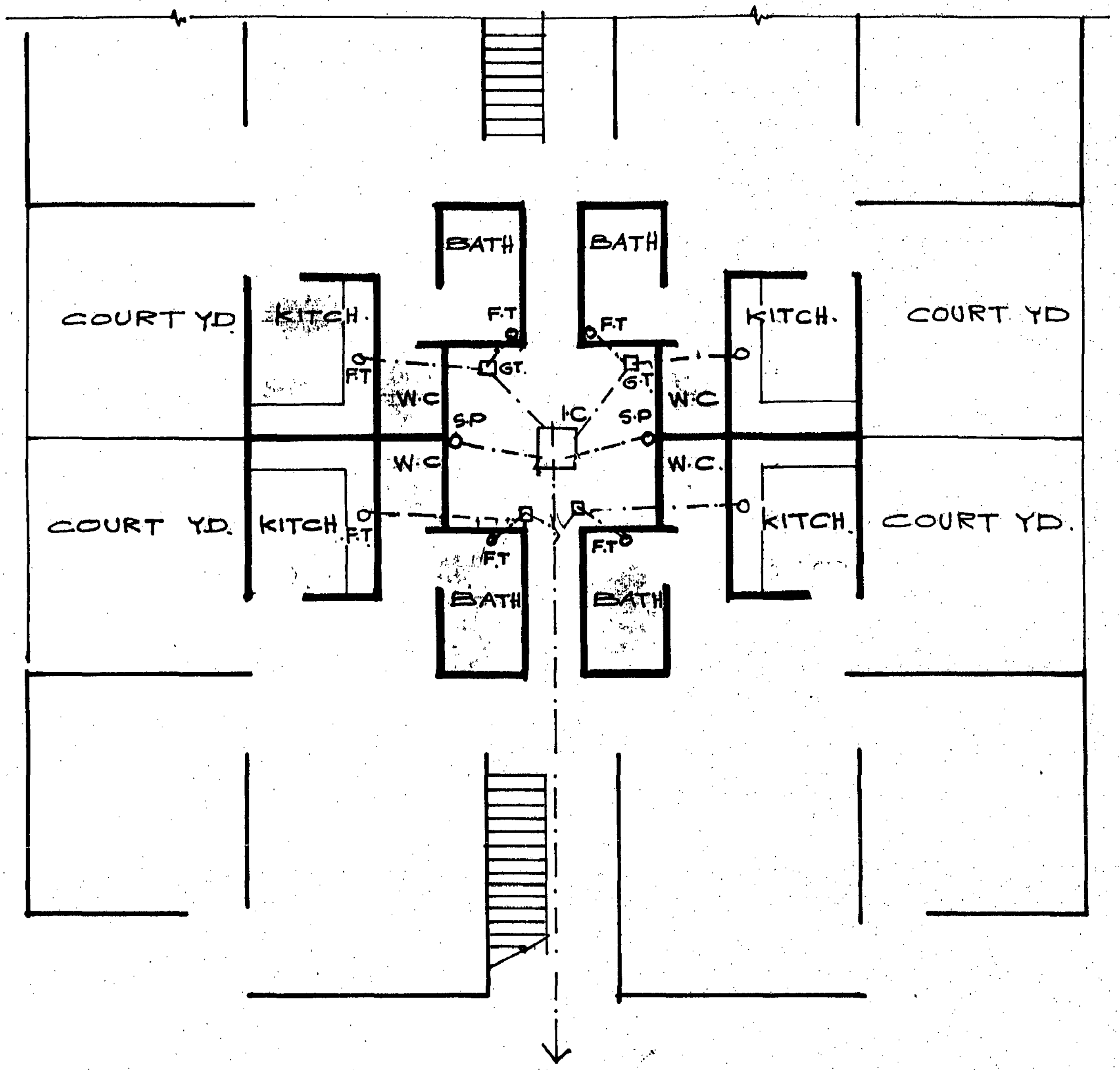


Services

ANALYSIS

- No. of F.T. - 2
- No. of G.T. - 1
- Length of W.P. - Less
- Location of W.C. is such that one I.C. can not be connected with more than one W.C.

PS-2



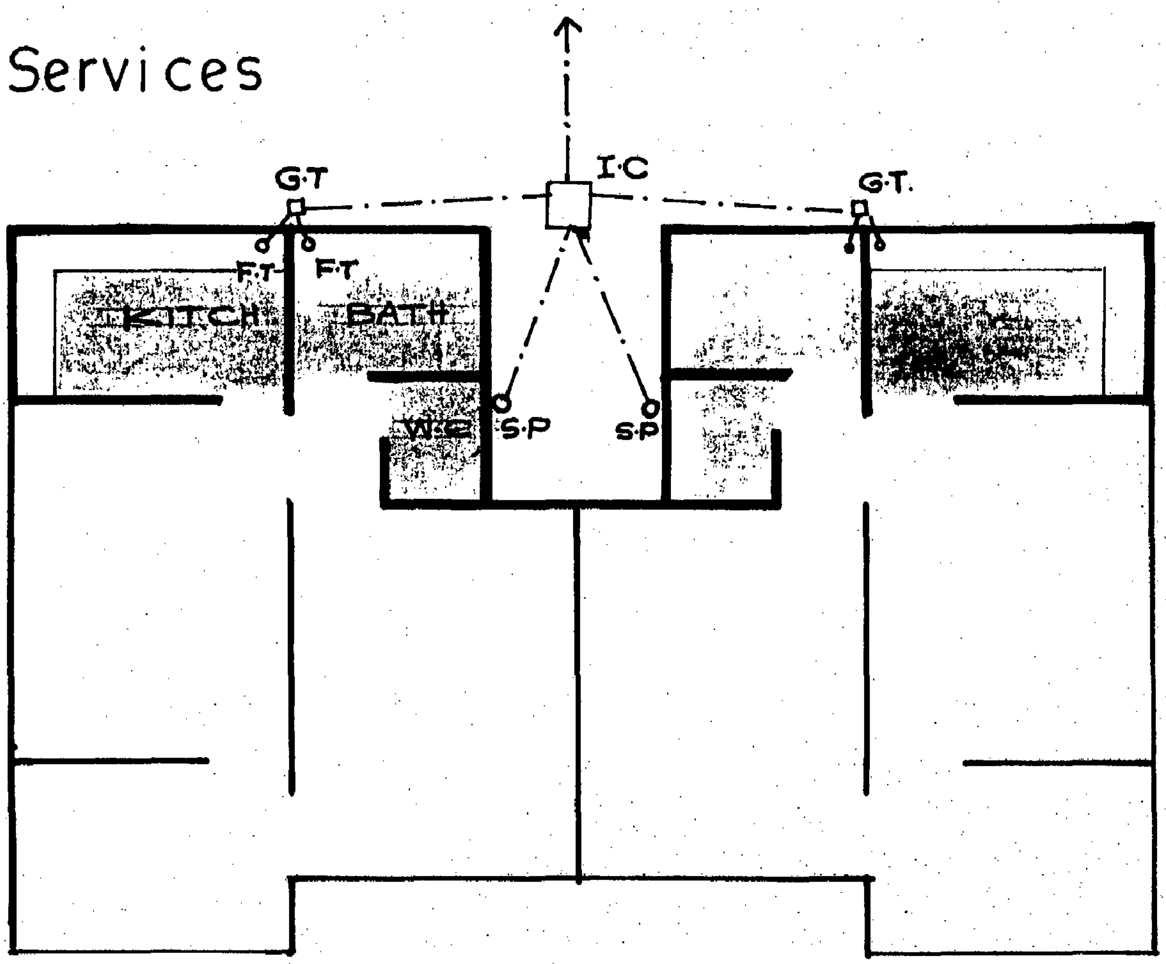
Services

ANALYSIS

- No. of soil vent - 2
- No. of F.T. - 4
- No. of G.T. - 1
- Length of S.P. - Less
- Length of W.P. - Less

PS-3

Services

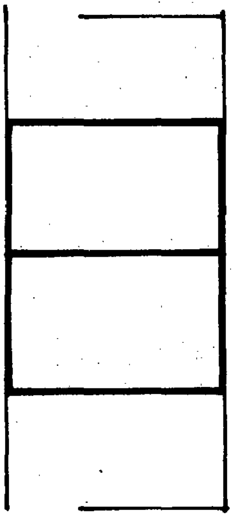


ANALYSIS

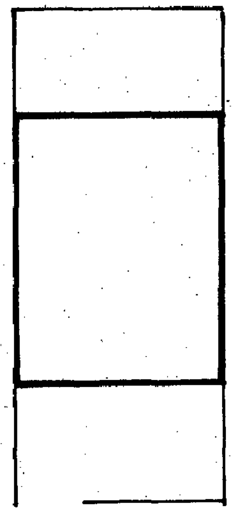
- No of soil pipe vent - 2
- No of floor traps - 4
- No of G.T. - 2
- Length of soil pipe - more
- Length of waste pipe - more

