DESIGN OF AN INSTANT SHELTER
(INSTANT STRUCTURE)

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Design of an Instant Shelter
(instant structure)

by Sanjay Ektate

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Diploma project

Design of an Instant Shelter
(Insta-nt Structure)

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1. Introduction

Shelter ranks amongst the three basic needs of a human being. Although architects have tried to improve the living conditions in buildings and houses for the last few centuries, few attempts were made to improve the conditions of smaller houses or huts or that of instant shelters or rescue shelters as they are sometimes called. The instant shelters are needed for construction workers (such as working for building big dams, telephone and high-tension lines, building workers) for military purposes where they can serve as semi-permanent posts (instead of the usual tents) or for refugees fleeing from flood havoc or earthquake etc.

The attempt, therefore, is to design a shelter which can be used for a period of more than one year, which can be erected very easily with better living conditions (e.g. improved ventilation) than the usual huts, or design a system for building a better shelter, complex.

2. Problem Statement

To design an instant shelter

(Portable instant structure)

3. Need for Design

The need for instant shelter arises from two different facts

The first being that the construction workers have to build their own shelter everytime they move to a new site and dismantle the old one which causes some loss of material also. At the same time they are neither hygenic or comfortable.

The shelters usually built are of semi-permanent nature from material point of view. So they are not dismantled and form huge slum colonies in an area which was previously an open ground causing suisance to the surrounding area and people. They also deprive the city of some very productive (valuable) business or commercial area (around high rise structure). This will not be so if the instant structure is erected and dismantled by the contractor

Another important need is that the refugees of various kinds who have lost their homes e.g. persons displaced due to floods, earthquakes, storms, for political reasons (Bangladesh refugees) etc.

since these refugees do not have any shelter they must be provided with shelters which will shelter them for about an year and the shelter should be also an instant one because the above said natural conditions render the situation very critical.

Another need is that for the military purposes which needs a more critical evaluation than this to come to any conclusion.

4. Information.

4. 1 Hutment dwellers

Most of the huts' occupants are immigrants to the cities from the village areas, or are villagers living in the villages.

The average family size of a hutment dweller is five.

Both male and female hutment dwellers work either as casual labour or as housemaids.

They are economically backward hence they prefer to use a temporarily built hut on a construction site as a permanent shelter.

4. 2 - Huts

Huts get flooded during the monsoons. The roof and the walls drip. So usually such areas are covered with plastic films. There is little ventilation as such inside a hut It is very smoky and hot inside the hut while cooking. Lighting and sanitation inside a hut is very poor. Sleeping problem is solved by sleeping on a dry surface specially elevated platform or concreted surface.

Fireplace is usually in a corner. The space inside a hut varies from 180 Cms.x180Cms.x135 Cms. to 360 Cms x 600 Cms.x 240 Cms.

The storage is usually in the form of trunks, shelves or tables.

The most usual shape of a hut is rectangular or a square shape. The others are circular, semicircular, polygonal and triangular.

Costs of Huts:

Wooden Post + Bamboo matting Hut-

240 Cms. x 240 Cms.x 240 Cms.= 110 Rs.

Wooden Posts + Bamboo matting hut

300 Cms.x 300 Cms.x 240 Cms = 150 Rs.

Mud Hut :

240 Cms.x 240 Cms. x 210 Cms = 70/- to 80 Rs.

Mud hut -

240 Cms.x 300 Cms. x 210 Cms.= 100 Rs.

Mud Hut

300 Cms. x 450 Cms. x 210 Cms. = 150 Rs.

Canvass- N.C.C. or camping type tents -

1000 Rs. to 1500 Rs.

Triangular Canvass tents 300 Cms.x 300Cms.-360 = 900 Rs.

4.3

Information about refugees and shelters provided to them.

Refugees belong to the following categories:

A) Earthquake victims

B) Flood victims

C) Cyclones/storm victims

D) Political victims

E) People displaced during slum development programmes.

Instant shelters provided to the refugees are of the following types :

1) Triangular tent type with canvass

2) Arch type canvass tent (also dome type)

3) Polyurthene foam domes.

- The instant shelters in most of the cases house the refugees for periods extending from 4 months to 2 - 3 yea rs.
- The refugees' camps because of poor sanitation, ventilation and poor lighting act as the major sources of diseases.
- Because of poor storage facilities even the edible things have to be rested on muddy ground thus creating further more unhygenic conditions.

- The needs of the refugees are similar to those of the usual hutment dwellers.
- The need of shelter for the refugees is the most urgent because the sudden deterioration of their living conditions if not made good quickly can have disastrous effect because of the natural calamities they have to face.

Temporary shelters used by military personnel are mostly tents made of canvass. A few other types of semi-permanent shelters are made from corrugated iron sheets, which are either usual but type or barrel vault type in section.

The temporary shelters are needed for temporary camps when a big group of army personnel is on move or for training reserves. The semi-permanent/temporary shelter also serve as command posts and offices near the border posts. However, further information is needed before coming to any conclusion about this.

4.4

Synopsis - Information

The economic condition of an Indian worker forces him to live in substandard shelter with poor lighting, poor ventilation, with little protection against rain and storms. Not only that there is not enough space inside to sit and sleep but even the outside space offers little because of a bad or lack of environmental design. This is partly due to workers' disinterest and partly because of negligence on part of contractor and the Government.

In case of refugees which many times number in millions (because of earthquakes, storms etc.) the problem is even greater. Their sudden exposition to the harsh climate leaves them defenceless against a hitherto unforeseen enemy.

To stand against such heavy odds man has been erecting shelters of various materials and of various types from very portable tents to rigid stone and lime works to suit to different needs as they arise. But even this 'centuries of struggle' has not helped man to overcome the harsh nature completely.