PS-4

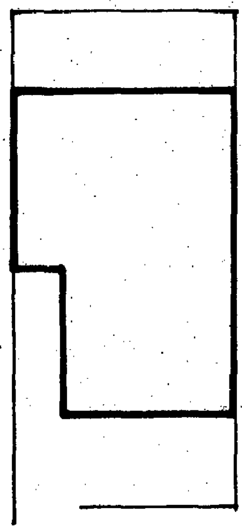
BOUNDARY WALL



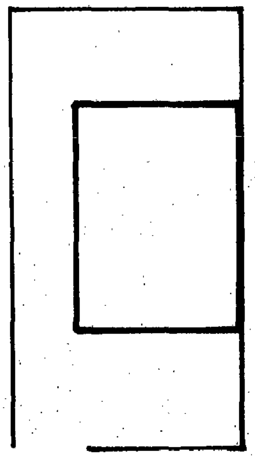
bw-1



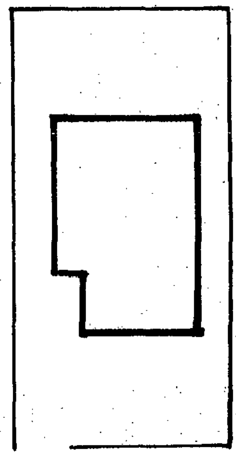
bw-2



bw-3

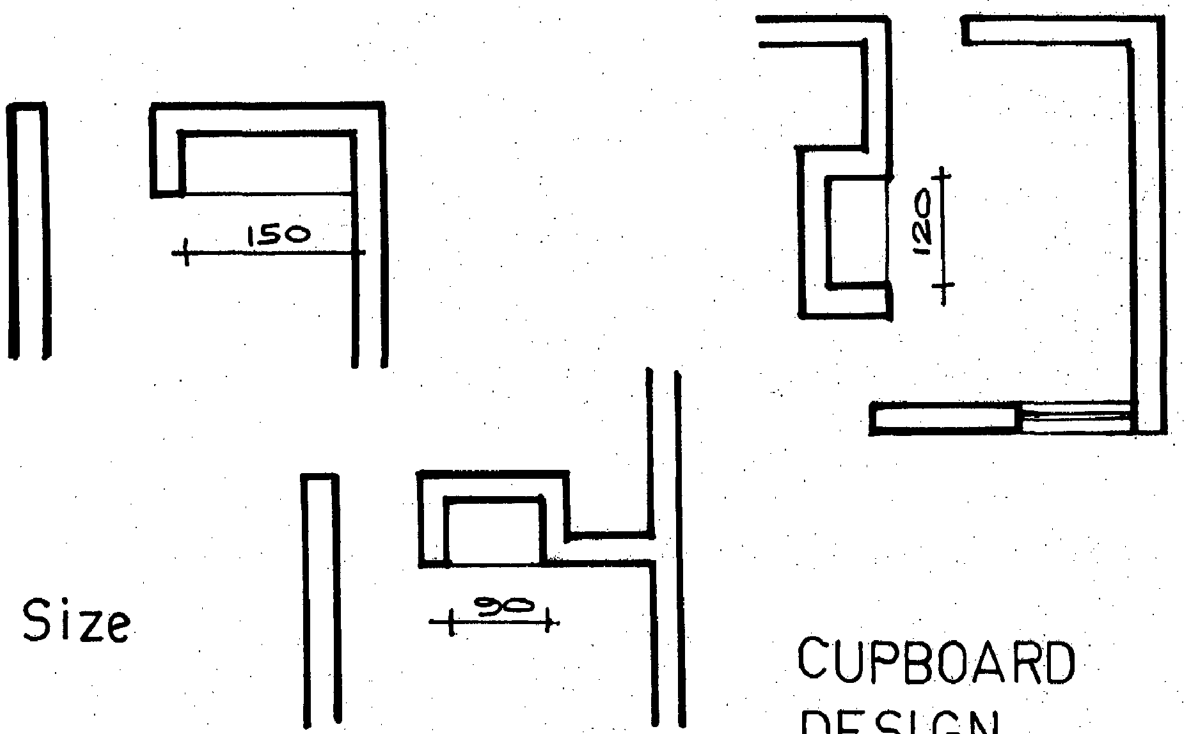


bw-4



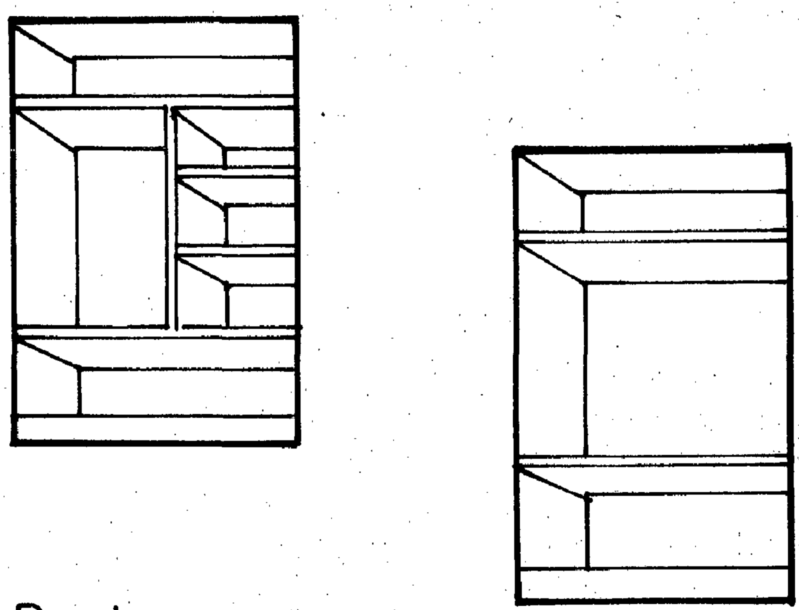
bw-5

fig - bw-1



Size

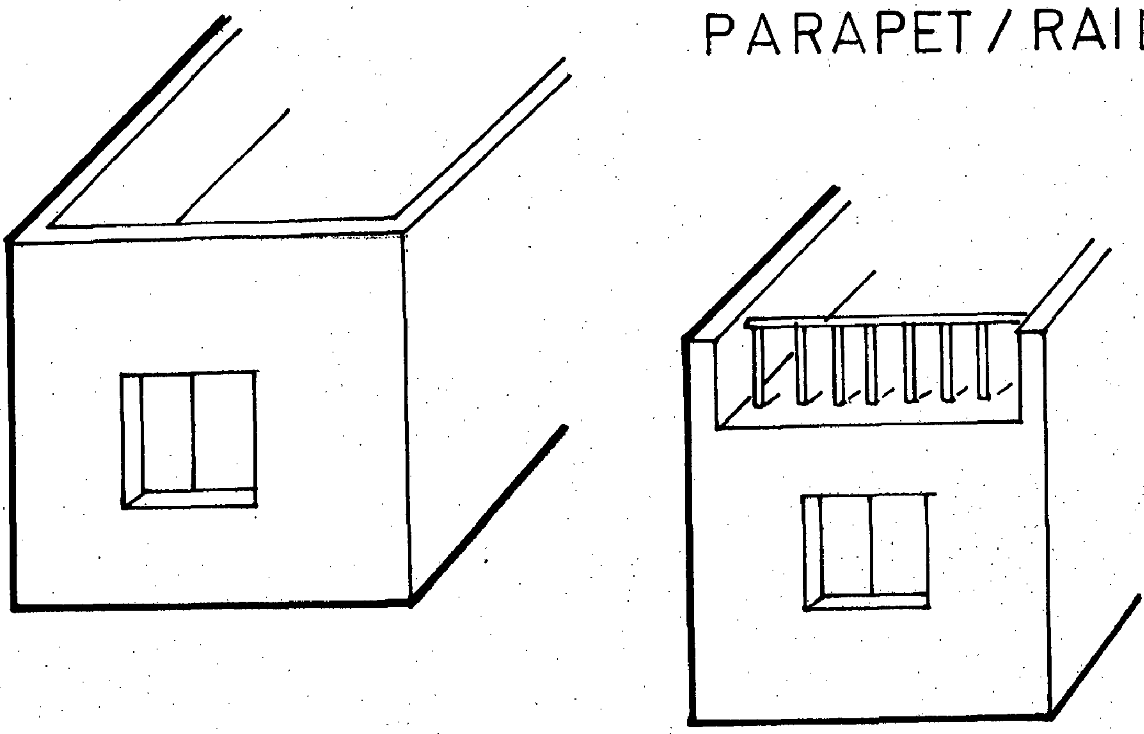
CUPBOARD DESIGN

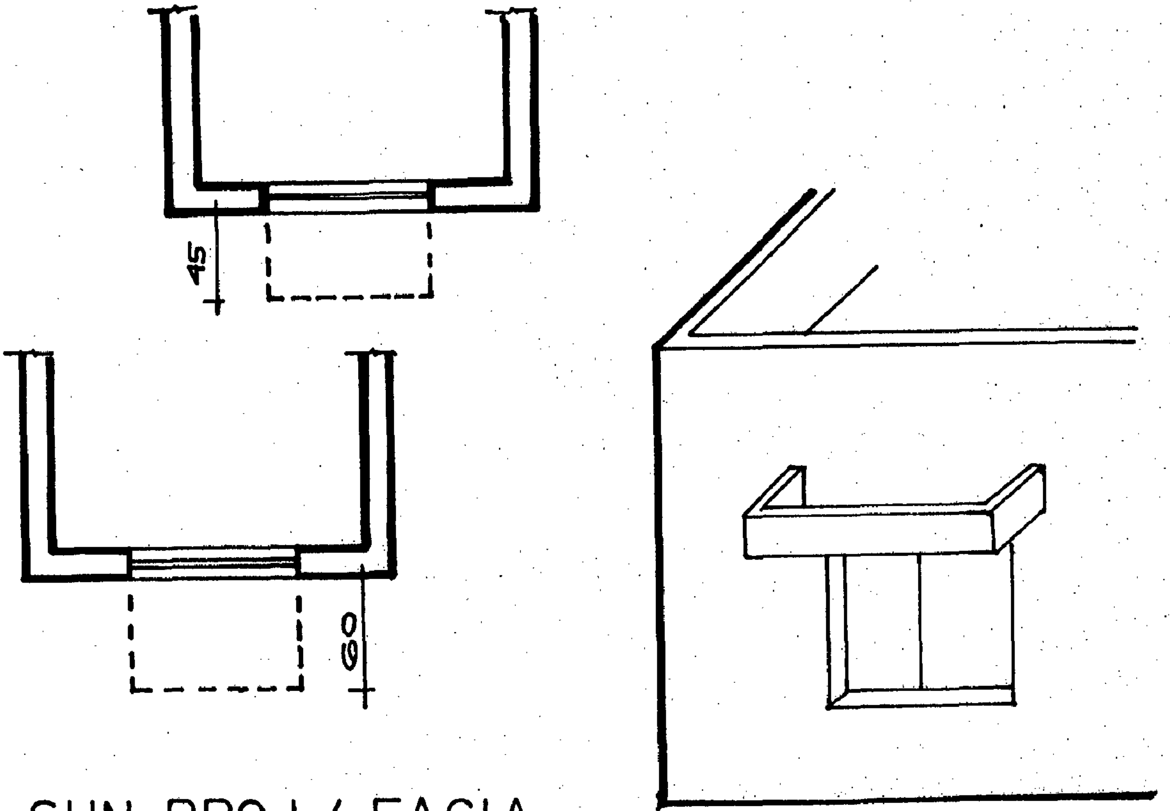


Design

fig cn_1

PARAPET / RAILING





SUN PROJ / FACIA
fig sjn-1

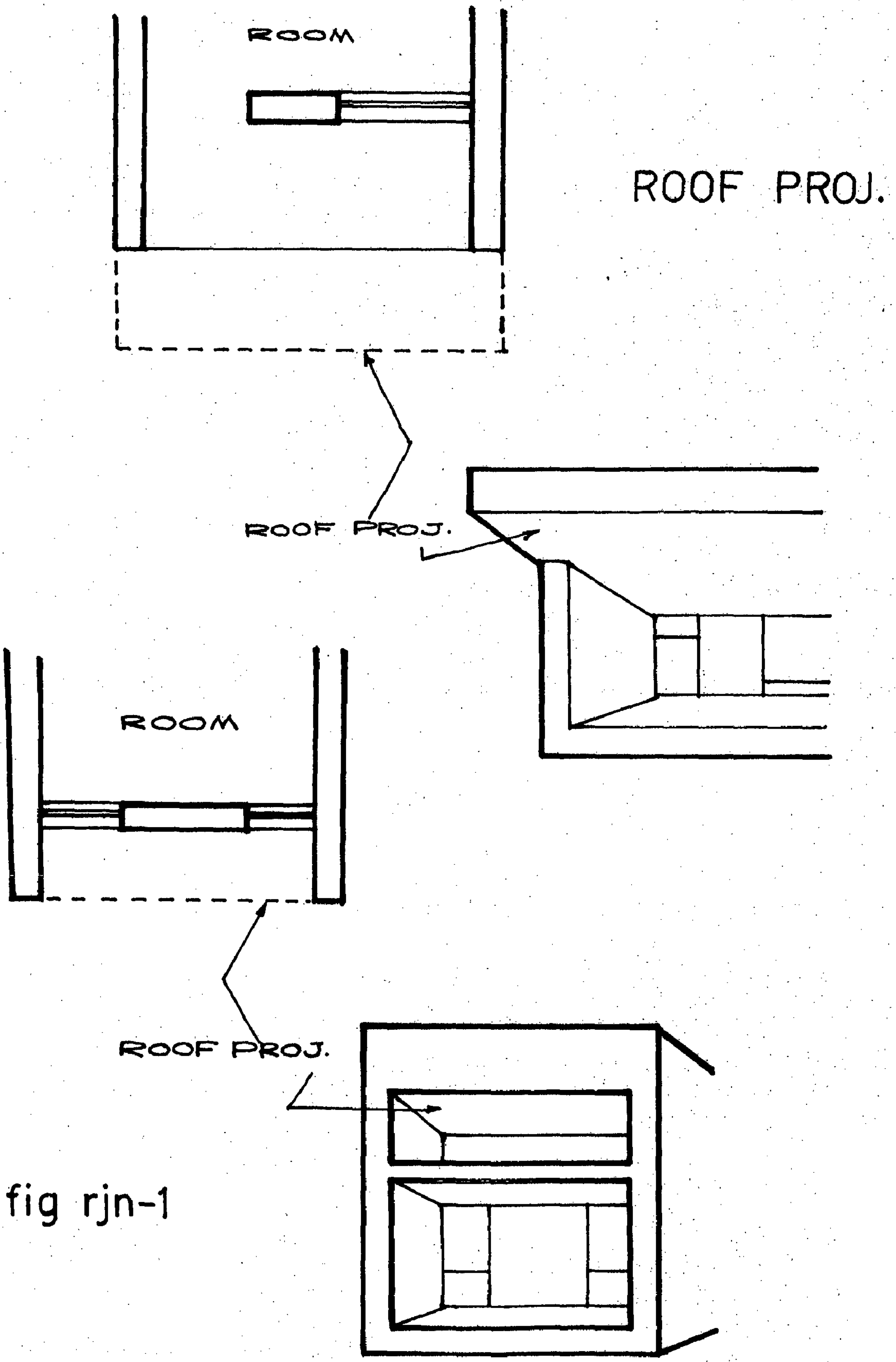
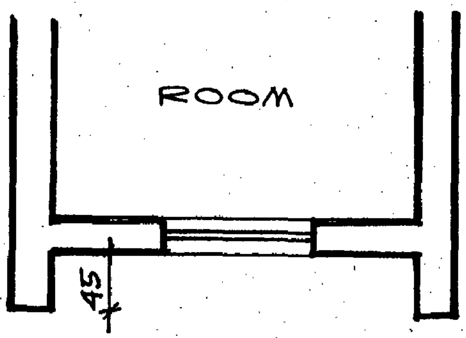
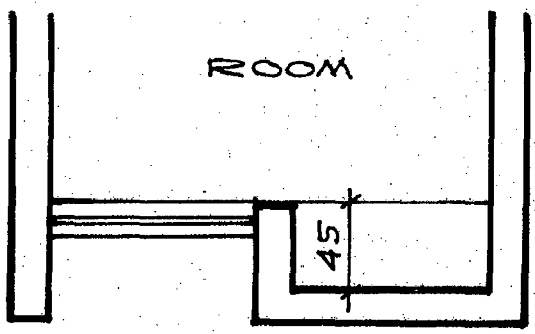


fig rjn-1

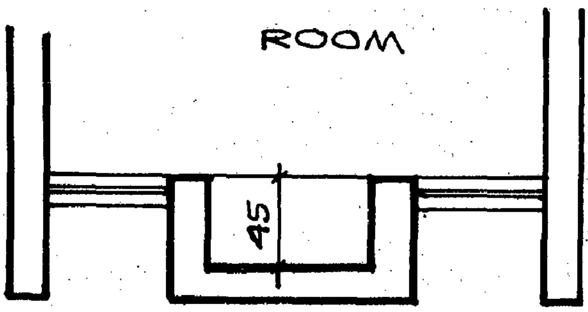
WALL PROJECTIONS



PJN-1



PJN-2



PJN-3

fig wpn_1

Table TS_1

Sl. No.	Plan No.	No. D.U.	Length of W.P.	Length of S.P (M)	No.of G.T.	No.of F.T.	No.of I.C.	Possibility of sharing (IC/SP)	No.of S.P.
1	PS_1	1	6.5	1.5	2	2	1	Yes(SP)	1
2	PS_2	1	2.5	1.5	1	2	1	No	1
3	PS_3	4	9	3	4	8	1	Yes	4
4	PS_4	2	7	4.5	2	4	1	Yes	2

Recommendations

1. In the case of one room dwelling unit and two room dwelling unit, combination of four units with centralised services is desirable and economical.

2. In the case of three units and above, combination of two units with centralised service core is desirable.

3. While doing the internal layout of G.I. pipes for water supply, minimum bends should be provided as no. of bends decreases the efficiency of water flow and also affects the cost to a great extent.

Electrical Services

The cost of electrical services in residential buildings depends on the following factors :

1. Type and no. of fixtures
2. Specifications

3. Length of electric line

4. Location of fixture

From the survey of type of fixtures, and layout, following inferences can be drawn :

1. Electric fixtures such as bulb or tube light, should be located as close to each other as possible to reduce the electric line length.

2. For one room and two room dwelling units bathened wiring should be done to save the cost by about 20 %.

3. For three room and above dwelling units, P.V.C. condoo pipe wiring should be done in stead of M.S.conduit.

6.16 MATERIAL

Cost of construction varies from material to material and the specifications used. To determine the optimum use of material following parameters are important.

1. Type of material

2. Availability

3. Use of new material.

Analysis has been done in the C.B.R.I. regarding the cost difference between the conventional material and new material of nearly same performance as indicated in the table TM-1. It is clear from the table that 5 % to 50 % saving can be achieved.

Managerial Aspects

Proper management at the site of construction plays key role in reducing the cost of building by following ways :

Table TM-1

Estimated cost of Conventional and New Materials

Sl. No.	Conventional Material	New proposed material of nearly equivalent performance	Saving in portland cement	Saving in cost
1	2	3	4	5
1.	Lean cement concrete	Flyash concrete	20	3 to 5
2.	Concrete over M 150	-do-	20	12 to 15
3.	Cement sand-mortar	Cement-flyash Lorters	15-20	13 to 20
4.	-do- (1:6)	Masonrycement sand (1:5)	30-50	15 to 20
5.	-do-	Lime based activated mortar	100	15 to 25
6.	Brick masonry with (1:6) mortar	Stone blocks masonry units with C-S mortar	9	19
7.	Random Rubble stone masonry (30 cm) with cement sand mortar	-do-	35	16
8.	Cement concrete floor 75mm 1:5:10 plus 35 mm 1:2:4	Clay flooring tiles with 1:3 cement-sand joints	83	7.5
9.	A.C. Roofing sheet (m^2)	Clay Roofing tiles (m^2)	100	27
10	-do-	Coir-cement corrugated sheet	15	50

.....2/-

1	2	3	4	5
11	Teak wood door frames	Magnesium oxychloride saw dust frames	-	40
12	Cement-concrete door frames	-do-	100	15
13	Burnt clay bricks 50 kg/cm^2 strength	Stabilized bricks 50 kg/cm^2 strength	-	25 to 50
14	Cement-Sand (1:6(mortar	Rice Husk Pozzolana Lime (1:3) mortar	100	30 to 40

Source : Central Building Research Institute, Roorkee

1. Quality control in terms of material and construction at site.

2. Check on wastage of material.

Quality control can be achieved by using good quality of bricks, by proper method of construction. Substantial quantity of scarce material like cement can be saved. Similarly by checking the wastage of material here and there, sizable economy can be achieved.

In case of prefabricated construction very high quality of management is desirable to save the material through wastage.

CHAPTER-7

APPLICATION OF OPTIMUM PARAMETERS

Usefulness of optimum parameters has already been explained in the Chapter 'Analysis of Elements' in detail. But to demonstrate its total impact on the building, scientist apartments, C.B.R.I., Roorkee has been chosen as a live case study.

In this study, I have first tried to analyse the existing building with respect to different parameters as shown in the figure EP-1, SAS-1, SAS-2, SSL-1, SSL-2, SSL-3, OP_1, SA OS-1 and then compared this with revised one to demonstrate the optimum saving.

CASE-I (Three roomed Scientist Apartments)

ANALYSIS WITH EXISTING PARAMETERS

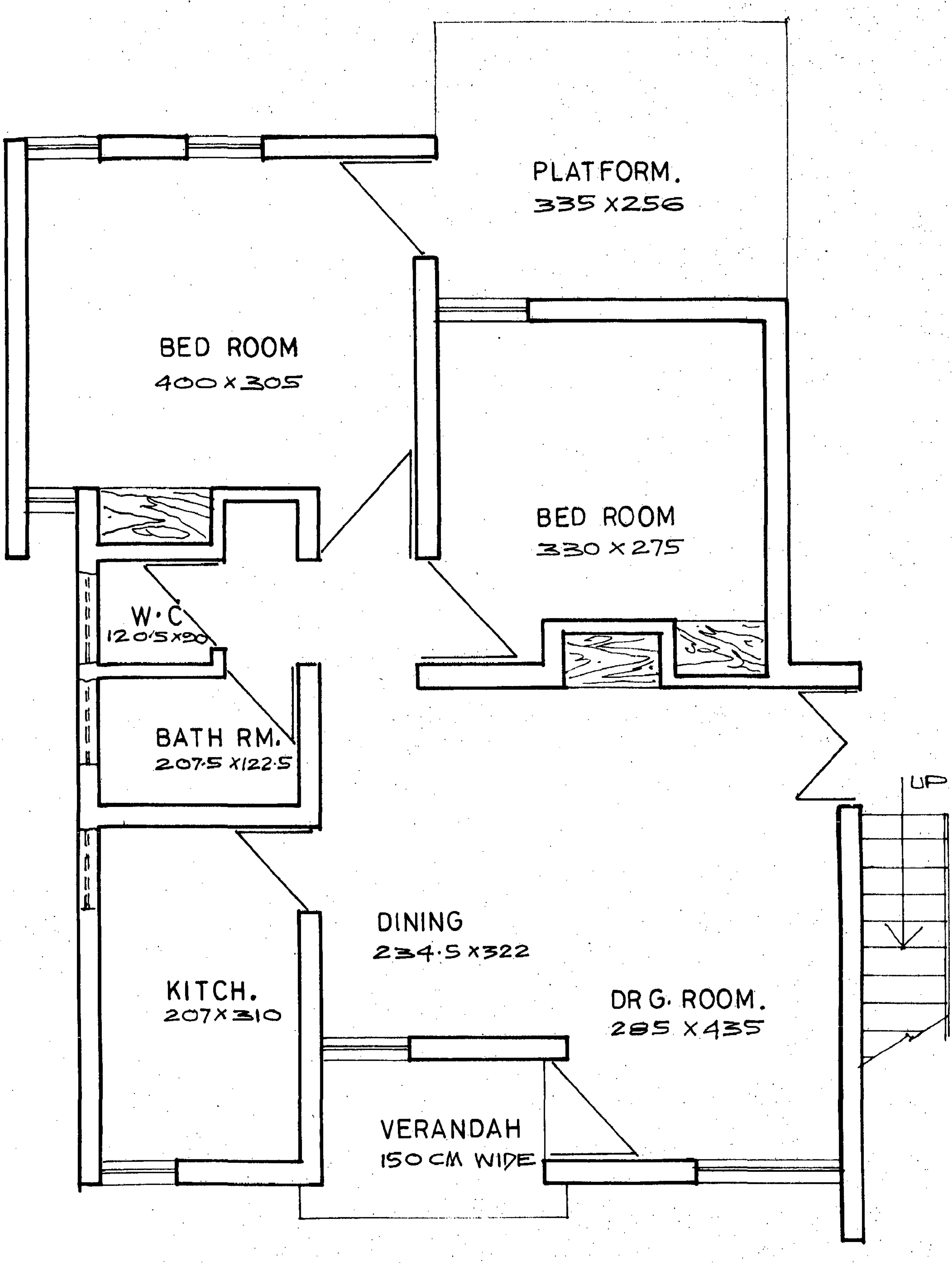
Land : It was low lying area, about 45 cm below the adjoining ground. There was problem of water logging. So area was filled with imported earth to raise the entire area upto existing ground level. Soil is alluvial in character.

Foundation :

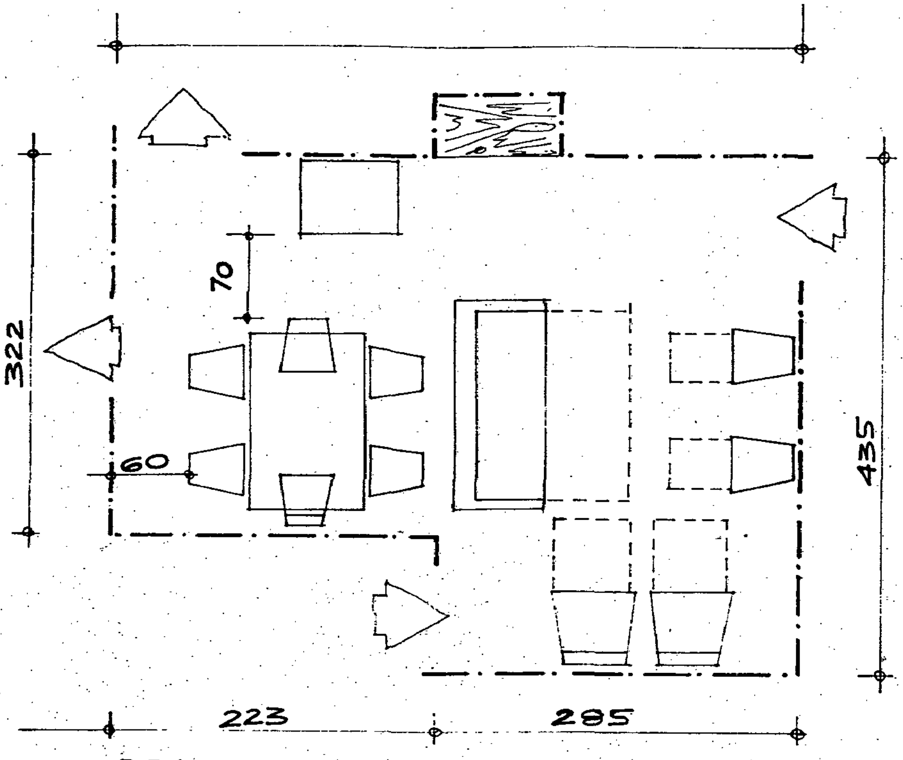
Type	Simple stripped foundation
Size	75 cm x 90 cm
Material	Brick, cement, sand

Plinth Height : Average plinth height is 30 cm from ground level.

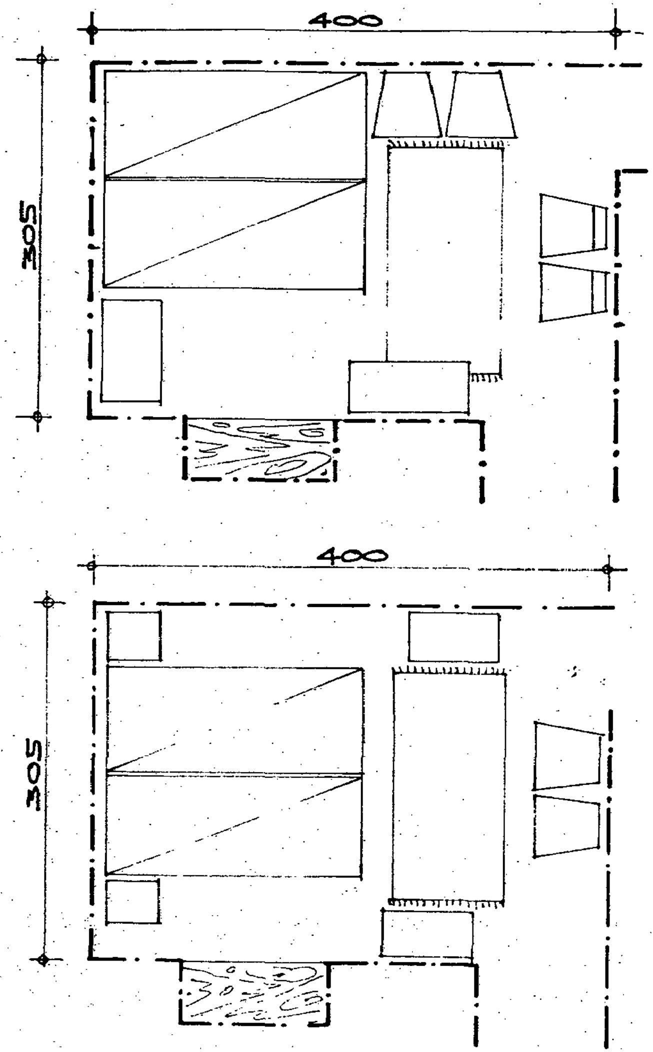
Damp Proof Course : 40 mm thick damp proof course in 1:2:4 Cem. conc.


PLATFORM.
335 X256
BED ROOM
400 X 305
BED ROOM
330 X 275
W·C
120·5 X90
BATH RM.
207·5 X122·5
UP
DINING
234·5 X322
KITCH.
207X310
DRG. ROOM.
285 X435
VERANDAH
150 CM WIDE

PLAN-1



DRAWING RM.



BED RM.

SPACE

Size = 305 x 400
Area = 12.2 M^2

FIG. SA S-1

Scientist Apartments
(3 ROOM)

Optimum size of Dining Room

Without refrigerator = 285 x 330 = 9.4 M^2
With refrigerator = 285 x 405 = 11.54 M^2

- Given size for the Dining = 234.5 x 322 = 7.55 M^2

% of under size = 19.6% - 34.57 %

This shows that given size of dining room can serve for 4 person only.

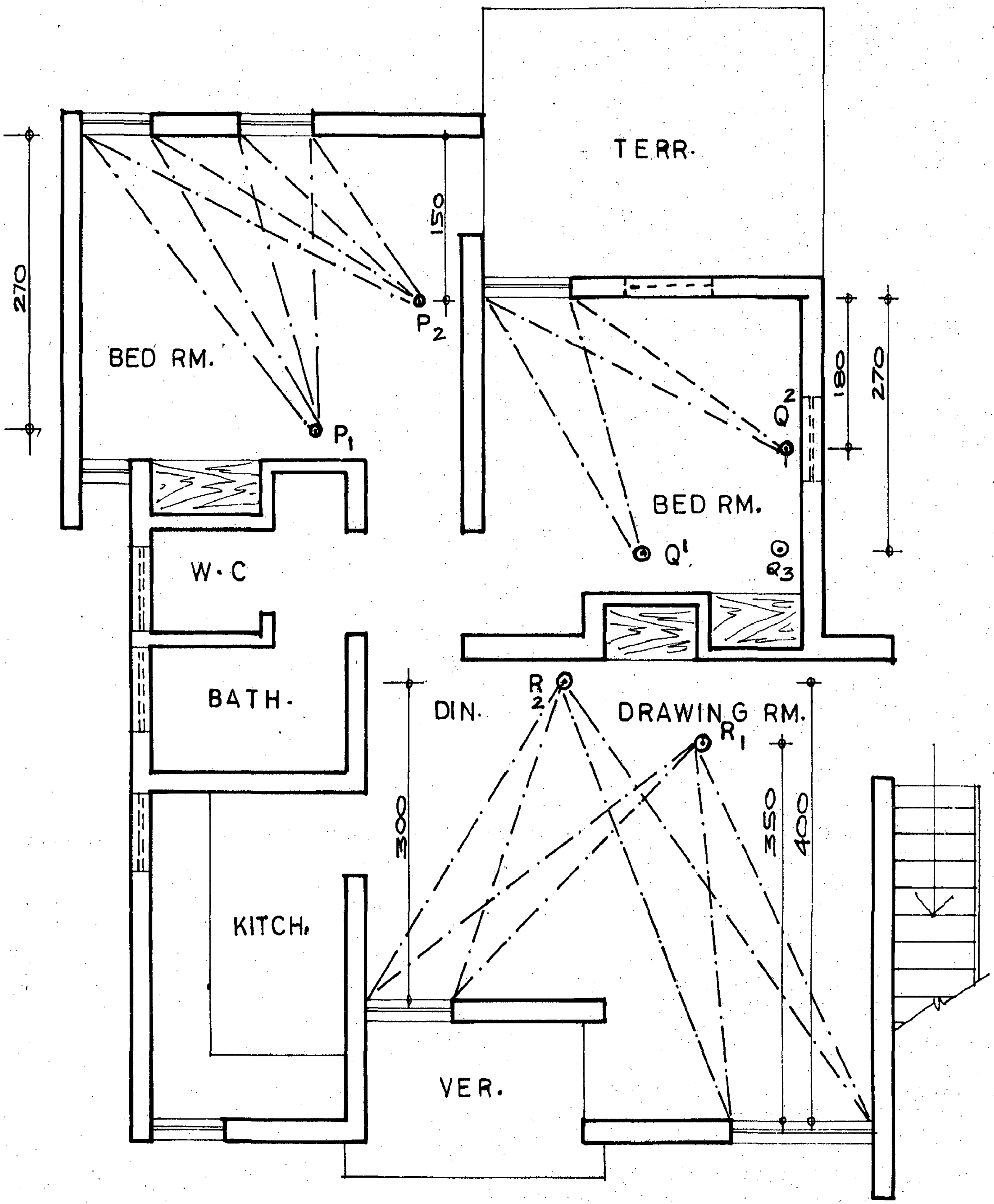


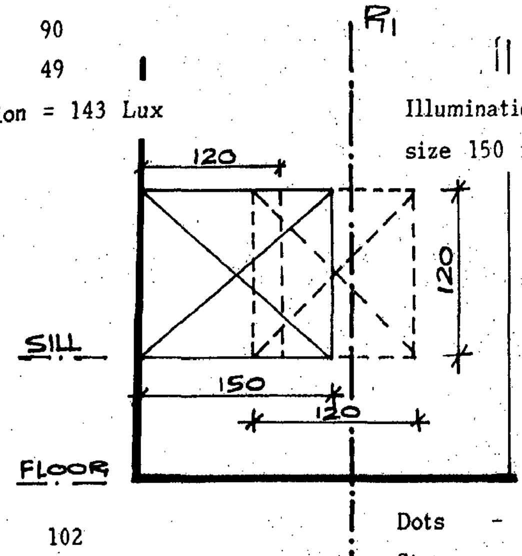
FIG. SSL-1

Scientist Apartments
(3 ROOM)

Illumination with window of size 120 x 120 cms.