5. ANALYSIS

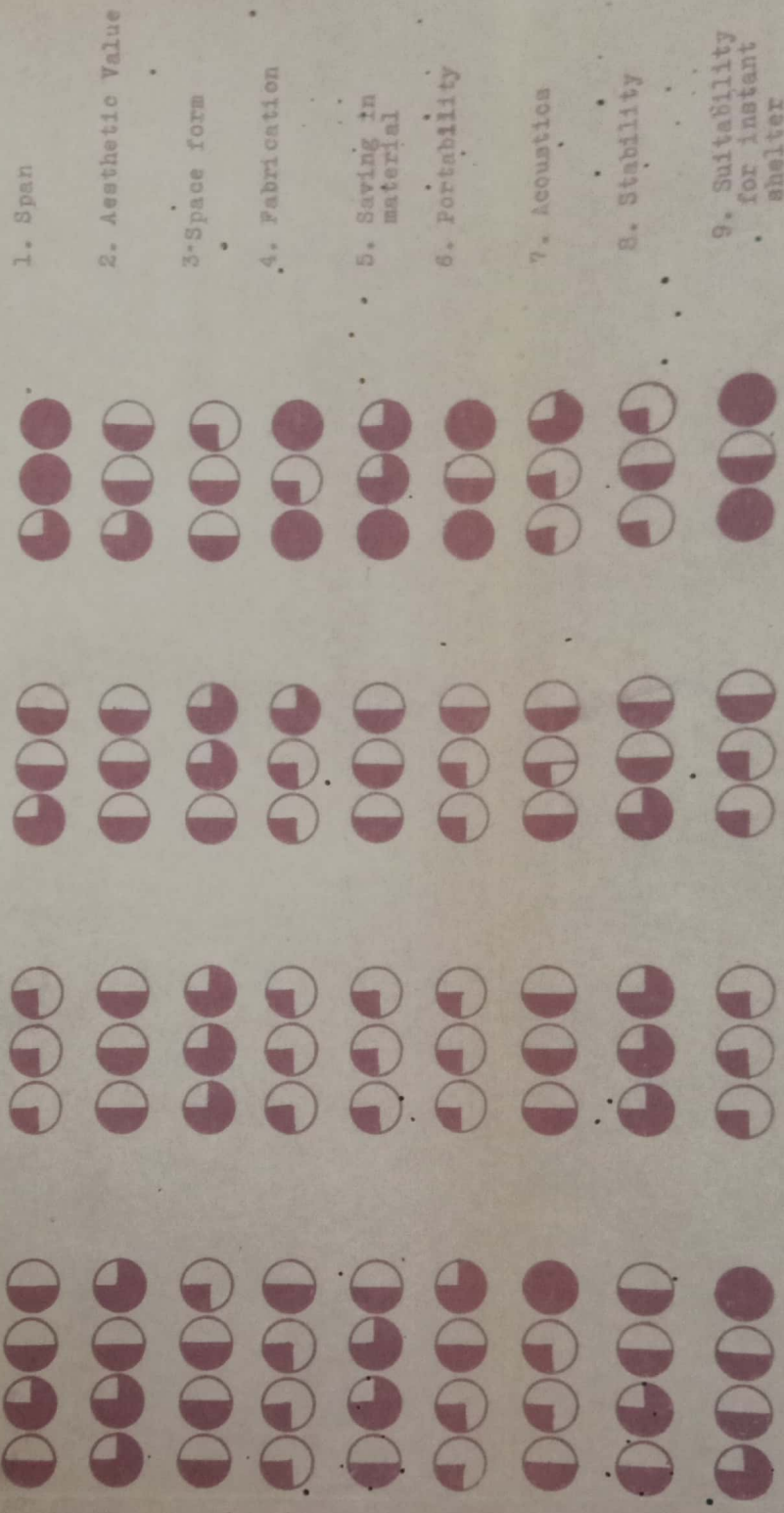
5. 1 Essentials of a hut

1. A hearth or fire-place for cooking.
2. A place for storage of firewood or woodflour.
3. A place for keeping 1 or 2 trunks.
4. A cot or sufficiently elevated platform or a place which does not get wet - to be used for sleeping.
5. Side walls and roof which would stand against wind and rain.
6. A line for drying clothes.
7. A place for keeping a container for water.
8. A shelf or storage space for keeping utensils.
9. Some space for sitting and dining which at night times can be used for sleeping.
10. A self sufficient lighting and ventilation system.

5. 2 Socio-economic analysis.

As the economic condition of a construction worker is never sound he is usually not in a position to buy new huts. If a big space is provided for him for comfort he gets tempted to keep subtenants in the space allotted. Since the living conditions of a construction worker directly affect his efficiency it is advisable to create conditions which are near optimum as any greater facility will tempt him to misuse it.

structural analysis



5. 3 Structural Analysis

Structure systems which can be used for instant shelter.

(A) Form Active structure systems - or structure systems in single stress condition -

There are three basic types of form active structure systems.

(a) Cable or tent systems.

(b) Arch systems.

(c) Pneumatic systems.

(a): Cable or tent systems:

Tent system is an interwoven cable system. It always takes the form of a funicular curve. The members in it are always in tension.

ADVANTAGES:

Structures are easy to erect and dismantle. There is an equal stress distribution in all the directions larger spans with lighter materials are possible. This system is the cheapest of all. Span/weight ratio is very good.

Disadvantages:

It is very uncomfortable in windy region as it can sway in high velocity winds.

Soil conditions affect the point of support drastically.

It is not suitable for long life structures (unless special care is taken)

There is wastage of space due to curving and tapering space at the top and at the sides.

(b) Arch system.

The ideal form of an arch is the inverted funicular tension cable for similar loading.

Advantages.

Equal stress distribution in all the directions under ideal conditions.

Comparatively longer spans with lighter materials are possible.

It is usually very cheap.

It is more stable than the tent system and there is less wastage of space.

Disadvantages

It is difficult to erect and because of rigidity of joints involved its portibility is affected.

(c) Pneumatic system - Air supported structure system.

Advantages

Very cheap for short periods.

Easy to erect and dismantle.

The structures are very light in wt.

Equal stress distribution is there in all the directions.

Disadvantages -

It is not very stable against wind.

It is rendered unsuitable for rough use due to possibility of the skin getting punctured. There is necessity of continuously pumping its air inside due to the continuous loss of air inside.

(B) Structures acting mainly through composition of compression and tension members - Vector active structure systems. There are three basic types of this system.

(a) Members spanning truss in horizontal or vertical direction in one plane : - Flat trus system.

Advantages

Horizontal roof surface - usable space above and below the roof is there.

Light in weight.

It is very stable in the plane of the truss and can be of permanent nature.