Dots - 90
Stars - 49
Illumination = 143 Lux

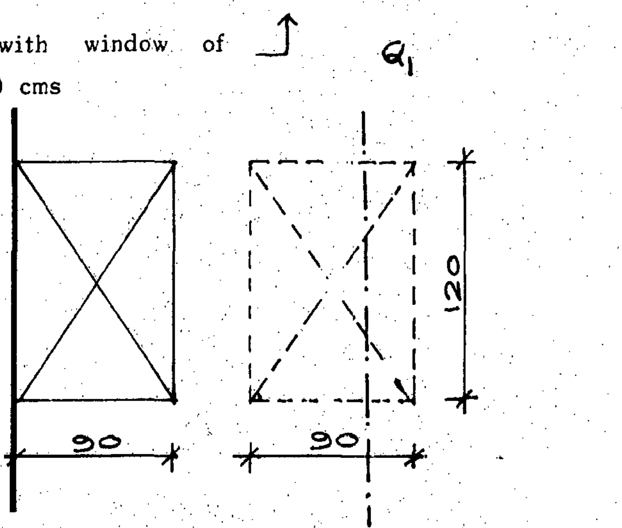
Dots - 114
Stars - 63
Illumination at R_1 = 183 Lux



Dots - 102
Stars - 56
Illumination = 163 Lux

DRAWING RM.

Illumination with window of size 150 x 120 cms

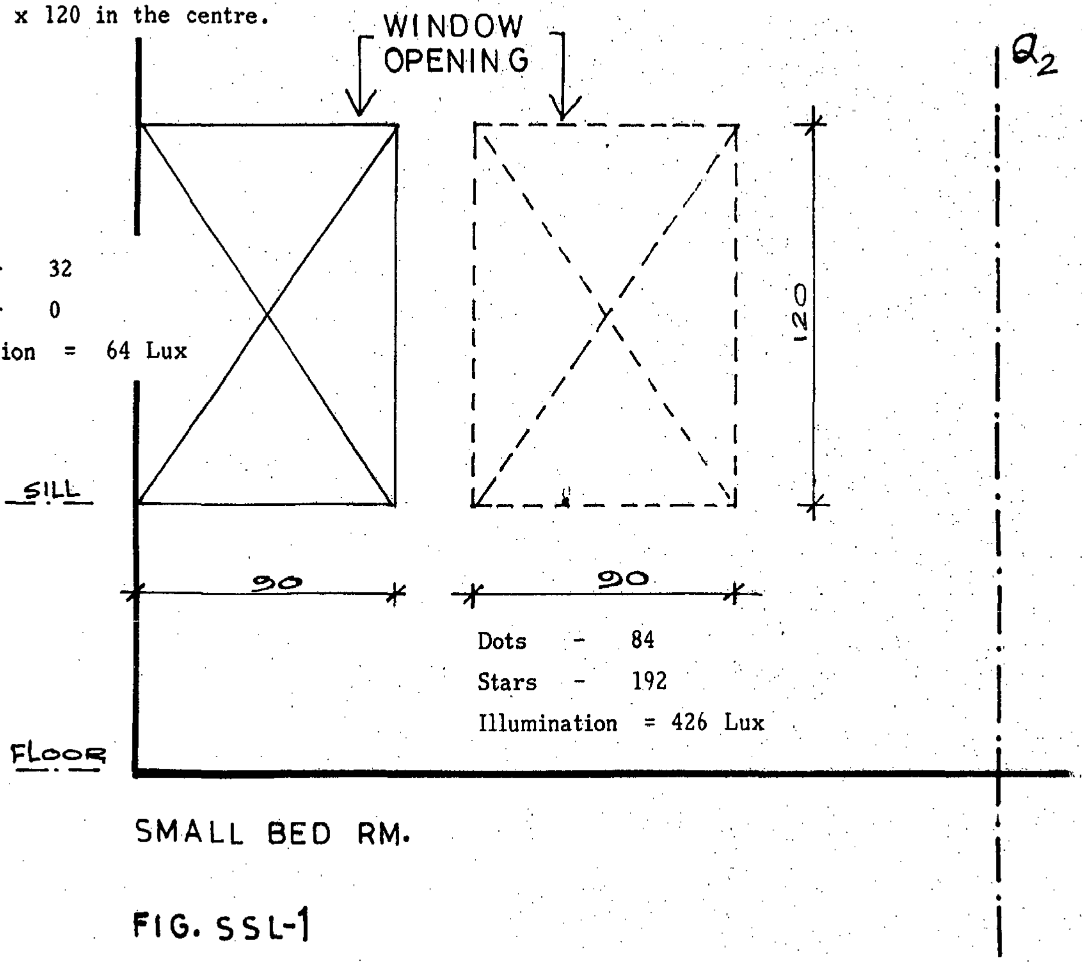


Dots - 48
Stars - 80
Illumination = 184 Lux.

Dots - 96
Stars - 85
Illumination = 216 Lux.

SMALL BED RM.

Illumination with window of size 120 x 120 in the centre.



Stars - 32
Dots - 0
Illumination = 64 Lux

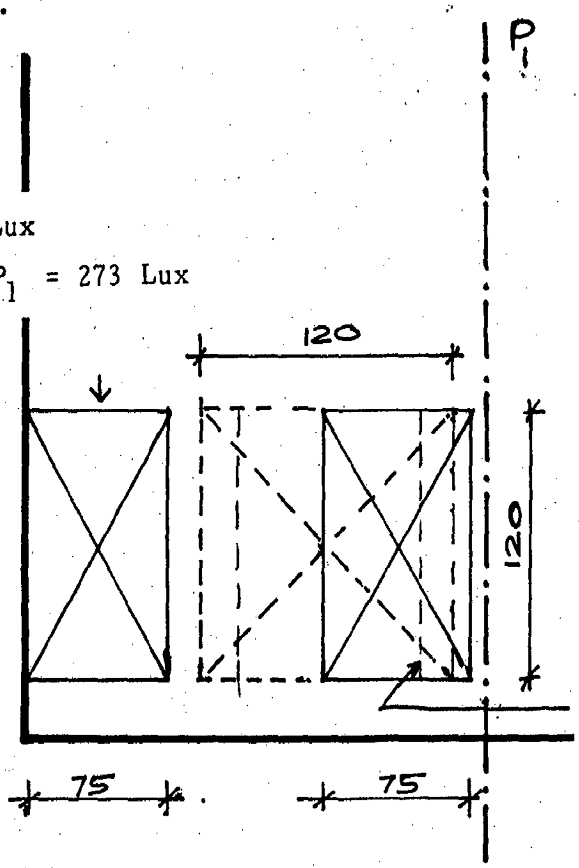
Dots - 84
Stars - 192
Illumination = 426 Lux

SMALL BED RM.

FIG. SSL-1

Dots - 50
Stars - 54
Illumination = 133 Lux.

Dots - 101
Stars - 45
Illumination = 140 Lux
Total Illumination at P_1 = 273 Lux



Dots - 166
Stars - 82
Illumination = 247 Lux

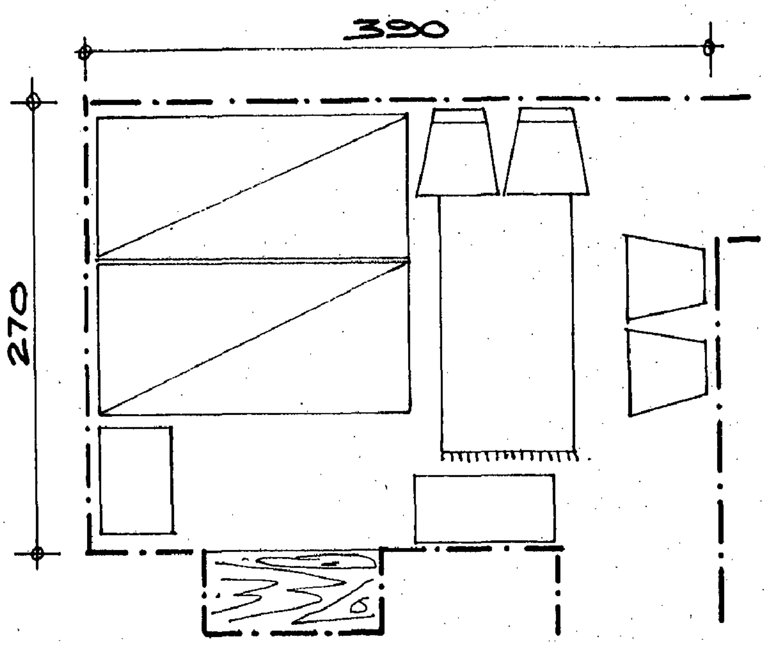
Dots - 124
Stars - 50
Illumination = 162 Lux

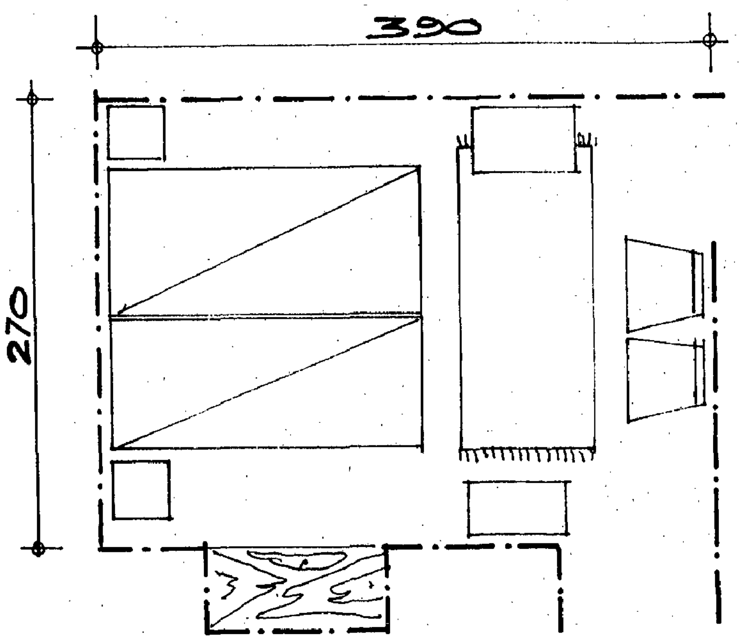
MASTER BED RM.

FIG. SSL-1

This shows that locational aspect is very important. Simply by shifting the location of window towards centre there is increase of illumination by 113 Lux. (35%)

This shows that illumination at P_1 with two windows of sizes 75 x 120 is 273 Lux which is not desirable. If the window size is reduced to 120 x 120, then illumination at P_1 is 247 Lux which is still undesirable. Now if the window size is further reduced to 90 x 120 cm, then illumination at P_1 is 162 Lux which is enough for even study purpose.





BED ROOM.
FIG. SA OS-1

Size - 3.9 x 2.7

Area - 10.53 m^2

Reduction in Area = 1.67 m^2

% Saving - 13.68 %

Walling

(i)	Length of 23 cm periphery wall	=	38.8 m
(ii)	Length of 23 cm internal wall	=	17.6 m
(iii)	Length of 11.5 cm internal wall	=	2.3 m
(iv)	Total wall length	=	98.7 m
(v)	Length of outer wall length to be shared	=	3.75 m
(vi)	% of outer wall, to be shared	=	9.66

Ceiling height : 3.05 from the floor level.

Roofing : Partially precast RCC joist and R.C. planks have been used in place of insitu 10 cm RCC slab.

Flooring :

(i) Composition
- 100 mm fine sand filling over rammed earth
- 75 mm base conc.
- 40 mm thick floor finish.

(ii) Floor Finish -

Drg. RM	Mosaic
Din RM	Mosaic
Kitchen	Mosaic
Bath, W.C.	Mosaic
Bed Rm	Plain cem.conc.

(iii) Dado

Kitchen	(Mosaic)	2.06 m
Bath	(Mosaic)	1.5 m

(iv) Glass strips — Plain glass, 6 mm thick

Architectural Planning Elements

Plan Form

Plan form is not compact as it has many offsets, more periphery wall length and less possibility of sharing outer walls as is clear from plan EP_1

Space :

Plinth area = 70.144 M^2

Floor area := **As per detail**

	Size	Area M^2
. Drg. Room	2.85x4.35	12.39
. Dining	2.47x3.22	7.95
. Master Bed room	4.0x3.05	12.2
. Small bed room	3.3x2.75	9.075
. Kitchen	3.07x3.1	6.417
. Lobby	2.0x1.5	3.0
. Bath room	2.07x1.22	2.52
. W.C.	0.9x1.2	1.08
	Total	53.28 M^2

Internal unavoidable movement area : 7.5 m^2

DOORS AND WINDOWS

Doors:

Size	No.	Section size	Type of shutter
80x206	2	6.5x12.5	Single leaf
100x206	1	6.5x12.5	Double leaf
100x206	2	6.5x12.5	Single leaf
75x206	3	6.5x12.5	Single leaf

Windows

Size	No.	Type of shutters
150x122	1	Three leaf
90x122	2	Double leaf
75x122	2	Double leaf
47x122	1	Single leaf
75x90	1	Double leaf

Combination of Units and Layout

- One block consists of four dwelling units being served by one staircase.
- All external walls are independent, not shared.
- It is a cluster type layout with community space in the centre.
- There are eight blocks located independently, with the result, there is increase in road length and no. of sides adding to the plastering and masonry work.

Services

Sanitary and water supply (for two dewlling units)

- Length of waste water pipe = 6.5 m
- Length of soil pipe = 5.1 m
- No. of floor traps = 2
- No. of G.T. = 2
- Length of vertical waste water pipe = 6 m
- Length of vertical soil pipe = 7.15 m
- No. of inspection chambers = 1
- Length of G.I. pipe for water supply = 13.0 m

Inferences :

1. Due to wrong position of sink, length of waste water pipe has increased.
2. Two gulley traps have been provided, which can be reduced to one.

3. Due to independent location of blocks, separate I.C., and sanitary pipes have been provided, thus increasing the cost.

4. Due to cluster layout plan, the length of external service has also increased.

Electrical (for one dwelling unit)

•	Length of electric line from meter	= Not known
•	No. of wall light	= 11
•	No. of power points	= 2
•	No. of 3 pin light sockets	= 4
•	No. of fans	= 4

Miscellaneous Elements

1. Width of cupboard = 90, 120
2. Length of 23 cm wide conc. Facia over sun projection =

ANALYSIS WITH OPTIMUM COST PARAMETERS

A revised plan as shown in Fig. OP-1 with minimum changes keeping the optimum cost parameters, into mind has been developed and analysed to prove the effective savings.

ANALYSIS

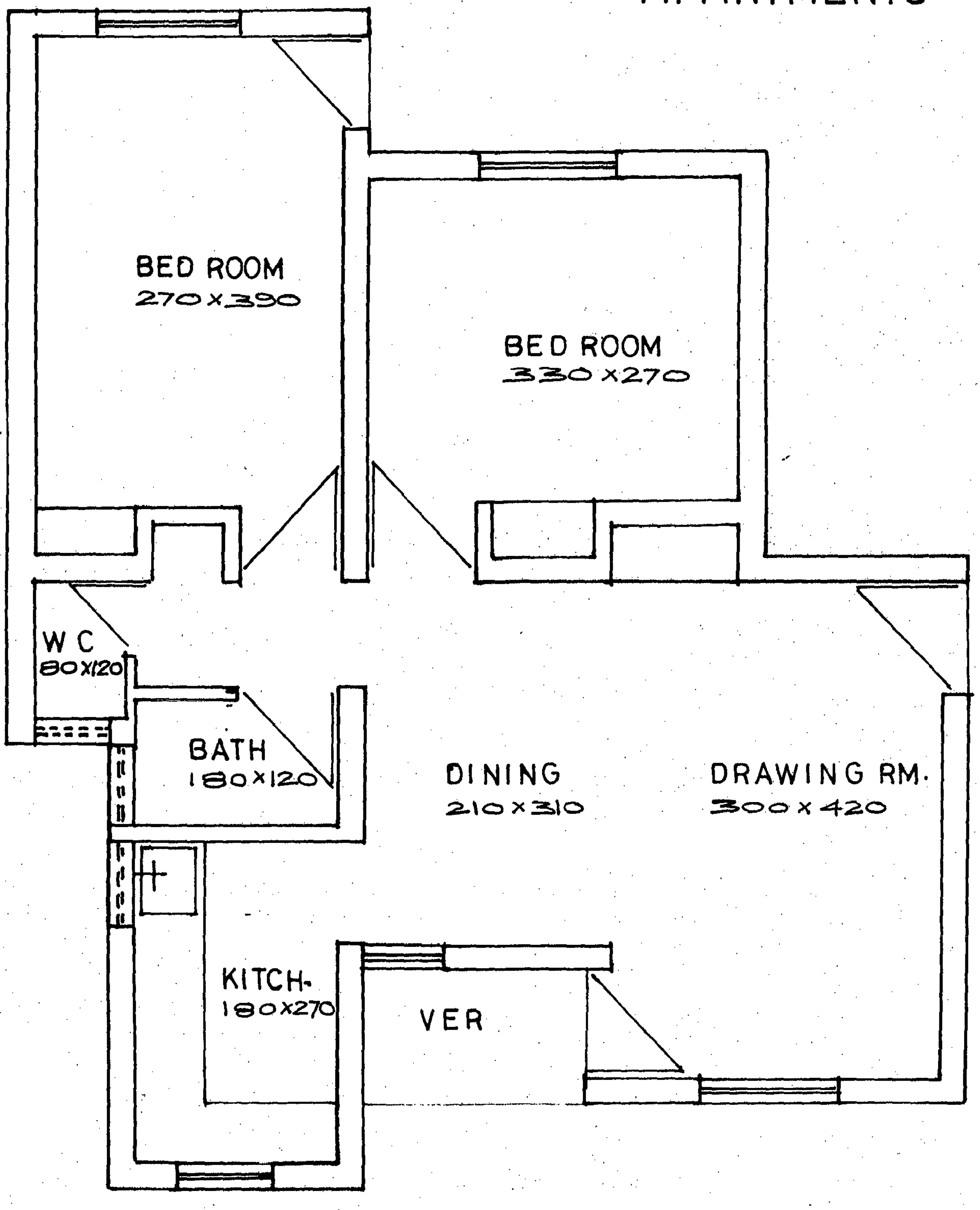
Land : Due to proper selection of site, cost of filling could have been saved.

Saving : earth filling cost.