Disadvantages

The space between the top and bottom of truss gets wasted. The truss is not very easy to dismantle.

(b) Curved truss system - Geodesic dome etc.

Advantages

It has the advantages of both the flat truss and arch systems.

It is very stable.

Disadvantages

It is more difficult to fabricate and dismantle than the flat truss system.

(c) Space truss system:

Although the system is very stable and is suitable for large span structure it is very difficult to erect and dismantle.

(C) Bulk active structure system.

The name itself implies that the system - is not very portable and i's unsuitable as instant structures- system.

(D) Surface active structure systems

There are four basic types of this system.

(a) The prismatic and pyramidical folded plate system.

Advantages -

Easy to fabricate and manufacture.

Aesthetically appealing.

Disadvantages

Some loss of usable space is there.

There is wastage of material.

(b) Singly curved shell system.

Advantages:

Structures are lighter and stiffer than folded plate system and are aesthetically good looking.

Disadvantages:

They are difficult to fabricate and less portable than the flat trus system.

(c) Rotational shell -system -

Advantages -

There is even stress distribution on all the sides. The structures are easy to fabricate and are of simple shape.

Disadvantages -

The structures may be difficult to dismantle.

(d) Anti-clastic shell systems -

Advantages-

The structures are sta ble and interesting looking.

Disadva-ntages

Stiff surface structures are very difficult to fabricate and dismantle.

(E) Vertical structure systems.

Not useful for a small shelter

5.4

Analysis - Ventilation systems

Two basic systems :

1) Artificial

2) Natural .

1) Artificial ventilation system is too costly to be in reach of a hutment dweller.

2) Natural ventilation system

The emphasis of natural circulation system is on keeping the special of airflow as high as possible and on making maximum amount of air-change in the enclosure and the surrounding.

For this purpose any enclosure should be designed with opening placed in such a way that they will oubstruct the minimum amount of air flow. The best position obviously for such opening is opposite to each other. The main air flow also also creates eddies which are 1/4 to 1/8 strong in the region surrounding then resulting in an overall cooling.

Another important thing is the top ventilation. This permits the hot exhaled gases (rich in Co_2 - O_2 p.c. lower) ...

and gases from cooking places excape from the top while sucking cool air through the openings below.

This is the best natural ventilating system available for any type of structure.

5.5

Analysis

Glare prevention shading devices and systems:

There are four basic systems for preventing hea-t rays and glare entering inside a structure.

1. Vertical louvre system
2. Horizontal louvre system
3. Canopies
4. Boxed windows system

1. Vertical louvre system:

Needs vertical straps which shade light. However, if they are not flexible, in certain position they let some glare penetrate inside. The whole set is a little bit complicated and costly one. Not suitable for instant shelter.

2. Horizontal louvre system:

Horizontal straps shading light. The capacity of this system varies according to the latitude of the sun (angle it is making to the horizontal plane) and is more satisfactory than the vertical louvre system for Indian conditions. But this system also is complicated and costly.
- Not suitable for instant shelter.

3. Canopies:

Canopies are horizontal sun shading devices which also can act as window shutters. They can be very simple, easy to operate and cheap. Suitable for instant shelter.

4. Boxed windows:

Windows are surrounded on two or more sides. However, it is rigid in nature and hence is unsuitable for instant structure.

5. 6

Analysis

Lighting systems -

1) Natural

2) Artificial

Artificial lighting:

a) With electric power - usually not supplied to huts - instant shelters.

b) Petromax or lantern - More dangerous of the two artificial lighting systems but more easily available and most often used.

The artificial lighting because of its cost is used ⊠only at night time.

Natural lighting - preferred lighting system for the huts.

a) Open window

b) Windows covered with plastic or glass panes.