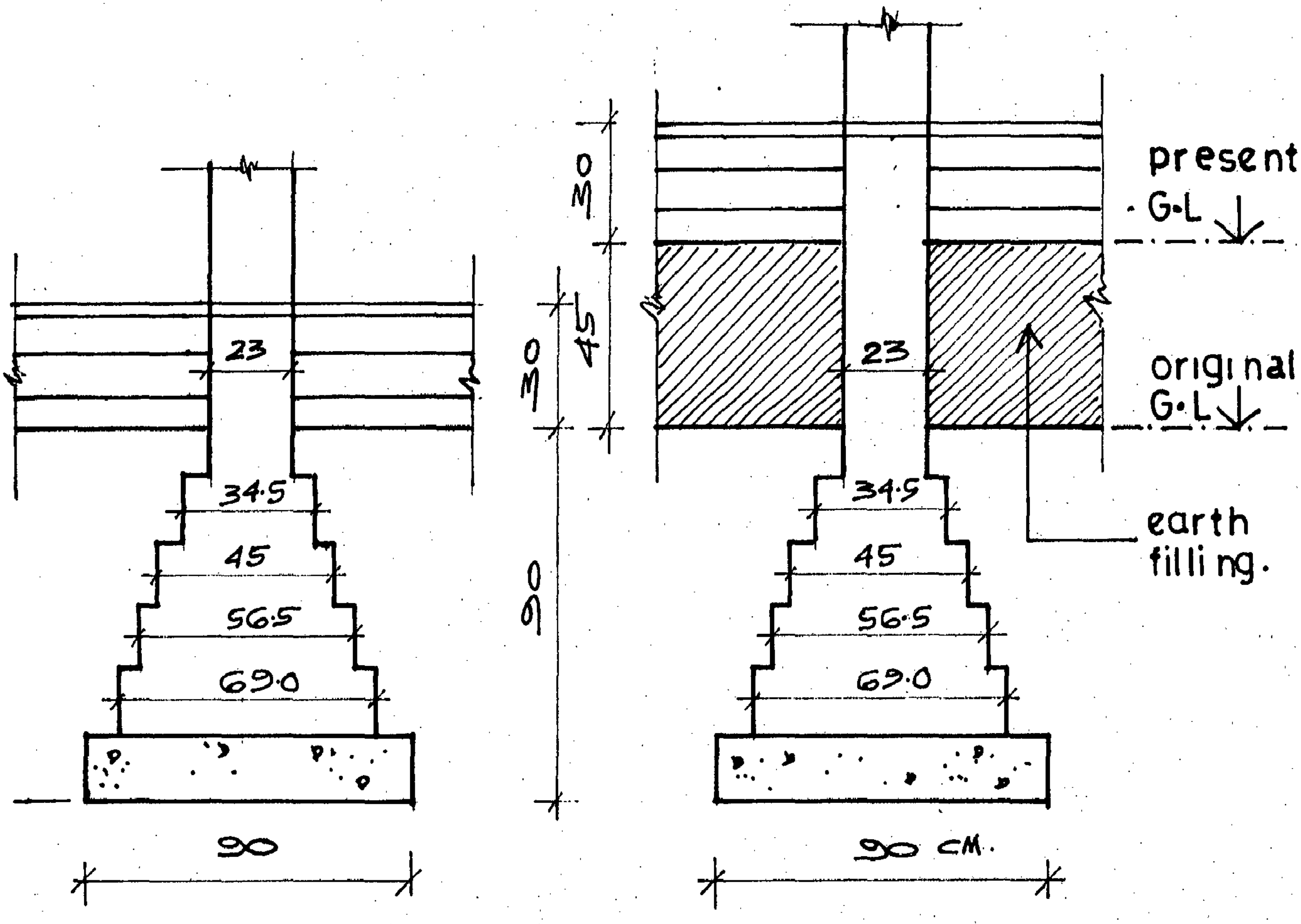
Foundation :

45 cm earth filling has increased the foundation depth from 90 cm to 135 cm, as shown in the figure.

SCIENTIST APARTMENTS



PLAN OP-1



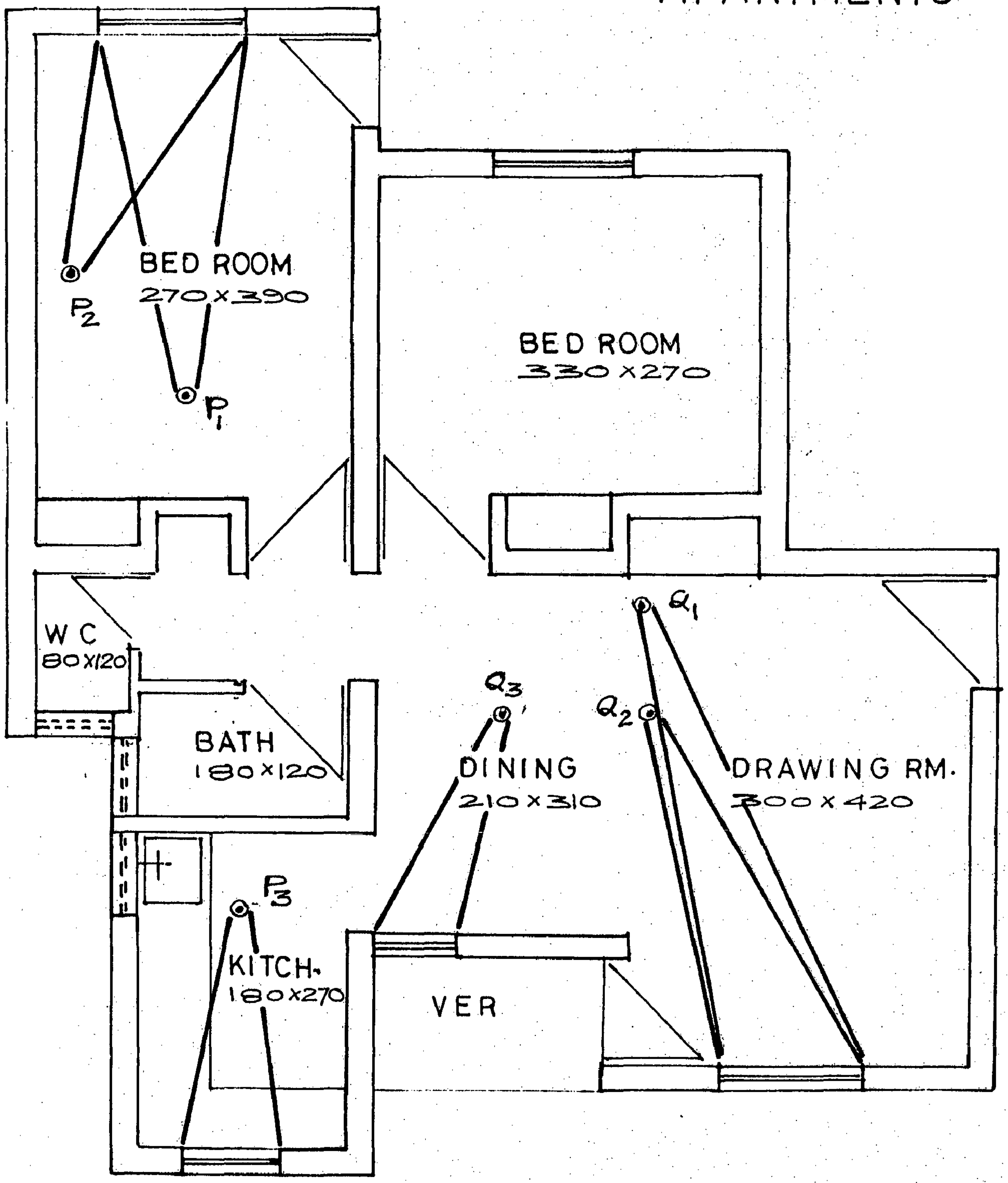
FOUNDATION As per original G.L

FOUNDATION As per present G.L

FIG. OF-1

P/100

SCIENTIST APARTMENTS

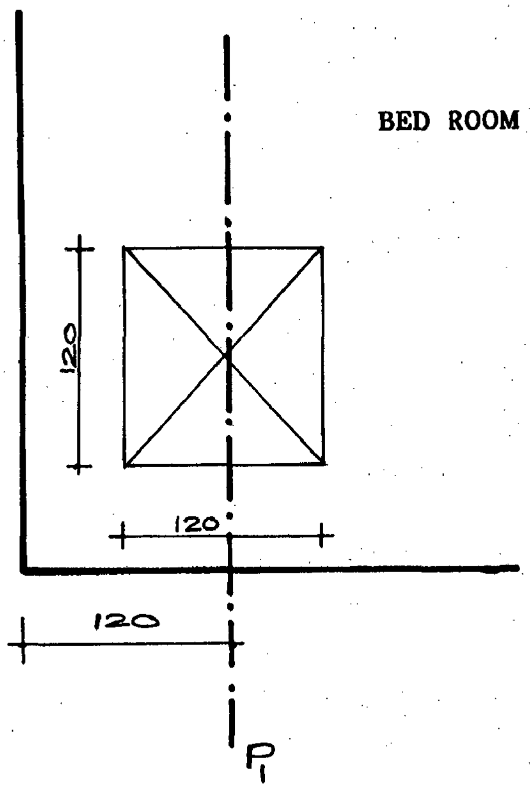


PLAN OP-1

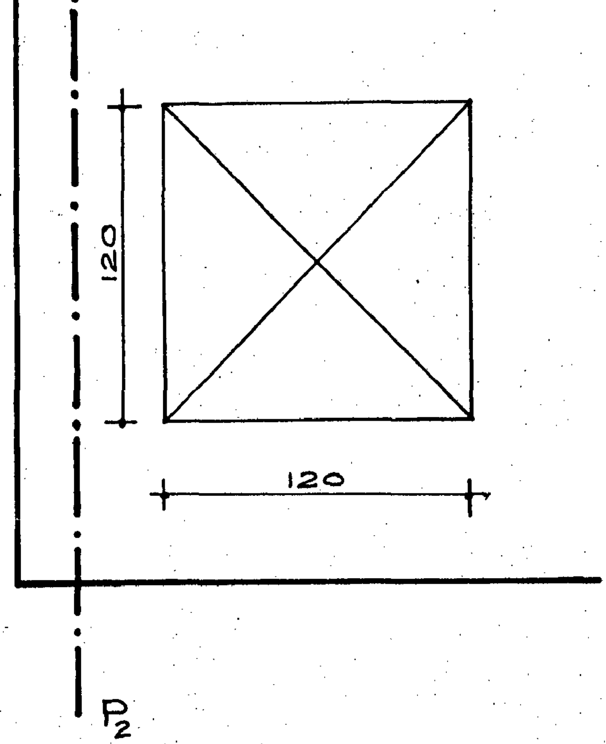
OP-1

Dots	128
Stars	64
Illumination	192 Lux

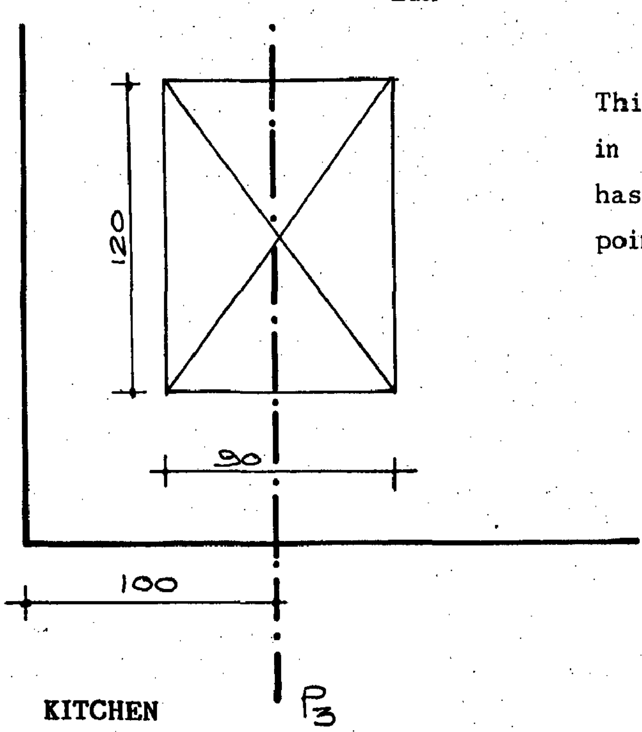
BED ROOM **270 x 390**



Stars	144
Dots	280
Illumination	284 Lux



Dots	182
Stars	108
Illumination	307 Lux



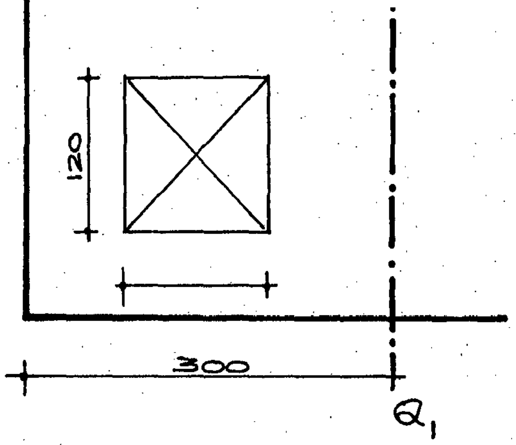
KITCHEN

This shows that by locating the window in the centre, 192 luse illumination has been achieved at the farthest point P_1.

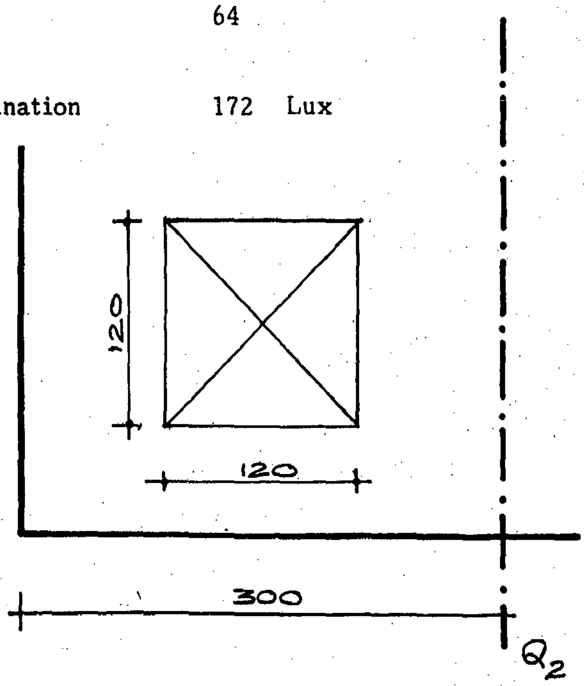
OP-1

DRAWING ROOM 300 x 420

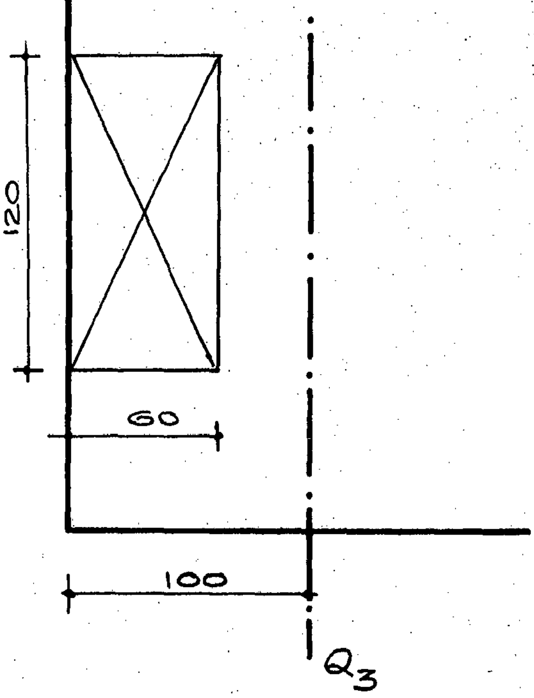
Dots	61	
Stars	33	
Illumination	96	Lux



Dots	88	
Stars	64	
Illumination	172	Lux



DINING ROOM



Dots	104	
Stars	72	
Illumination	196	Lux

Increased quantity or saving per dwelling unit :

Material	Saving in quantity	Unit	Saving in Rupees
Brick	2616	No	1308
Cement	69.96	Bag	4897

Plinth height

30 cm. from ground level.

So, no saving due to this element.

Damp Proof Course (1:2:4)

Suggested optimum thickness of damp proof course is 2.5cm

Saving : 45.8 %

Material	Saving in quantity	Unit	Saving in Rs.
Cement	1.1	Bag	77

Walls (Superstructure)

(i)	Length of 23 cm periphery wall	= 37.1 m
(ii)	Length of 23 cm internal wall	= 10.0 m
(iii)	Length of 11.5 cm internal wall	= 3.6 m
(iv)	Total wall length	= 50.7 m
(v)	Length of outer wall length to be shared	= 6.1 m
(vi)	% of outer wall to be shared	= 16.4 %

Saving in total wall length = 8.0 m

% of saving = 13.6 %

Saving in terms of main material like cem. and bricks :

Material	Saving in Quantity	Unit	Saving in Rupees
Brick	2477	No	1238-5
Cement	66.24	Bags	4636.8

Ceiling ht = 270 m, 1 bag cem. = Rs. 70/-

500 No Bk = Rs. 1000/-

Ceiling ht

Suggested optimum ceiling height is 2.7 m

Saving = 0.35 M

% saving = 11.47 %

Saving in terms of material cem. and bricks :

Material	Saving in quantity	Unit	Saving in Rupees
Brick	1744	No	872
Cement	46.6	Bag	3262

Roofing :

Partially precast RCC roof has been used in place of conventional RCC, RBC or R.B. roofing which is about 20 % cheaper.

Flooring :

i) Composition : Same as given, so no further saving.

ii) Floor Finish : P.C.C. flooring for drg. room and dinining considering that most of the floor is covered with carpet and in terior furniture. Mosaic finish is four times expensive than P.C.C. floor finish. So considerable saving can be achieved. Use of 3 mm glass strips in place of 6 mm will give further saving. 2 m mosaic.

Saving = 1.66 m^2

% saving = 3 %

This will result in saving inflooring and roofing considerably.

Doors and Windows :

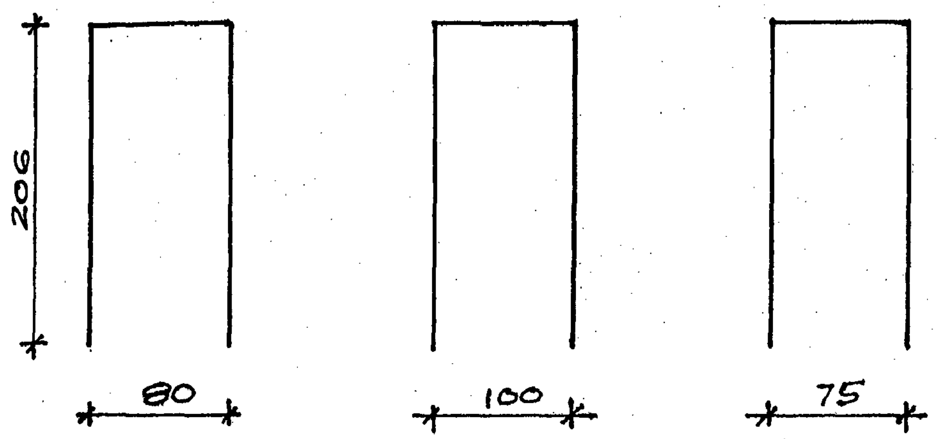
Doors

Sl. No.	Frame size	Sheet size	No.	Type of shutter
1	100x200	12.5x6.5	1	Single leaf
2	90x200	12.5x6.5	1	Single leaf
3	90x200	10x6.5	2	Single leaf
4	75x200	12.5x6.5	1	-do-
5	75x200	10.0x6.5	2	-do-

Frame size

Saving	Total wooden quantity	=	0.234 M^3
	Saving	=	0.076 m^3
	% saving	=	24.5 %

DOOR FRAME Sec. 6.5 x 12.5

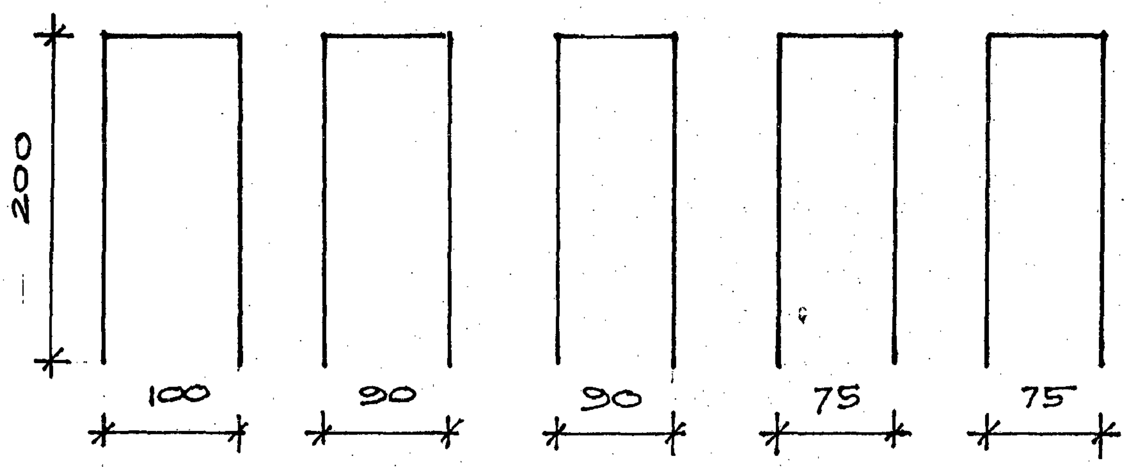


0.0383 x 2
= 0.0766 m^3

0.0399 x 3
= 0.1197 m^3

0.0379 x 3
= 0.1137

Total : 0.31 m^3



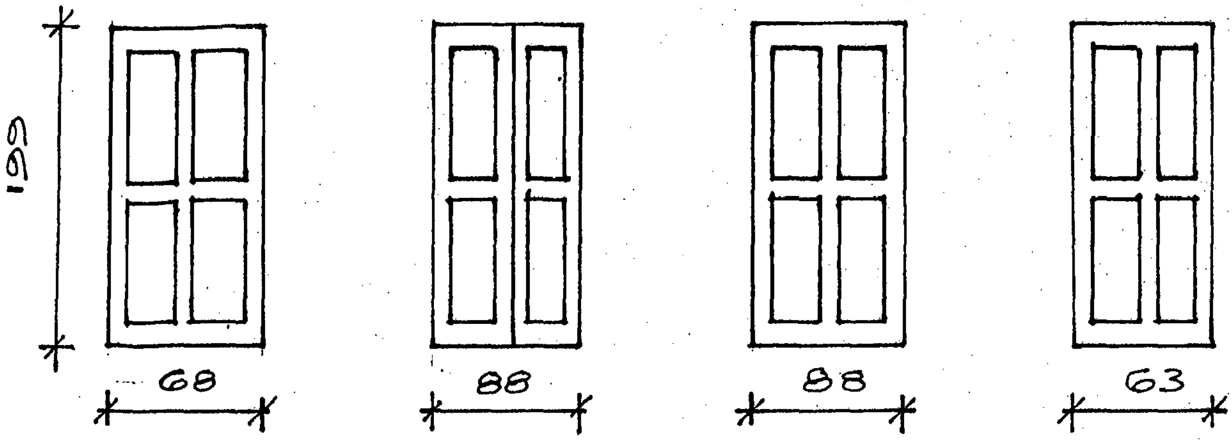
Sec. 12.5 x 6.5	Sec. 12.5 x 6.5	Sec. 10 x 6.5	Sec. 12.5 x 6.5	Sec. 10 x 6.5
0.039 m^3	0.0382 m^3	0.0306 x 2 = 0.0612 m^3	0.037 m^3	0.0296 x 2 = 0.0593 m^3