The open window system of the above two is the best as it provides both the lighting and ventilation. The plastic panes are used in the roof sometimes too get additional light where open window cannot be used. But this is needed only for ⊠ very big enclosures of the size of 12' x 16' and above.

materials analysis

A Plastics sheets or films.
B Galvanised iron sheets
C A. C. Sheets
D Treated Aluminium sheets
E Canvass
F Terpulin
G Bamboos
H Cane
I Timber planks, boards or posts
J Plywood/Hardboards
K Aluminium sections
L Steel sections
M Cotton/jute fabrics
N Polyurethane foam
O Impregnated paper
P Rubber sheets
Q Leather
R Reinforced light weight concrete panels
S Welded mesh
T Rolled clay blocks

Excellent ; ○ A very poor

Waterproof

Fireproof/Heatproof

Corrosion resistance

Thermal insulation

Portability(Ease to construct & dismantle)

Finish/Appearance

Joinery/Fabrication

Stiffness

Availability

Cheapness/Cost

Tensile strength

Compressive strength

Strength/Wt.ratio

Strength/Cost ratio

Suitability(for an instant structure).

Analysis of materials and their feasibility of using them to construct an instant shelter:

1. Plastics

a) Sheets

Sheets can be joined together very quickly to make a permanent instant shelter. Sheets can also be used with flexible joints to form foldable instant structures.

b) Films

Films can be used together with rigid frame or supports or as pneumatic structures to construct a temporary/instant shelter.

Advantages of plastics :

- Light in weight
- Easy fabrication
- Good finish with various colours

Disadvantages :

- Comparatively weak
- Not very stable against ultra-violet rays
- Affected by a very little heat/ temp.rise
- Comments: Suitable for a temporary instant shelter.

2. Galvanised iron sheets (Tin sheets) - - corrugated. Together with supporting members they may be used in construction of an instant shelter.

Advantages :

* Very resistant against bending in one direction
* Strong

Disadvantages :

* Get very hot
* Fabrication not very easy
* They are costly
* Bulky

Comment : Not very suitable for instant shelter.

3. Asbestos cement corrugated sheets. With supports may be used and are currently used for making hut.

Advantage :

* Quite stiff

Disadvantages :

* Fabrication not easy
* Not very strong against shocks
* Bulky

Comment : Not suitable for instant shelters.

4. Treated aluminium sheets.

With supports or suitable joints may may be used for making instant shelters.

Advantages :

- Shiny white surface, resistant against corrosion

Disadvantages :

- Very costly
- Gets hot very quickly
- Comparatively weak
- Cannot stand shocks well (without bending)
- Fabrication not very easy

Comment : Unsuitable for instant shelter.

5. Canvass

Together with supports can be used for instant shelter.

Advantages :

- Strong
- Flexible - can take quite some tension
- Does not get hot very easily

Disadvantages :

- Costly

Comment : If cost is not a problem, it is an excellent material for making an instant shelter.

6. Tarpaulin - same as canvass except that it is not very good in appearance but is excellent in its water resistan

Comment : Excellent material for covering instant shelter.

7. Bamboos

Advantages :

- Not very costly
- Indigenous material, so can be made available even at rural sites
- Not very heavy

Disadvantages :

- It cracks under impact or when it comes alternately and frequently in contact with water and dry air.
- Bulky
- Making joints is very difficult

Comment : Very good for an instant shelter, if it has to be cheap and if it is indigenously available.

8. Cane

Advantages :

- Not costly
- Indigenous mat - can be made available at rural sites
- Not very heavy

Disadvantages :

- Very thin and, therefore, not very strong
- Stiffness very little
- Making joints is difficult

Comment : Suitable for very small instant shelter.

9. Timber planks or boards

Advantages :

- Indigenous materials
- Joinery very simple

Disadvantages :

- Not very proff against dampness
- Bulky
- Costly
- Heavy

Comment : Not very suitable for instant shelter which has to be dismantled and erected.

10. Plywwod/Hardboards

Advantages :

- Light in weight
- Good finish
- Joinery simple

Disadvantages :

- Cracks in contact with water
- Not very strong

Comment : Suitable for frame type temporary instant shelters for dry regions only.

11. Aluminium sections

Advantages :

- Light weight
- Good looks
- Strong
- Resistant against rusting

Disadvantages :

- Near its ultimate loading capacity it bends very quickly losing its strenght

Comme nt : Excellent material for portable instant structures.

12. Steel sections

Advantages :

- Very strong
- Welding easy

Disadvantages :

- Rust easily
- Heavier as compared to aluminium

Comment : Very suitable for an instant shelter particular where the members are taking heavy loads.