Total : 0.234 m^3

SAVING : 0.076 m^3

Saving % : 24.5

DOORS SHUTTERS



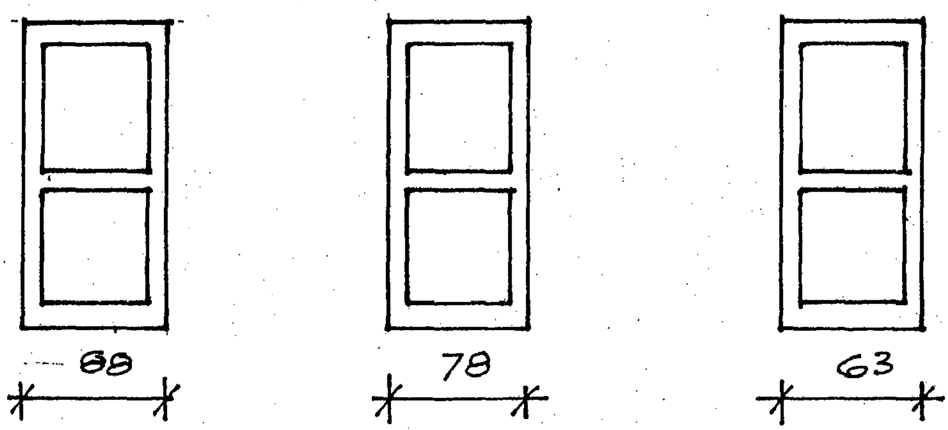
0.0238 m^3 x 2 = 0.0476

0.0476 m^3

0.0396 x 2 = 0.0792

0.0351 x 3 = 0.1054

Total = 0.3102 m^3



0.0317 m^3

0.0299 x 3 = 0.0897

0.0272 x 3 = 0.0816

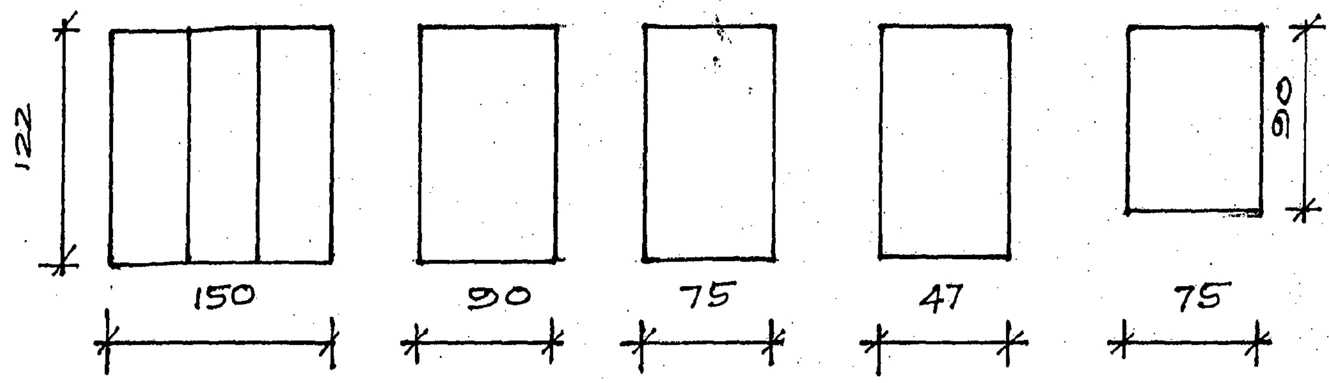
Total = 0.203 m^3

SAVING = 0.1072 m^3

Saving % = 34.4

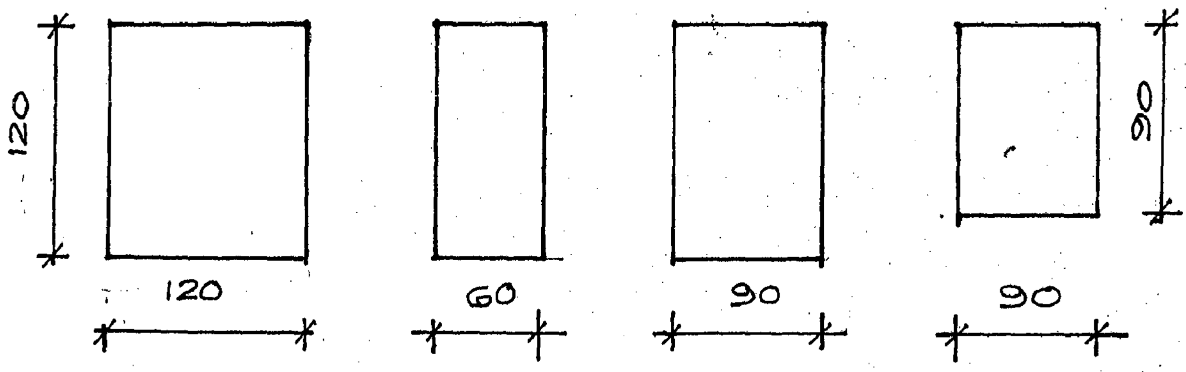
WINDOW FRAME

Frame Section 6.5 x 12.5 cm



0.0614 m^3 | 0.0330 x 2 = 0.066 m^3 | 0.0307 x 2 =0.0614 m^3 | 0.0263 m^3 | 0.0257 m^3

Total = 0.2408



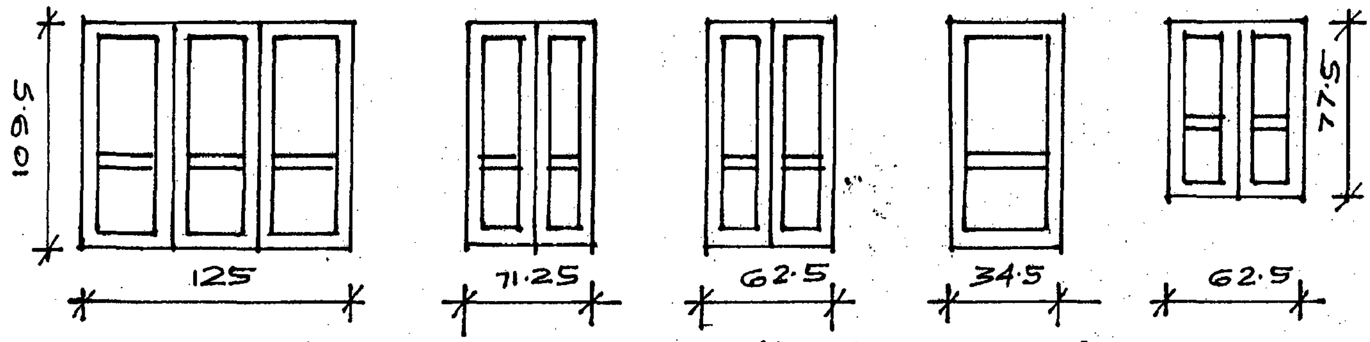
0.03744 x 2 =0.0748 m^3 | 0.0280 m^3 | 0.0327 m^3 | 0.0280 m^3

Total = 0.1635 m^3

SAVING = 0.0773 m^3

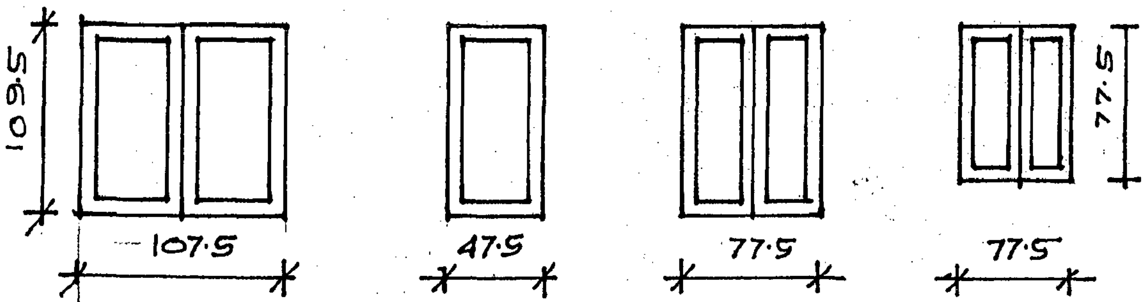
Saving % = 32.1

WINDOW SHUTTERS



0.0272 m^3 0.0131 x 2 = 0.0263 m^3 0.0168 x 2 = 0.0336 m^3 0.0086 m^3 0.0130 m^3

Total = 0.1087 m^3



0.01959 x 2 = 0.0391 m^3 0.0094 m^3 0.0177 m^3 0.0139 m^3

Total = 0.0801

Saving = 0.0286 m^3

Saving % = 26.3

Shutter Design

Saving : Total wooden quantity = 0.203 M^3

Saving = 0.1072 M^3

% saving = 34.5 %

Windows :

Sl. No.	Size	Sect.	No.	Type of shutters
1	120x120	As per figure	2	Double leaf
2	60x120	-do-	1	Single leaf
3	90x120	-do-	1	Double leaf
4	90x90	-do-	1	Double leaf

Frame size :

Saving : Total wooden quantity = 0.1635 M^3

Saving = 0.0773 M^3

% saving = 32.1 %

Shutter Design :

Saving : Total wooden quantity = 0.0801 M^3

Saving = 0.0286 M^3

% saving = 26.3 %

Dado in the kitchen can be avoided.

Architectural Elements :

Form of new plan developed is more flexible with the possibility of sharing wall. This can result in more saving.

Saving in one dwelling unit :

Length of additional shared wall = 2.35 M

% Length of shared wall = 38.5 %

Material	Saving in quantity	Unit	Saving in Rupees
Brick	404	No	808/-
Cement	10.8	Bags	756/-

HT = 3.0 m

Space :

Area	Size	Area
B.R.	2.7x3.9	10.53
B.R.	3.3x2.7	8.91
Drg	3.0x4.2	12.6
Dining	2.4x3.1	7.56
Kitchen	1.8x2.7	4.86
Bath	1.8x1.2	2.16
W.C.	0.8x1.2	0.96
Wash Basin	1.83x1.4	2.562
Lobby/cupboards		1.48
	Total	51.62

Combination of Units and Layout

Revised layout plan has been developed with same cluster concept keeping the optimum cost reduction parameters into mind, as shown in figure OL-1.

Saving :

1. Due to sharing of wall and clubbing of three blocks in a row, road length has been decreased.

2. Due to sharing ofwalls, there is substantial saving in material like BK and cem. as stated below :

Total length of shared wall = 24.4

Saving due to sharing = 9.4 m

Saving in material like BK and Cem.

Sl.No.	Material	Saving in	Savingin Rs.
1	BK	1616	3202/-
2	Cem.	43.2	3024/-

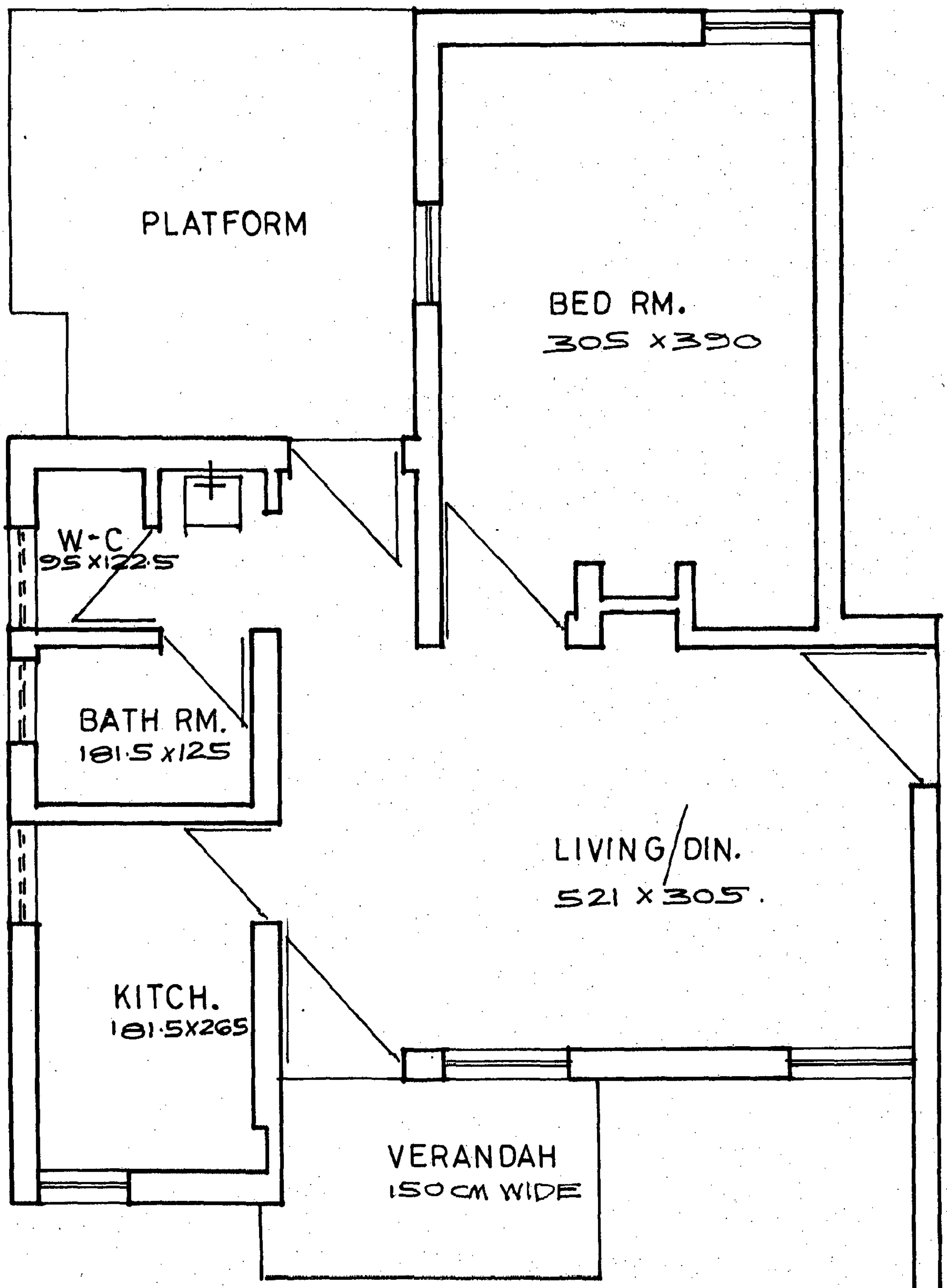
CASE II (Two roomed Scientist Apartments)

ANALYSIS WITH EXISTING PARAMETERS

Land : It was low lying area, about 45 cm below the adjoining ground. There was problem of water logging. So area was filled with imported earth to raise the entire area upto existing ground level. Soil is alluvial in character.

Foundation :

Type	Simple stripped foundation
Size	75 cm x 90 cm
Material	Brick, cement, sand


PLATFORM
BED RM.
305 X390
W-C
95X122.5
BATH RM.
181.5 X125
LIVING/DIN.
521 X 305.
KITCH.
181.5X265
VERANDAH
150 CM WIDE

PLAN - 2

Scientist Apartments
(2 ROOM)
BED ROOM

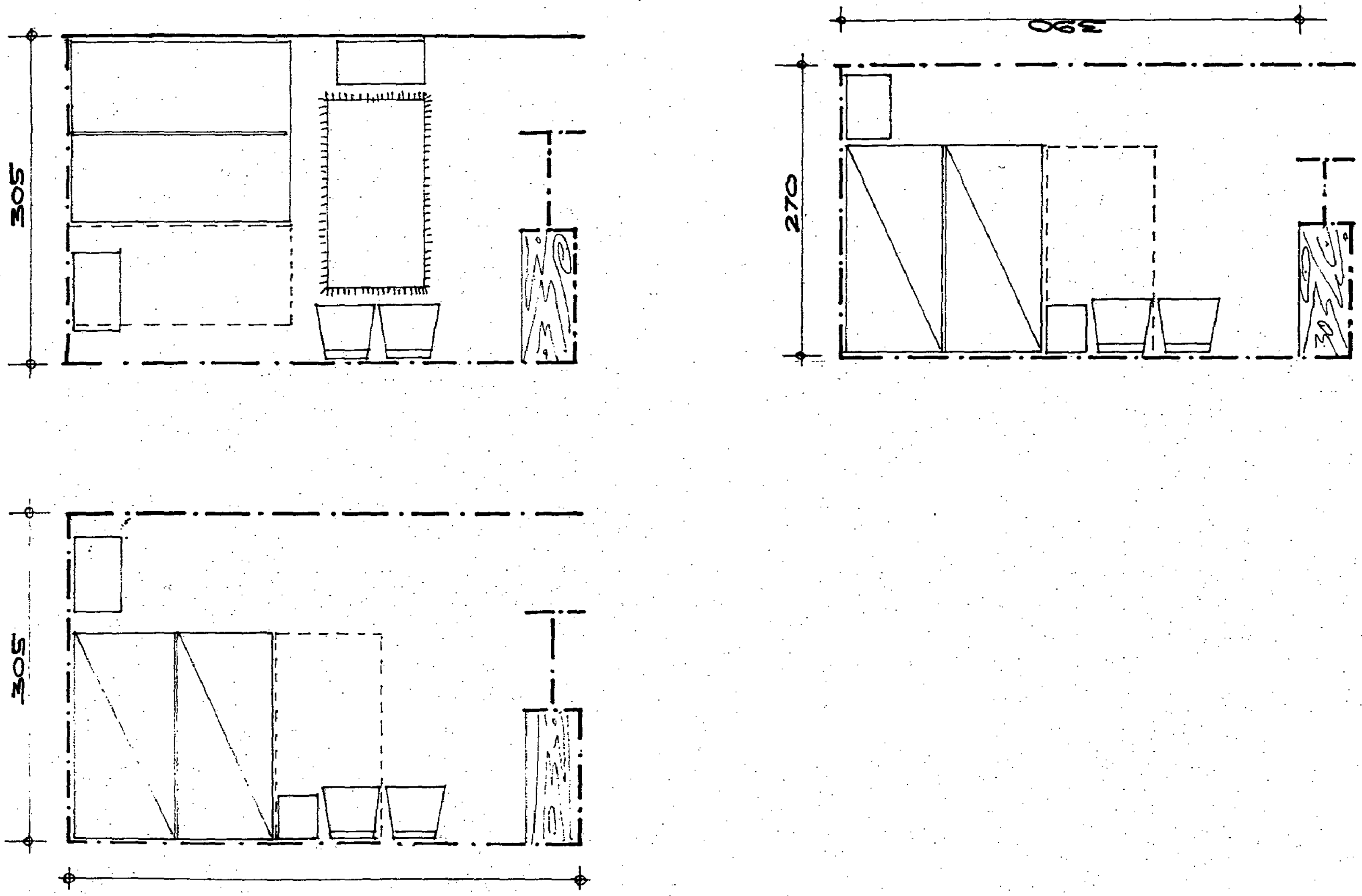


FIG. S1AS-1

Scientist
Apartments
(2 ROOM)
DRAWING RM.

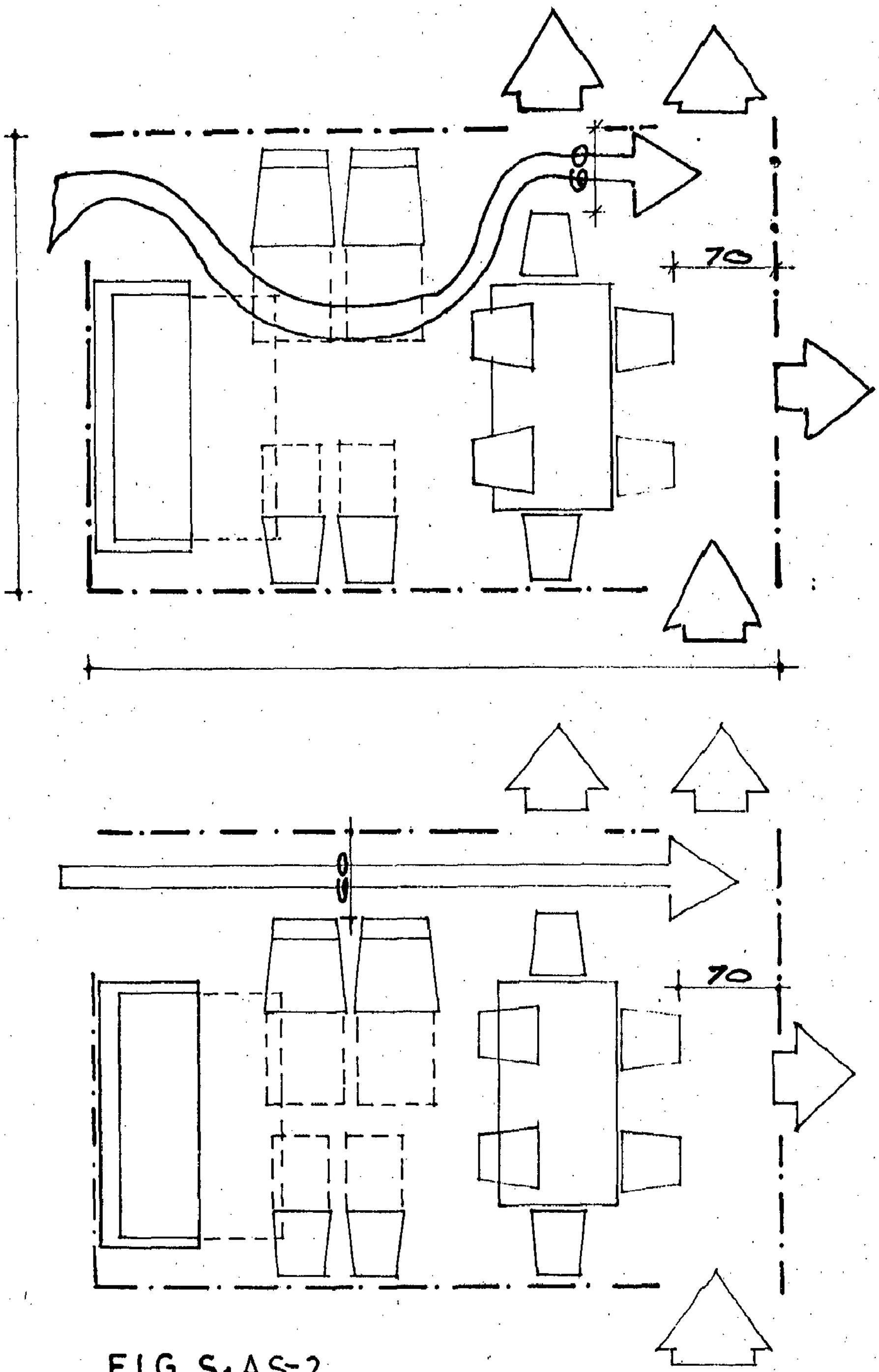


FIG S_1AS-2

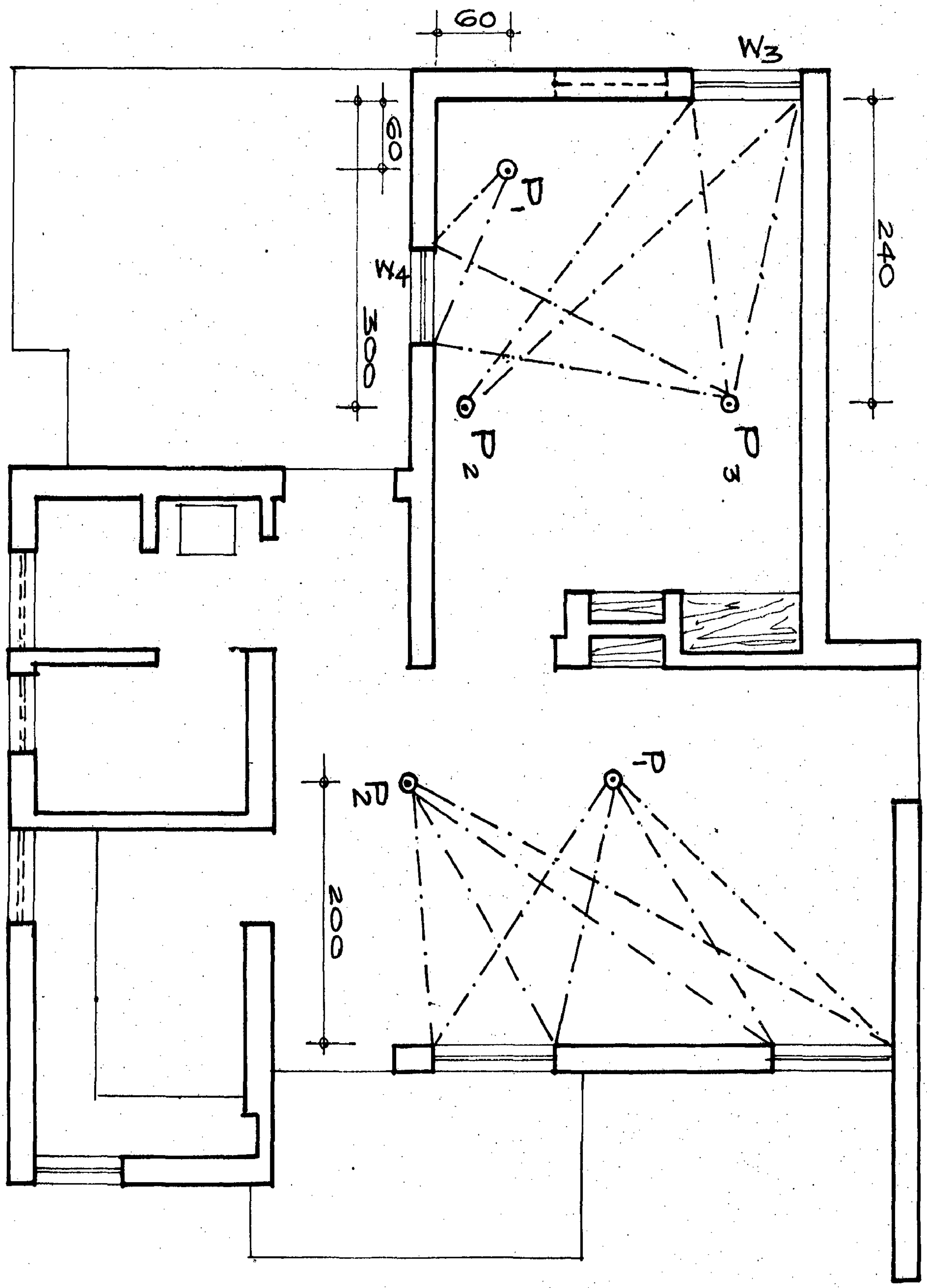
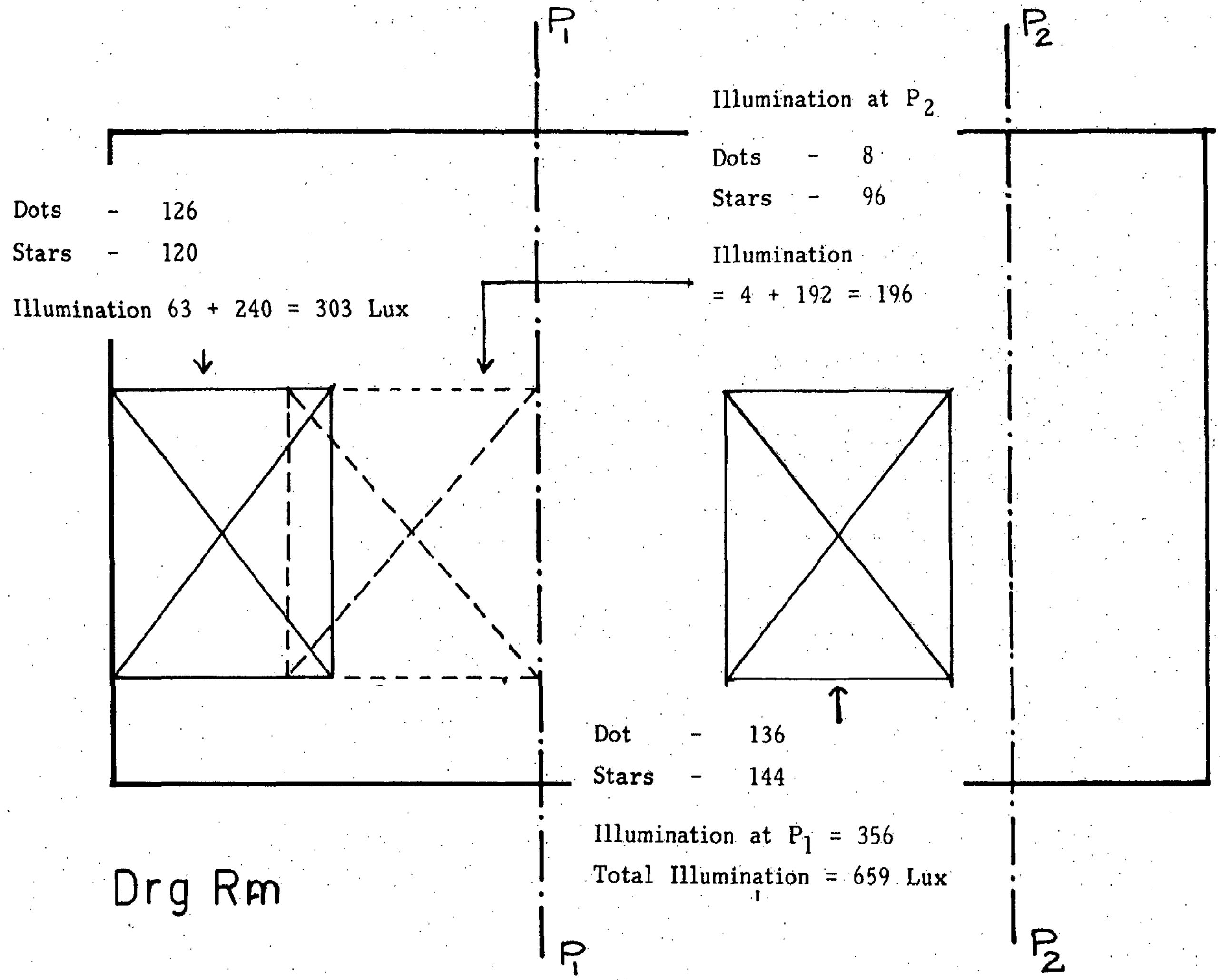


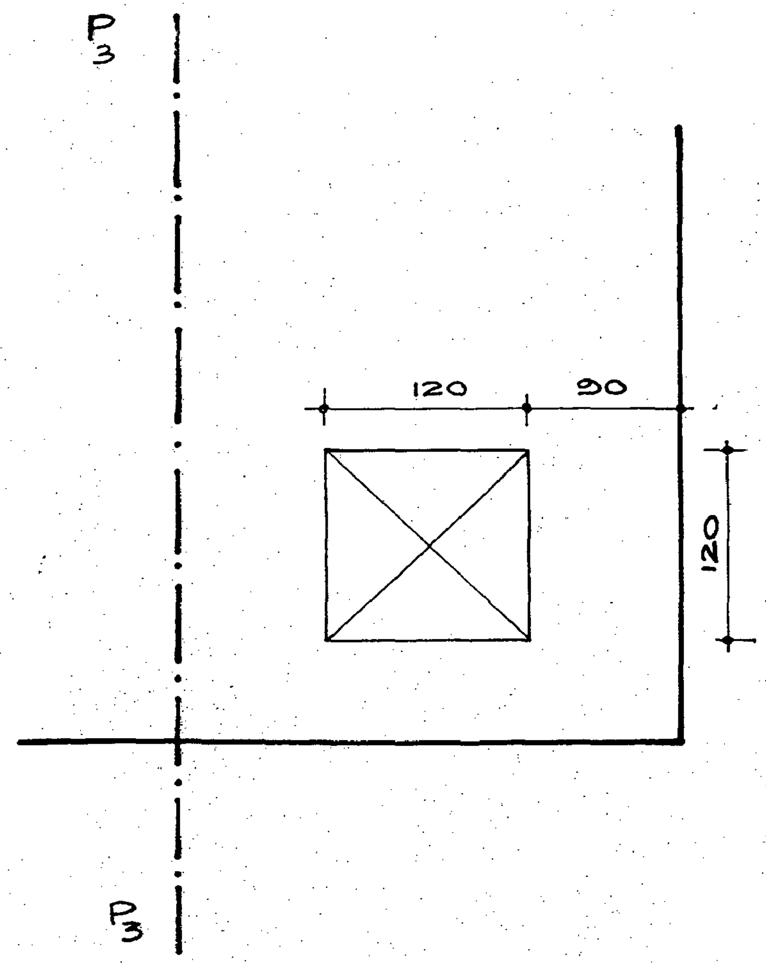
Fig SSL-2
Scientist Apartments
(2 Room)



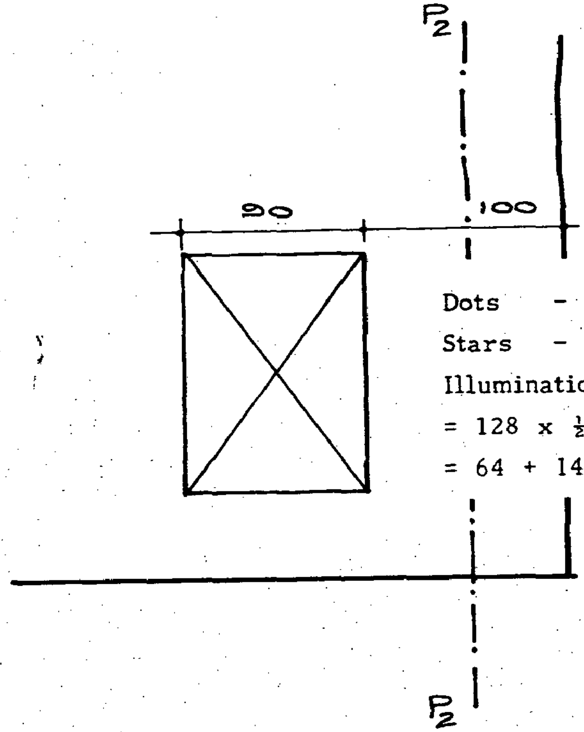
Study shows that by providing two windows, 659 Lux illumination has been received at P_1 which is not desirable.

Fig SSL-2

Now if instead of two windows of 105 x 120 cms, only one window of size 120 x 120 is provided, then even at the farthest point that is P_2, 192 Lux illumination is received which is more than desirable in a living room. This has further proved that 1.44 sq.m. window area is sufficient than 2.52 sq.m for day light function, thus resulting in the cost saving.



Dots - 96
Stars - 64
Illumination
$= 96 \times \frac{1}{2} + 64 \times 2$
$= 48 + 128 = 176$ Lux



Dots - 128
Stars - 70
Illumination at P_2
$= 128 \times \frac{1}{2} + 70 \times 2$
$= 64 + 140 = 204$ Lux

If size of w_3 is increased by 30 cm i.e. made 120 x 120 and its respective location is shifted toward centre, then as per study 170 lux illumination can be achieved at P_3 the farthest point. Thus we can avoid the window w_4 and can result in saving of cost.

Bed rm.
Fig SSL-2

Plinth height :	Average plinth height is 30 cm from ground level.
Damp proof course :	40 mm thick damp proof course in 1:2:4 cement concrete.

Walling

(i)	Length of 23 cm periphery wall	=	33.11 m
(ii)	Length of 23 cm internal wall	=	8.1 m
(iii)	Length of 11.5 cm internal wall	=	4.85 m
(iv)	Total wall length	=	46.06 m
(v)	Length of outer wall length being shared	=	Nil
(vi)	% of outer wall, to be shared	=	Nil

Ceiling height : 3.05 cm from the floor level

Roofing : Partially precast R.C.C. joists and R.C. Planks have been used in place of insitu 10 cm R.C.C. slab.

Flooring :

i)	Composition	100 mm fine sand filling over rammed earth 75 mm base concrete 40 mm thick floor finish	
ii)	Floor Finish	Drg. RM	Mosaic
		Drn. RM	Mosaic
		Kitchen	Mosaic
		Bath W.C.	Mosaic
		Bed Room	Plain cement concrete
iii)	Dado	Kitchen (Mosaic)	
		Bath (Mosaic)	
iv)	Glass Strips	Plain glass, 6 mm thick	

Architectural Planning Elements

Plan Form

Plan form is not compact as it has many effsets, more periphery wall length and less possibility of sharing outer walls as is clear from plan EP_2

Space :

Plinth area = 49.29 m^2

Floor area = As per detail

	Size	Area
. Drg. Room cum Dining Room	5.21x3.05	15.89 m^2
. Master Bed Room	3.05x3.9	11.89 M^2
. Kitchen	1.815x2.65	4.80 m^2
. Lobby	1.98x1.225	2.425 m^2
. Bath room	1.815x1.25	2.268 m^2
. W.C.	0.99x1.225	1.163 m^2
	Total	38.436 m^2

Internal unavoidable movement area = 6.945 m^2 - 17.38 %

Doors and Windows

Doors

Size	No.	Type of shutter
105x206	3	Panelled, single leaf
90x206	1	Panelled, -do-
75x206	3	Panelled, -do-

Windows

Size	No	Type of shutter
105x122	2	Panelled
90x122	1	Panelled
75x122	1	Panelled
75x90	1	Panelled

Combination of Units and Layout

- One block consists of four dwelling units being served by one staircase.
- All external walls are independent, not shared.
- It is a cluster type layout with community space in the centre.
- There are eight blocks located independently, with the result there is increase in road length and number of sides adding to the plastering and masonry work.

Services

Sanitary and Water Supply (for two dwelling units)

• Length of waste water	=	6.5 m
• Length of soil pipe	=	5.1 m
• No. of floor traps	=	2
• No. of G.T.	=	2
• Length of vertical waste water pipe	=	6 m
• Length of vertical soil pipe	=	7.15 m
• No.of inspection chambers	=	1
• Length of G.I. pipe for water supply	=	13

Inferences

1. Due to wrong position of sink, length of waste water pipe has increased.

2. Two gulley traps have been provided, which can be reduced to one.

3. Due to independent location of blocks, separate I.C., and sanitary pipes have been provided, thus increasing the cost.

4. Due to cluster layout plan planning, the length of external service has also increased.

Electrical (for one dwelling unit)

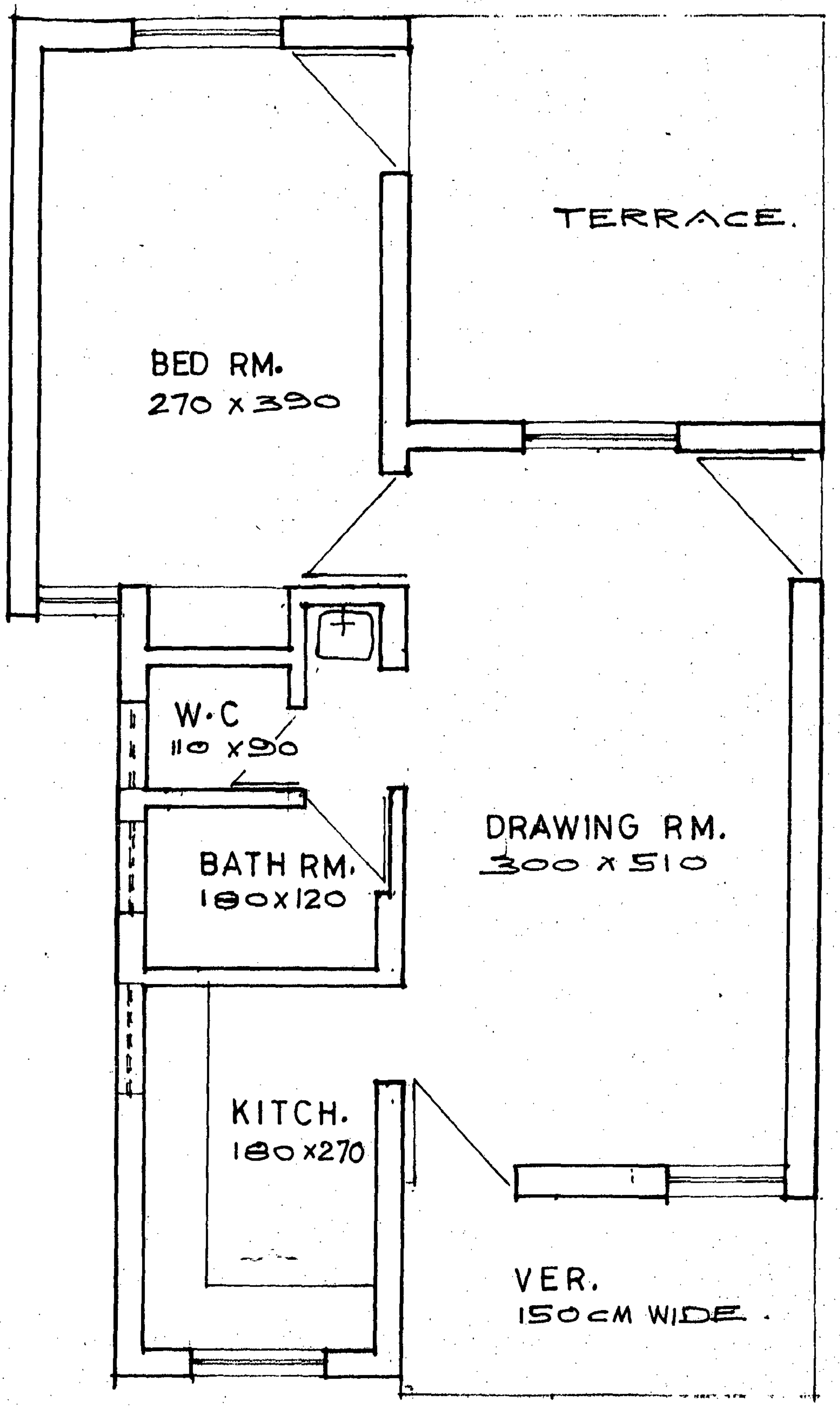
. Length of electric line from meter	=	-
. No. of wall lights	=	9
. No. of power points	=	2
. No. of 3 pin light sockets	=	3
. No. of fans	=	3

Miscellaneous

1. Width of cupboard	=	100
2. Length of 23 cm wide concrete facia over sun projection	=	

ANALYSIS WITH OPTIMUM COST PARAMETERS

A revised plan as shown in Fig. OP 2 with minimum changes keeping the optimum cost parameters into mind has been developed and analysed to prove the effective savings.