13. Cotton fabrics/Jute fabrics

Advantages :

- Very cheap
- Light in weight
- Flexible

Disadvantages :

- Not very strong
- Not very proff against water

Comment : Suitable for instant structure if made waterproof and where cheapness is the criteria.

14. Polyurethene foam (domes system)

Advantages :

- Easy to construct
- Light in weight

Disadvantages :

- Not fireproff and waterproof
- High mould costs

Comment : Excellent as instant structures which are not to be dismantled.

15. Impregnated paper

Advantages :

- Light cot
- Cheap
- Joining easy

Disadvantages :

- Not good for rough use
- Joining material is costly

Comment : Suitable for temporary use portable instant structures.

16. Rubber sheets - films

Advantages :

- Extremely flexible
- Light in weight
- Air inflated structures very easy to construct

Disadvantages :

- Not very cheap
- Not fire-proff
- Attacked by moist air

Comment : Suitable as pneumatic instant structure (for for rough use).

17. Leather

Advantages :

- Strong
- Quite resistant to water

Disadvantages :

- Very costly

Comment : Cost rules out any instant Structure in Indian condition of this material.

18. Treated grass (held together by bamboos and wires).

Advantages :

- Indigenous material
- Very light in weight
- Very cheap

Disadvantages :

- Does not last very long

Comment : Suitable material for a rur type cheap instant shelter.

5.8 Cost Analysis

- Cost of ballies (timber posts)
  = 12 Rs./Balli
  - 2 Rs./Running ft. - 4" dia

- Cost of bamboos
  - 2.5 Rs./Running ft.
    for 3" dia bamboo - 12' long

- Cost of aluminium
  - 2.5 Rs./ Running Ft.
    for 1" Sq.section

since aluminium is the costliest of the above three, it is better to use ballies or timber posts and bamboos for the instant shelter system when they are indegenously available.

However, the bulkiness and heavy weight of bamboos and ballies make them costlier for portable or re-erectable structures for which aluminium or steel should be preferred.

- Cost of galvanised iron sheet
  size 8' x 3'-3" - 60 Rs.

  cost of covering 360 Sq.Ft. area - 830 Rs.
- cost of 10' x 3'-3" asbestos - 75 Rs.
  cost of covering 360 Sq.ft. Rs. 830

- Cost of 8'x3' asbestos - 64 Rs.
  cost of covering 360 sq.ft. - 960 Rs.

...

- Cost of timber planks - 70 Rs./Cft.
  Cost of covering 360 Sq.ft. with 1/2" thick planks - around 1000 Rs.

- Cost of canvass 1.5 Rs., to 2 Rs./ ft^2
  (15 Rs. to
  (20 Rs./ M^2)

  Cost of covering 360 Sq.ft. = 720 Rs. to 540 Rs.

- Cost of Jute cloth 1.8 Rs./ 10 $ft.^2$
  cost of covering 360 Sq.ft. - 65 Rs.

Therefore, it is advisable to use jute cloth made waterproof with tar or some other medium. However, if the material retrival is possible upto 95 p.c. to 100 p. and if the material is indegenously available it can be used for a shelter. For better quality, very flexible type instant shelters, however, canvass remains the main choice.

5.9 Space Form Analysis

Circular space form

A) With an opening.

1. All the space opening out towards the opening.

2. The feeling of privacy is lost to a still further extent as the form of the space cannot hide the occupant from the view through the opening.

B) Space to surface relationship.

1. Compara-tively a very small surface enclosing a big and effectively usable space.

2. The space/surface has the maximum value in a hemisperical dome, a little lesser in a cylindrical and still lesser in a conical space.

C) Best suited for concentric arrangement of furniture, segmental arrangement is also not bad. Rectangular or cubical arrangement (and objects) is amongst the worst possible in the circular space/form.

Comment : Not very useful for usual type of furniture and other accessories used in crude shelters.

Polyhedral/Polygonal space form.

A) With an opening

1. A great deal of space opening out towards the opening.

2. Some feeling of enclosure is lost. The greater the angle between two sides of polygon the lesser is the feeling of privacy.

B) Space - surface relationship.

1. A small surface effectively enclosing a comparatively big space (though not as big as the circular space).

2. Space/surface - dome shape - maxm. value.

C) Best suited for arrangement in concentric polygons of the same number of sides.

Comment:

Not very useful for the usual type of furniture, boxes and other cheap type of accessories. Hence not very suitable for shelter.

Rectangular/cubical space form

A) With an opening.

1. Some space opening out towards the opening but a great deal of space forming packets retain the feeling of privacy.

2. The 90^{o} angle between walls obscure the vision of the person facing the corner thus creating a feeling of intimate space.

B) Space - Surface relationship

1. Space/surface valve less than the polygonal space.

C) Best suited for arrangement in rectangular or square pattern.

Cement : Best suited for the rectangular i.e. usual type of furniture, boxes and other easy to make type of accessories very suitable for shelter.

Triangular space form

A) With or without opening

1. Space upto some extent radiating from the centre of triangle.

2. A good enclosure, however, the feeling of a homogeneous space is lesser because of forming of huge space pockets at the corners.

3. In the space pockets at the corners the feeling of enclosure reaches its maximum extent.

4. Opening affects only a small portion of space but in pockets there is sometimes a feeling of overburdening enclosed space.

5. Effectively usable space very less.

B) Space/surface relationship

1. Space enclosed/surface valve less than the rectangular space form.

C) Best suited for arrangement in triangular manner.

Comment : Not very useful for the usual type of furniture and accessories. However, cheap type of specially made triangular furniture may be useful.

Space Analysis - Ergonomical Analysis

A) Diamensions of door

1. Height of an average man 5'-6"

+ clearance .. 6"

Height of door.. = 6'-0"

2. Shoulder width of an average man .. = 1'-6"

+ 6' clearance on both the sides .. .. .. = 1'-0"

width of the door = 2'-6"

.. dimensions of door

6'-0" x 2'-6"

B) Diamensions of window and its position.

1. Height of the lower edge.

= slightly more than half the height of an average man (for keeping balance)

= 1/2 x 5'-6" + 2'-8" + a few inches

= Maxm. clear view (vision) height for a normal child of the earliest outdoor playing age = 3' about.

2. Minimum height of the topmost edge = Clear unobstructed horizontal vision for a normal man = 5'-6"

3. Minimum width of a window

= shoulder width of an average man

+ 6" on both the sides

= 1'-6" + 1'-0" = 2'-6"

∴ Minm.dimension of a window

are = 2'-6" x 2'-6" the lowest

edge starting at a height of about 3'.

C) Working platform height

2'-6" to 3'.

D) Minimum height of the roof

6' for 95 percentile + 6" air cushion

to minimise the effect of radiant heat.

= 6'-6" - for most of the actively

usable floor area.

E) Highest reach of a woman - 6'-6"

∴ 6'-6" maximum height for things

for every day use (Height of clothes-

line)

F) Total ground floor space required

+ F(a) day time

At day time more circulation space is

needed than at night time,

1. Day time cooking space

4' x 3' - 12' Sq. one person

(cooking woman) occupying the

cooking space.

2. Remaining 3 occupants of the huts + 2 guests.

Space per person (sitting space = 3' x 2' = 6 Sq.Ft(inclusive of non-usable space surrounding him)

∴ space needed for seating = 6 x 5 = 30 Sq.Ft.

3. Storage space - 6' x 3' = 18 Sq.Ft.

4. Plus 50 p.c. of the above circulation space.

∴ total space need at day time = $12 + 30 + 18 + \frac{12+30+18}{2}$ = 90 Sq.Ft.

+ F(b) total ground space needed at night time.

1) Night time cooking space (after use) - The person occupying it at day time is not there at night time = 3' x 2' = 6 Sq.Ft.

2) Sleeping space (on ground) = 1'-6" x 6' x 4 = 36 Sq.ft.

3) Storage space = 6 x 3 = 18 Sq. ft.

4) Plus 33 p.c. circulation space

therefore, total night time space required = $6 + 36 + 18 \frac{6+36+18}{3}$. =

80 Sq.Ft. therefore, total area reqd. for shelter is 90 sq. ft.

5.11 Marketing Analysis

The military equipment like tents etc. is manufactured by special industrial establishments governed by the ministry of defence.