TERRACE.
BED RM.
270 x 390
W·C
110 x 90
BATH RM.
180x120
DRAWING RM.
300 x 510
KITCH.
180 x270
VER.
150 CM WIDE.

PLAN OP-2

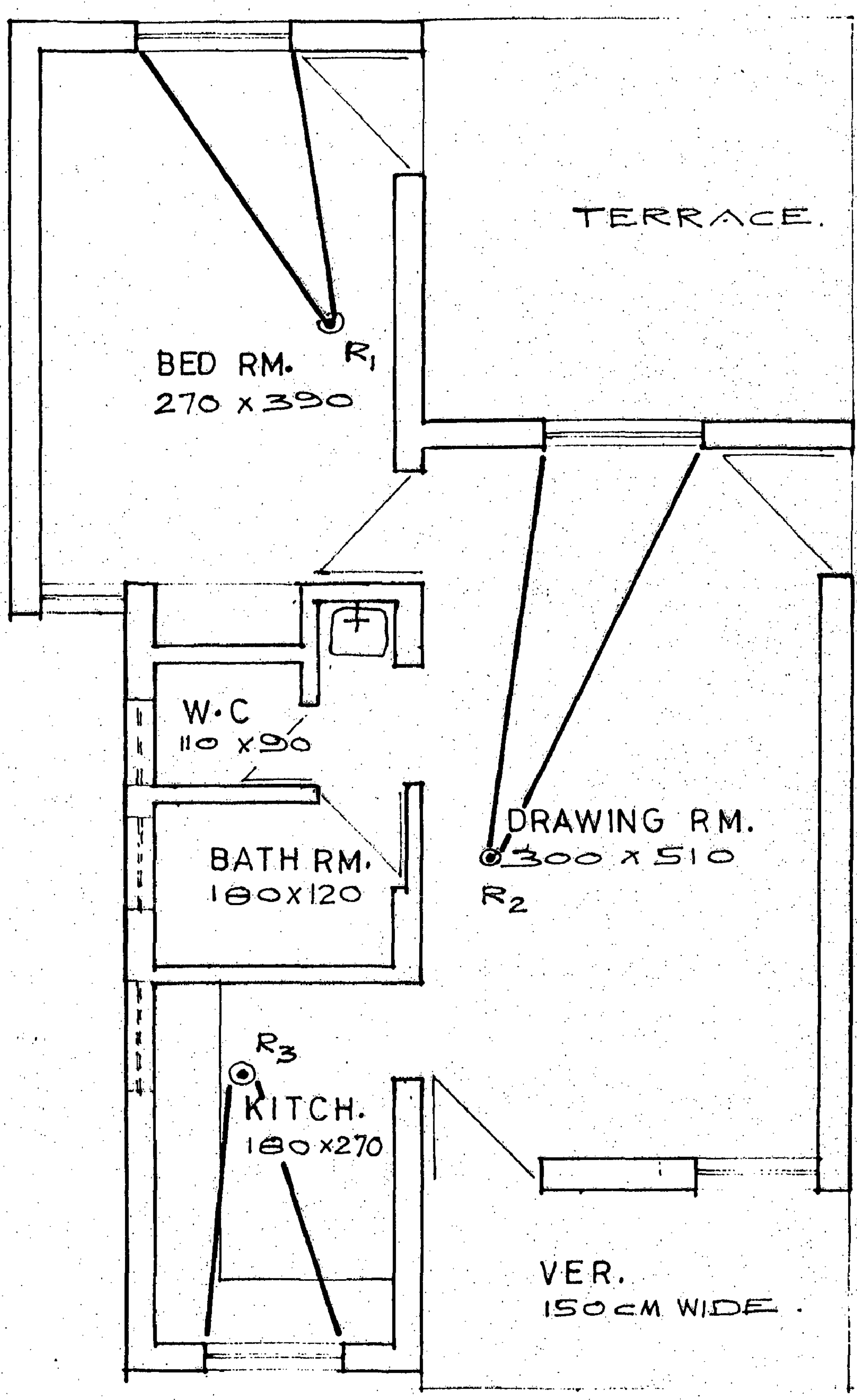
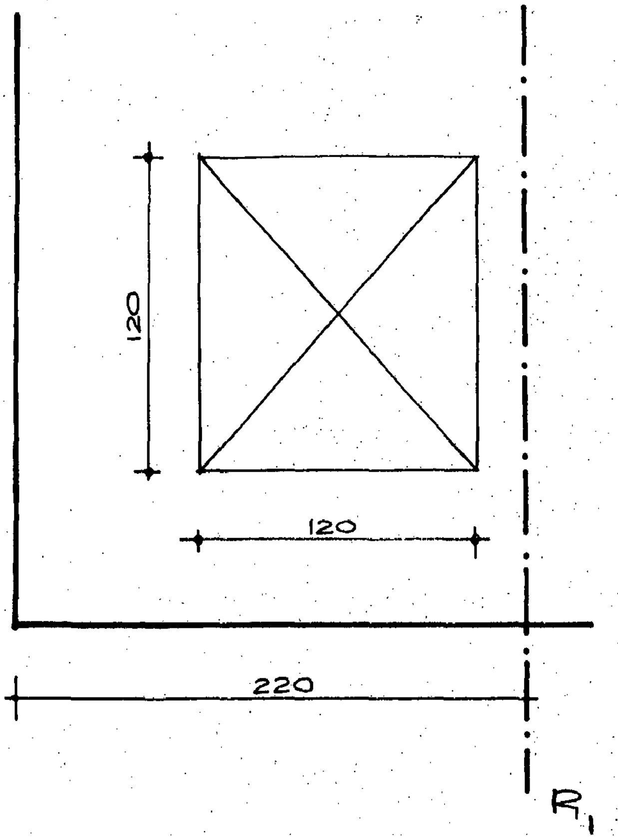

TERRACE.
BED RM.
270 x 390
R1
W.C
110 x 90
BATH RM.
180X120
DRAWING RM.
300 x 510
R2
R3
KITCH.
180 x 270
VER.
150 cM WIDE.

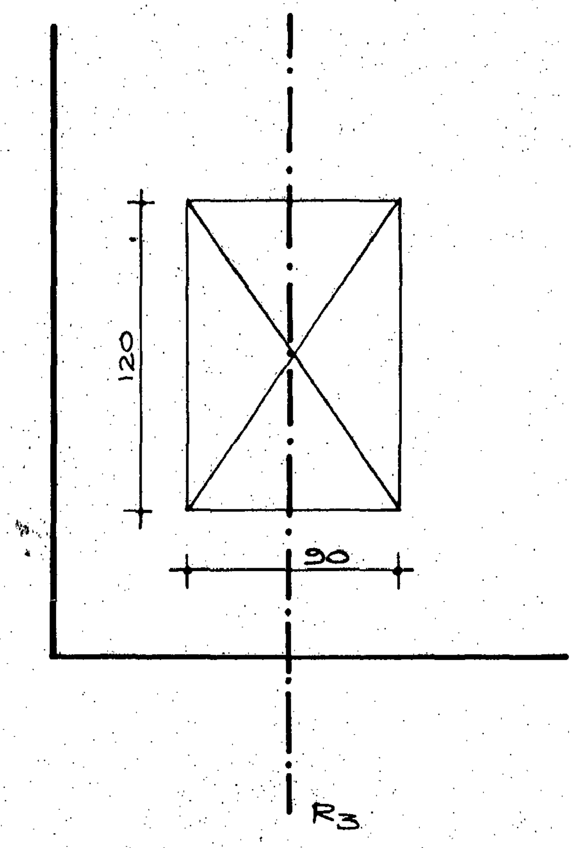
FIG OP-2

BED ROOM 270 x 390

Window Size	120 x 120
Dots	190
Stars	144
Illumination	386 Lux

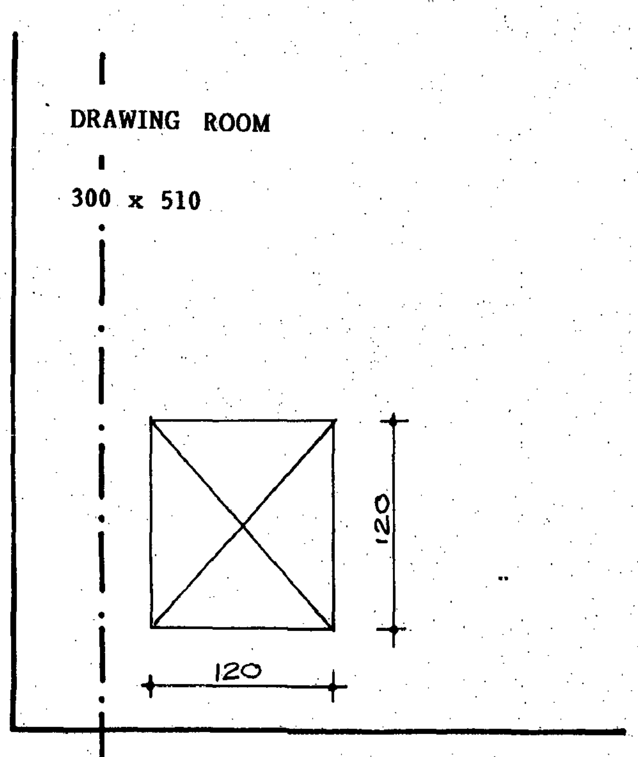
OP -2





DRAWING ROOM

300 x 510



Window size	120 x 120
Dots	124
Stars	64
Illumination	190 Lux

Analysis

Land : Due to proper selection of site, cost of filling could have been saved.

Saving : Earth filling cost

Foundation:

45 cm earth filling has increased the foundation depth from 90 cm to 135 cm, as shown in the figure.

Increased quantity or saving per dwelling units :

Material	Savingin quantity	Unit	Saving in Rupees
Brick	2346	No	1173
Cement	63.48	Bag	4443.6

Plinth height

30 cm from ground level

So, no saving due to this element.

Damp Proof Course (1:2:4)

Suggested optimum thickness of damp proof course is 2.5 cm

Saving : 40 %

Material	Saving in quantity	Unit	Saving in Rs.
Cement	1.25	Bag	87.5

Walls (Superstructure)

(i)	Length of 23 cm periphery wall	=	31.02 m
(ii)	Length of 23 cm internal wall	=	6.0 m
(iii)	Length of 11.5 cm internal wall	=	5.43 m
(iv)	Total wall length	=	42.45 m
(v)	Length of outer wall length to be shared	=	4.36 m
(vi)	% of outer wall to be shared	=	14 %

Saving in total wall length = 3.61 m

% saving = 7.8 %

Saving in terms of main material like cement and bricks :

Material	Saving in quantity	Unit	Saving in Rs.
Brick	1117	No	2234
Cement	30	Bags	2100

Ceiling ht. = 270 m, 1 bag cem. = Rs. 70/-
500 Nos BK = Rs. 1000/-

Ceiling Height

Suggested optimum ceiling height is 2.7 m

Saving = 30 cm

% Saving = 10

Saving in terms of material cement and bricks

Material	Saving in quantity	Unit	Saving in Rs.
Brick	1460	No	2920
Cement	39	Bag	2733

Roofing :

Partially precast R.C.C. roof has been used in place of conventional R.C.C., R.B.C. or R.B. roofing which is about 20 % cheaper.

Flooring

i) Composition : Same as given, so no further saving.

ii) Floor Finish : P.C.C. flooring for drg. room and dining room considering that most of the floor is covered with carpet and interior furniture. As mosaic finish in floor is four times expensive than P.C.C. finish, so considerable saving can be achieved. Use of 3 mm glass strips in place of 6 mm will give further saving.

This will result in saving in flooring and roofing considerably.

Saving in floor area = 4.68

% saving = 11.7 %

Doors and Windows

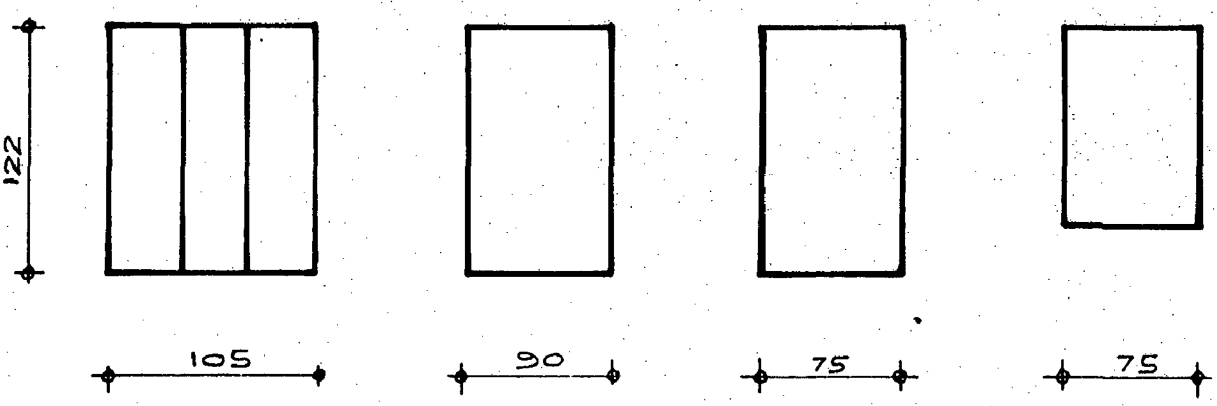
Doors

Sl.No.	Frame size	Sect. size	No.	Single leaf panelled
1	100x200	12.5x6.5	2	Single leaf panelled
2	90x200	12.5x6.5	1	''
3	90x200	10.0x6.5	1	''
4	75x200	10.0x6.5	2	''

Saving = 0.068 M^3

% saving = 24.9 %

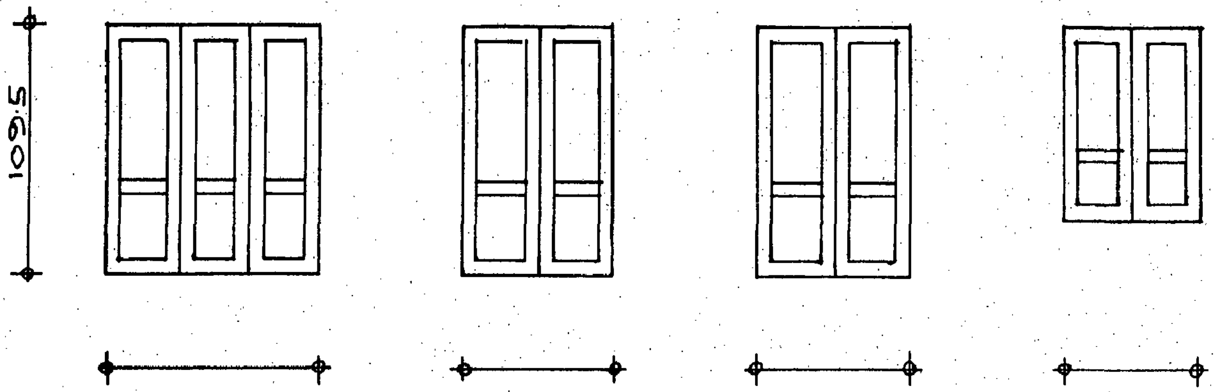
FRAMES



0.1088 0.033 0.037 0.0257

Total = 0.1982

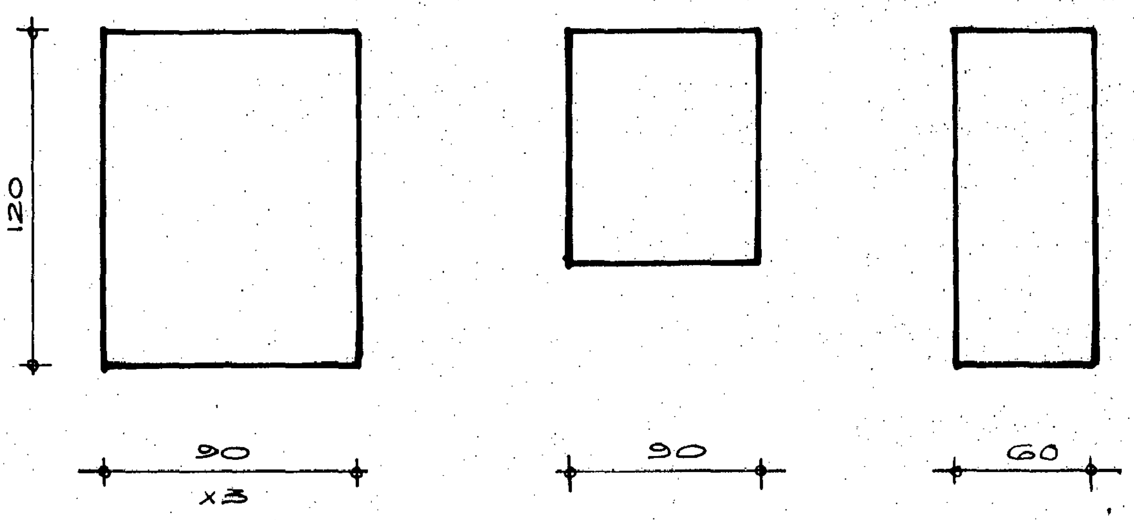
PANELS



0.0729 0.028 0.025 0.0199 m^3

Total = 0.8007 M^3

FRAMES

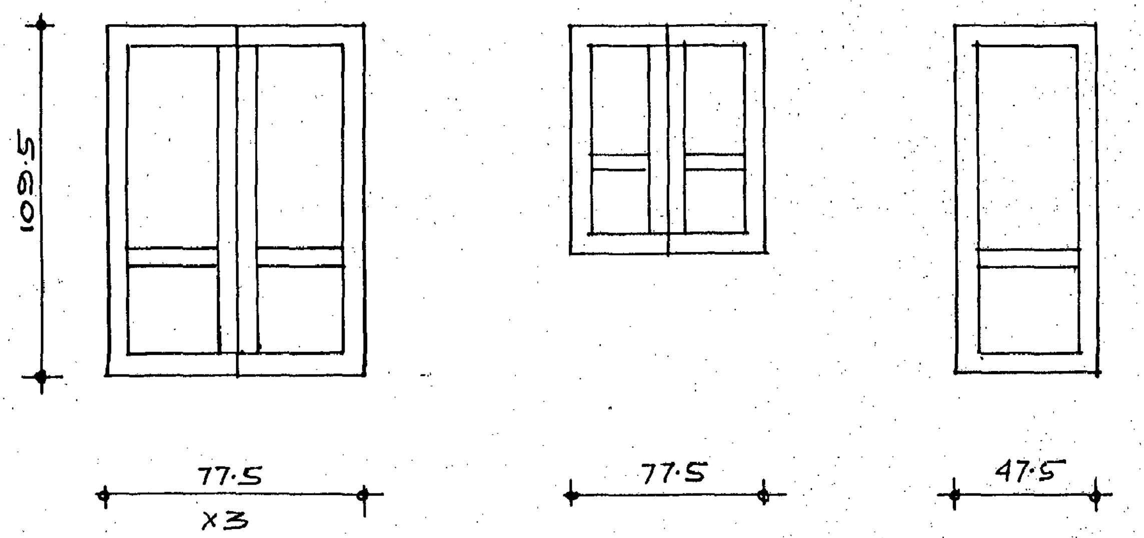


0.0398 0.028 0.028 M³

Total = 0.154 M³

Saving = 0.0442
Saving % = 22.3

PANELS

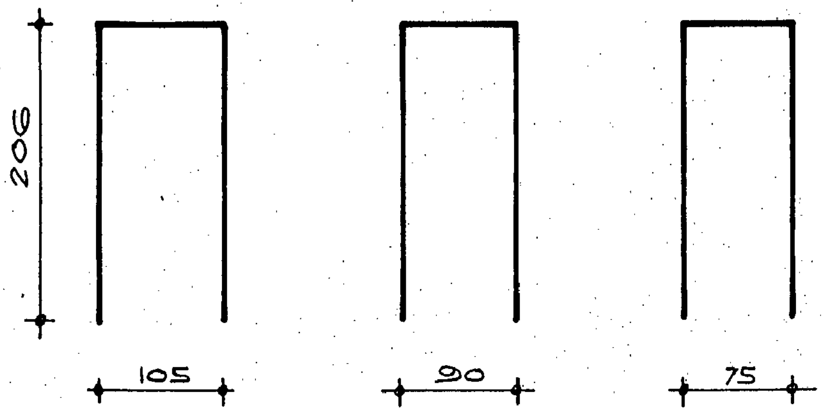


0.531 0.0139 0.0094 M³

Total = 0.5543 M³

Saving = 0.2464 M³
Saving % 30.7

FRAMES

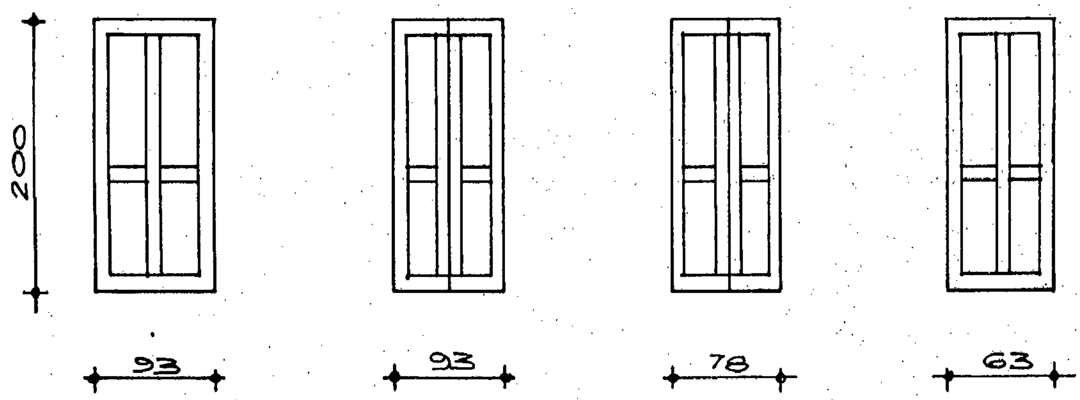


Size	No.
105 x 206	3
90 x 206	1
75 x 206	3

0.12 0.039 0.1139 m^3

Total = 0.273 m^3

PANELS

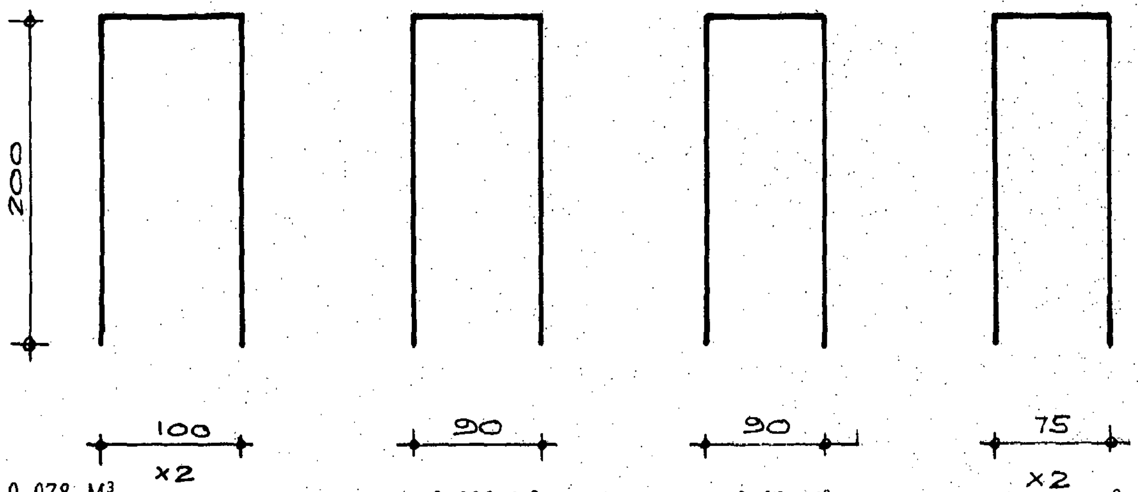


0.066 0.043 0.033 0.09 m^3

Total = 0.229

FRAMES

12.5 x 6.5   12.5 x 6.5   10 x 6.5   10 x 6.5



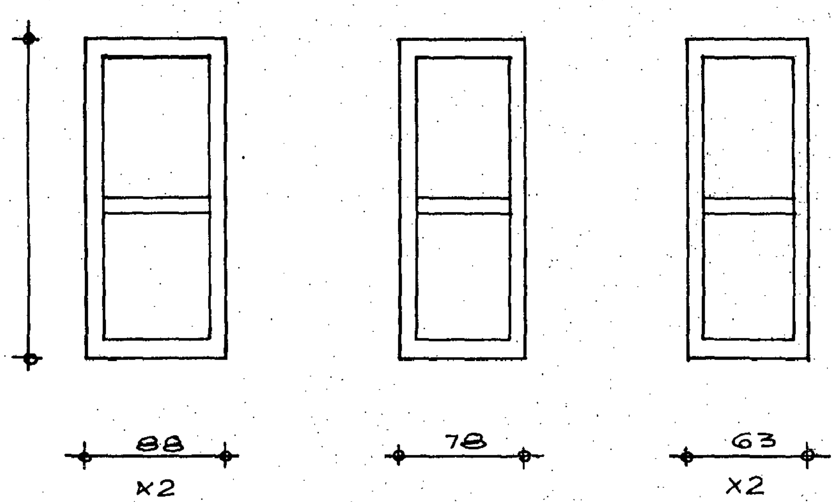
0.078 M^3 0.038 M^3 0.03 M^3 0.0593 M^3

Total = 0.205 M^3

Saving = 0.068 M^3

Saving % = 24.9 %

PANELS



0.0634 M^3 0.0598 M^3 0.0544 M^3

Total = 0.1776 M^3

Saving 0.0514 M^3

Saving % = 22.41

Shutter Design

Saving :

Total wooden quantity = 0.1776

Saving = 0.0514

% Saving = 22.4

Windows

Sl.No.	Size	Section	No.	Type of shutters
1	90x120	3.5x7.5	3	Panelled
2	90x90	3.5x7.5	1	Panelled
3	60x120	3.5x7.5	1	Panelled

Frame Size :

Saving :

Total wooden quantity = 0.154 m^3

Saving = 0.044 M^3

% saving = 22.2 %

Shutter Design

Saving : Total wooden quantity = 01554 M^3

Saving = 0.2464 M^2

% saving = 30.7 %

Dado in the kitchen can be avoided.

Architectural Elements

Form of new plan developed is more flexible with the possibility of sharing wall, This can result in more saving.

Saving in one dwelling unit

Length of additional shared wall = 4.36 M

% length of shared wall = 14 %

Material	Saving in quantity	Unit	Saving in Rs.
BK.	1100	No.	750
Cem.	3	bag	210

HT. = 2.7 m

Space :

Area	Size	Area (M^2)
B.R.	2.7x3.9	10.59
Drg.cum Dining	3.00x5.10	15.3
Kitchen	1.8x2.7	4.86
Bath	1.8x1.2	2.16
W.C.	1.1x0.9	0.99
Wash Basin	1.35x0.6	0.81
Lobby/Cupboards	1.1x0.5	0.55

Combination of Units and Layout

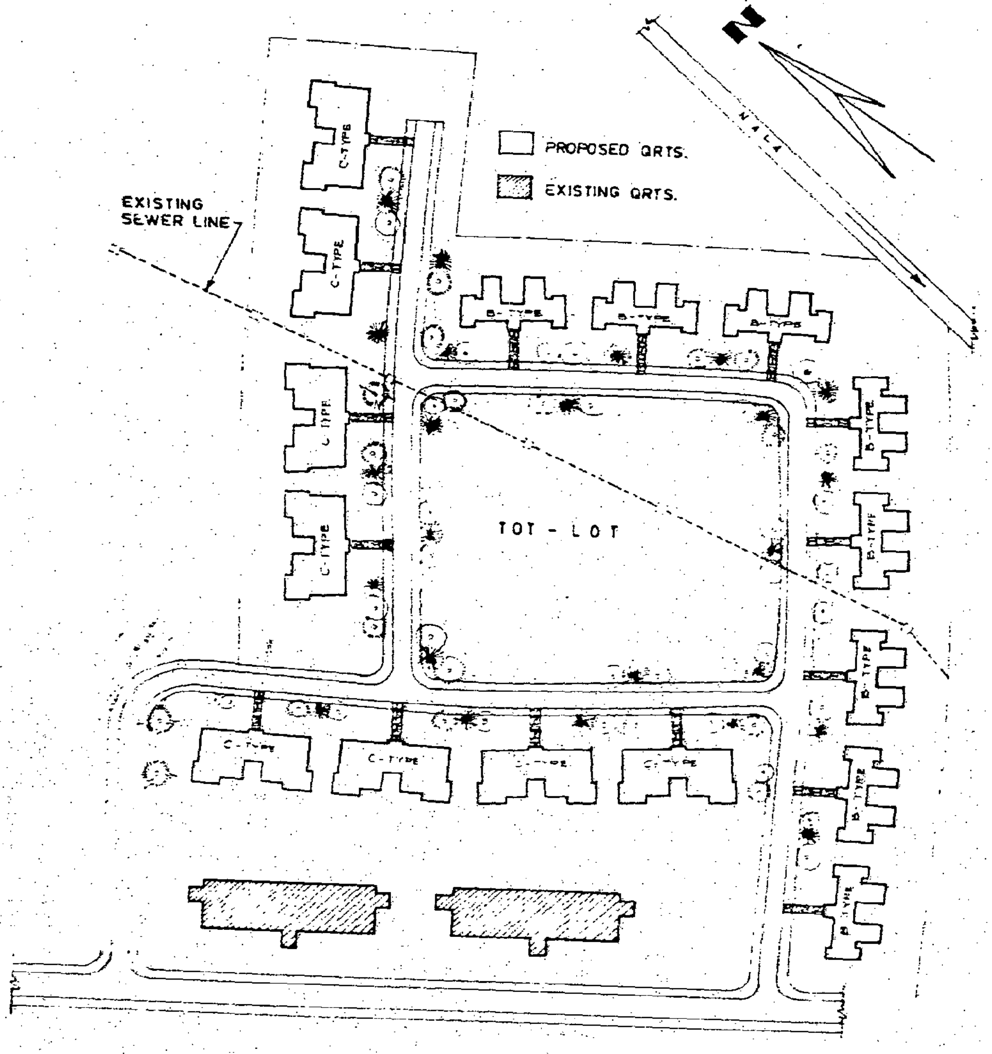
Revised layout plan has been developed with same cluster concept keeping the cost reduction parameters into mind, as shown in figure OL-2

Saving :

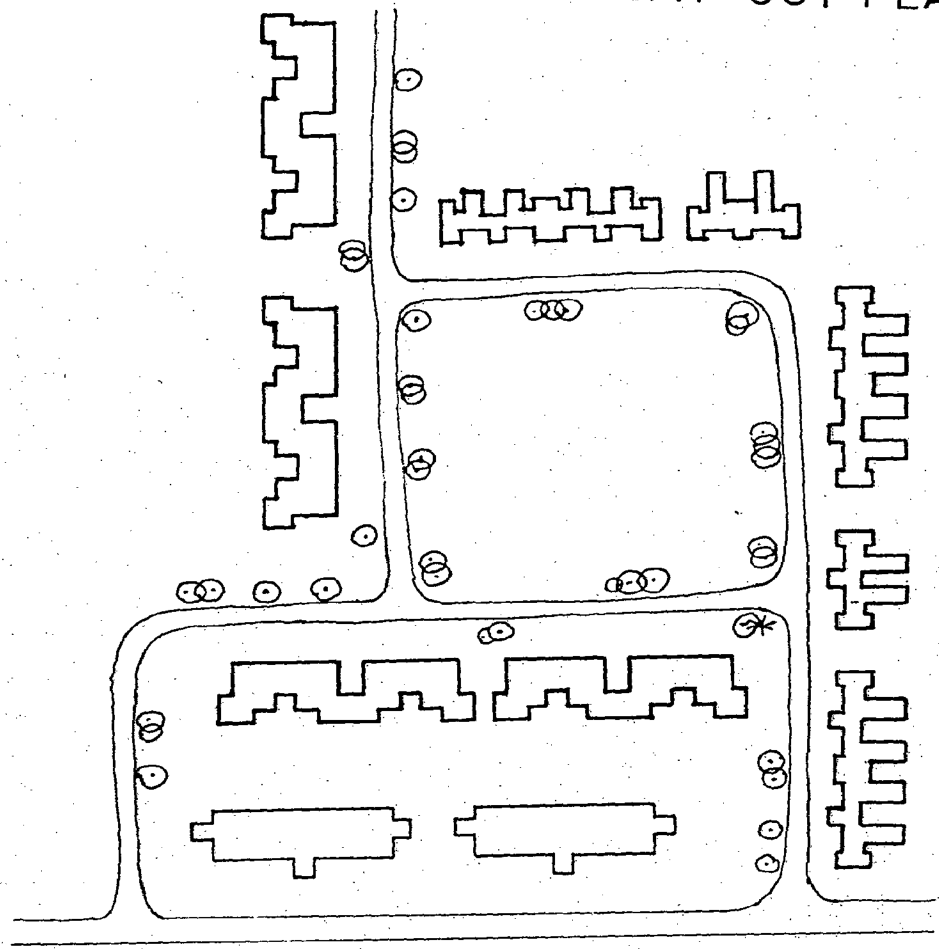
1. Due to sharing of wall and clubbing of three blocks in a row, road length has been decreased.

P/121

LAY OUT PLAN



L-1



OL-1

2. Due to sharing of walls, there is substantial saving in material like Brick and cement as stated below.

Total length of shared wall = 13.08 m

Saving due to sharing = 18.75 %

Saving in material like BK and cement

Sl.No.	Material	Saving in quantity	Saving in Rs.
1	Brick	3300	2250
2	Cement	9	630

CHAPTER-8

CONCLUSIONS AND RECOMMENDATIONS

Though the inferences have been given at the end of analysis of elements, conclusions in the form of guidelines are as followed :

1. Land selected for the house construction should not be low lying and should be free from undulations.

2. Design of foundations is governed by the soil bearing capacity and load of structure. So while deciding about the future expansion of building, the factor vertical expansion must be kept intommind as cost of foundation increases in the initial stage itself. So house builders should be definite about the future, planning. For the average double storeyed house with good bearing capacity soil, 60x75 cm foundation size has been recommended for this region. It has been proved that cost of foundation may increase by 15% to 20% properly designed foundations are not used.

3. Plinth height in the residential buildings should not be more than 30 cm. However, it may be reduced to 15 cm in case of E.W.S. category. Due to this, saving upto 25% can be achieved.

4. 25 mm thick, 1:2:4 cem.conc. damp proof course is sufficient. The thickness above this will only increase the cost upto 20% can be reduced in this component of building.

5. As 34% of the building cost is consumed by walls, so this element should be given due care. No. of internal walls, thickness of wall total wall length, common wall length are some of the parameters which should be properly considered. So plan should be as compact as possible.

   With due considerations of this parameters, saving upto 30% can be achieved.

6. 2.7 cm optimum height of ceiling is recommended as it satisfies the fan height as well as thermal condition to a desirable limit. Height beyond 2.7 m is undesirable and will simply affect the cost.

7. There should be as minimum offsets is a building as possible as this will increase the wall length. Thus consuming more searce material like brick, cement.

8. Width of room should be 2.7 m for bed rooms and 30 m for living room.

   If it is only one room dwelling unit i s E.W.S., width can be reduced to 240 cm but in that case there should be minimum doors opening inside the room.

9. In case of E.W.S., elongated rooms with width 2.4 m are more useful than the square rooms with same area.

10. For one room dwelling unit, size of kitchen should be 2.4x1.5 or 1.8x2.4 m. And for two room and three room dwelling units 2.7x1.8 and 2.7x1.8 respectively. The

kitchen with more than 2.7x1.8 m size will add more in cost than the function.

11. Size of cupboard should be governed by the width 0.9 m and 1.2 m. 0.9 m width of cupboard is more recommended as its shutters will cover less space.

12 Cupboards are costly items. There should not be more than one cupboard of width 0.9 m or one room.

13 Cupboards should be located near the entrance door and along the unavoidable movement area.

14 The room sizes are guided by the sitting capacity, type of furniture and room function. Following sizes for different type of rooms are recommended.

<u>One Room Dwelling Unit</u>

Multi purpose room	2.4x4.2
	2.7x3.75
Kitchen	2.4x1.5
	2.7x1.5
W.C.	0.80x0.11
Bath	1.2x1.2

<u>Two Room Dwelling Unit</u>

Drg. Room	2.7x3.9 m
Bed Room	2.4x3.9 m
	2.7x3.3 m
Kitchen	1.8x2.4 m

Bath	1.2x1.5
W.C.	0.8x0.11

Three Room Dwelling Unit

Drg. Room		3.0x3.9
Dining Room		
Master bed room		2.7x3.9
Children bed room		2.4x3.6
	or	2.7x3.3 m
Bath		1.2x1.5
		1.2x1.8
W.C.		1.8x0.11 m

15. Following clubbing of units shall be more economical for various categories.

E.W.S. (1) Combination of four units with central courtyard and front open.

(2) Combination of units with partial rear yard and front open.

L.I.G. (1) Combination of four units with partial rear yard and front open.

(2) Combination of two units with partial rear yard and front open.

M.I.G. (1) Combination of two units with partial rear yard and front open.

(2) Combination of two units with full rear yard and front open.

(3) Combination of two units with rear yard, partial side and full front open.

16 <u>Doors and Windows</u>

a) There should be as minimum internal doors as possible.

b) Door in the kitchen and door between drg. room to multi purpose room or lobby can be avoided.

c) Angle iron frames are more economical than the wooden frames.

d) Sections of wooden frames of all internal doors and single rebated windows should be 6x10 cm where as wooden section of all double rebated frames of doors and windows are recommended as 6 cm x 12 cm.

17 Doors with single panel or maximum two panels are more economical.

18 Single leaf panel door is more economical than double leaf panel door.

19 A substantial cost can reduced by locating the windows with reduced size in the centre of the room.

20 Ventilators above windows located in the windward direction are not effective and simply increase the cost and should be avoided. Ventilators opposite to windows above doors or windows are functionally more useful.

21 If windows are designed as per room size and internal furniture layout, substantial saving can be achieved.

22 Row type layout is economical than cluster type layout as road length and wall length is largely shared in the previous case.

So in the case of E.W.S. and L.I.G., row housing concept should be recommended to reduce the building and and development cost.

23 Services should in combined and near to each other as possible as it will greatly reduce the pipe length.

24 One way span roofing is more economical than two way span for E.W.S. category where only single storey construction is being suggested or where no intermediate walls are proposed.

25 For mass housing programmed prefabricated units are economical than conventional R.C.C. or R.B. slab.

In areas where bricks are of very good quality, R.B. or R.B.C. roofing is economical than R.C.C. roof.

26 Mosaic finish in flooring is four times expensive than the ordinary cement flooring. It has also been observed that most of the area is occupied by the furniture and carpet in the rooms of M.I.G./H.I.G. categories. So use of mosaic finish for these category of houses is undesirable and should be avoided.

Saving due to this will enable the planners to provide floors to houses of E.W.S. category which are being denied of this element at present. If it becomes very necessary to provide mosaic flooring to MIG/HIG it should be limited to kitchen, W.C., Bath and Drg/Dining, Kitchen, W.C., bath in the case of M.I.G., H.I.G./ respectively.

B I B L I O G R A P H Y

1. Housing a factual analysis by Beyer.

2. Economics of Housing by Lieonel Need leman, a Lecturer in Economics, the London School of Economics.

3. Housing, the social and economic Elements by Wallace F. Smith, University of California Press Berbeley and Los Angeles, 1970.

4. Low-Income Housing-Technology and Policy proceedings of the International Conference on Low-income Housing-Technology and policy in Bangkok organized by Asian Institute of Technology June 1977.

5. Papers submitted in the Fourth Afro-Asian Housing Congress held in New Delhi India, from 24-30 Nov. 1975.

6. Proceedings International Conference on Low cost housing for developing countries, Nov. 12-17, 1984 in C.B.R.I., Roorkee, India.

7. Report of 'The Development group on Low cost Housing including minimum economic specifications', Sept. 1977.

8. Housing the Family M.T.P. Constraction 1974.

9. Design with climate by OLGYAY

10 Climatelogical and solar Data for India related to Ventilation.

11 Estimating and costing by K.L.Datta.

12 Housing and Urban Development in Uttar Pradesh, 1980

13 Low cost Demonstration Houses, organised by Delhi Development Authority and National Building Organisation, New Delhi.

14 Housing in Relation to resources and to the developing Economy, Housing Convention organised by N.B.O. and Indian Institute of Architects 1969.

15 Current Housing and Building Statistics 1979-80, Monograph on Housing Situation in India by N.B.O.

16 Three Decades of Building Research in India, Dinesh Mohan Volume.

17 Government policy for the management of public enterprises, a scope publication.

18 Significance of Housing, information and data Brochure by N.B.O.

19 Design and Research Series by HUDCO on comparative cost studies and Analysis.

20 Lectures on Housing by Shamsher Prakash.

21 Report of the Expert Panel constituted by the Minister of state of works and Housing for evalving Guidelines for reduction in the cost of Buildings.

22 Current housing and building statics, 1979-80, Statistical tables pvt. Sectors.

23 CHAR APNA, HUDCO PRAKASHAN, 1983-84.

24 C.B.R.I. Building Digests and Research Notes.

- Design for day lighting
- Climate and environmental zones for India
- Climate design data and its application (Hot and dry region)
- Thermal considerations in building design
- Design of windows for natural ventilation in tropies
- Guidelines for designing airy buildings.
- Man power and material requirements in residential buildings
- Man power and material requirements for building services.
- Thin R.C. Ribbed slab for floors and roofs.
- Channel units for floor/roof.
- Precast RCC plank flooring/roofing scheme
- Precast stone masonry block walling scheme
- Single stack system of building drainage
- Plastic pipes for water supply and drainage in buildings.
- Precast brick panel system for roofing.
- Zonewise economic specifications for building construction.