Presently no instant shelter is being manufactured for housing the workers or the very poor people. The contractor is not worried about the living conditions in the workers quarters as long as the shelters can be cheaply made. There is a great deal of wastage due to the removal of material from a hut which is usually built as a semi-permanent shelter.

Therefore it is necessary for the contractors, workers and the government to make co-ordinated efforts to design and manufacture a shelter which is cheap, comfortable and reusable.

5.12 Synopsis - Analysis

There is a need of shelter which can be quickly erected, quickly dismantled without loss of material and easily re-erected thereby saving unnecessary effort. For such type of cheap shelters, cheap but strong materials like bamboos or more permanent materials like aluminium and steal together with a strong and water-proof cloth or similar cheap membrane should be used. The optimum type of a structure for such light and portable structure for rough use is the flat roof truss system structure. The optimum space form is a square or cubical space form and the optimum effective space is 90 ft.^{2} for ground area and effective optimum height is 6' to 6-1/2'.However, such type of reform in the living condition of workers by providing better shelters must be backed by the Government. Otherwise, the shelter which not only will help the workers but will also prove very much economical and useful to the contractors will have trouble in setting its foot.

6.

Hypothesis

To design a shelter and a shelter system, which is

1. a portable
2. a foldable - or is easy to dismantle
3. is easy to re-erect
4. has a floor area equivalent to 90 sq.ft.
5. has a door opening of dimensions 6' x 2-1/2' minimum.
6. has a minimum window openings dimensions of 6'-6" x 2'-6" with bottom edge starting at a height of 3'.
7. has minimum two window openings placed opposite to each other (facing each other) with glare preventing canopies.
8. has a storage space around 18 sq.ft.
9. has a top ventilation system.
10. has a waterproff cloth or membrane over it, or only such system preventing water from dripping inside.

The system should make use of indigenous materials available.

7.1

Final solution

The final solution to the problem has been achieved in two different ways.

1) A product design of the whole shelter

2) A system design with specially designed joints to be used with any suitable indigenous material available for the system.

1) Product design (of the whole shelter)
For telephone line layers, high tension line layers, water supply system workers, military uses, refugees (as refugees' instant shelters) and for building construction workers wherever the contractor wants to use it.
Materials used for the above are aluminium and steel together with water-proof cloth and P.V.C., polythene or nylon wires.

The product is a quickly erectable instant shelter which is foldable, light in weight and portable (which for refugees may be dropped by parachute over the needed area).

2) System design

Mostly for construction workers as ample building materials like bamboos and ballies are available at construction sistes and the contractor may be reluctant to buy a whole shelter. In this case the joints and the system design can be used together with the indigenously available materials to make a shelter which can be dismantled again and using the same joints for a new structure can be erected at some different site.
The joint material used for the system design is plastics, rubber and mild ateel.

The whole system, however, unless backed by the Government cannot become a success. By adopting the system we can achieve an improvement both in the living conditions of workers, refugees and that of the surrounding area which will not be faced with the problem of slums. The same can be used to solve low - cost housing problem.

2. Side walls

A) They are made of waterproof cloth attached to vertical and horizontal members.

B) The side walls are 6' high x 10' long each enclosing a square space inside. Square space was chosen because of the following :

a) Even lenghts of members needed - making it easy for production.

b) Space enclosed/surface enveloping ratio is higher in square space form than in rectangular one.

C) Vertical posts are kept in position with the help of horizontal spacers.

3. Windows

A) Window frame shutter uses horizontal spacers as one of its members and connects them.

B) Windows' openings - 2 Nos., are between the horizontal spacers - top and bottom.

C) Window shutter is also covered with waterproff cloth.

4. Door

A) Door is 6' x 3' and is accommodated in between two vertical posts and two spacers.

B) The door has waterproof cloth hung to the top spacer with the help of rings which slide with the help of a sliding vertical aluminium pipe making the whole thing a sliding - folding door.

5. Storage space

Storage spaces are there at the corners of the shelter formed by spanning distance between two vertical posts with the help of aluminium or bamboos which also act as stiffners and covering the same with cloth.

6. Sleeping

A hammock bed made out of polythene net and interwoven wire and hung at the ends to the vertical posts would serve the purpose of bed.

7. Ventilation, lighting and cooking

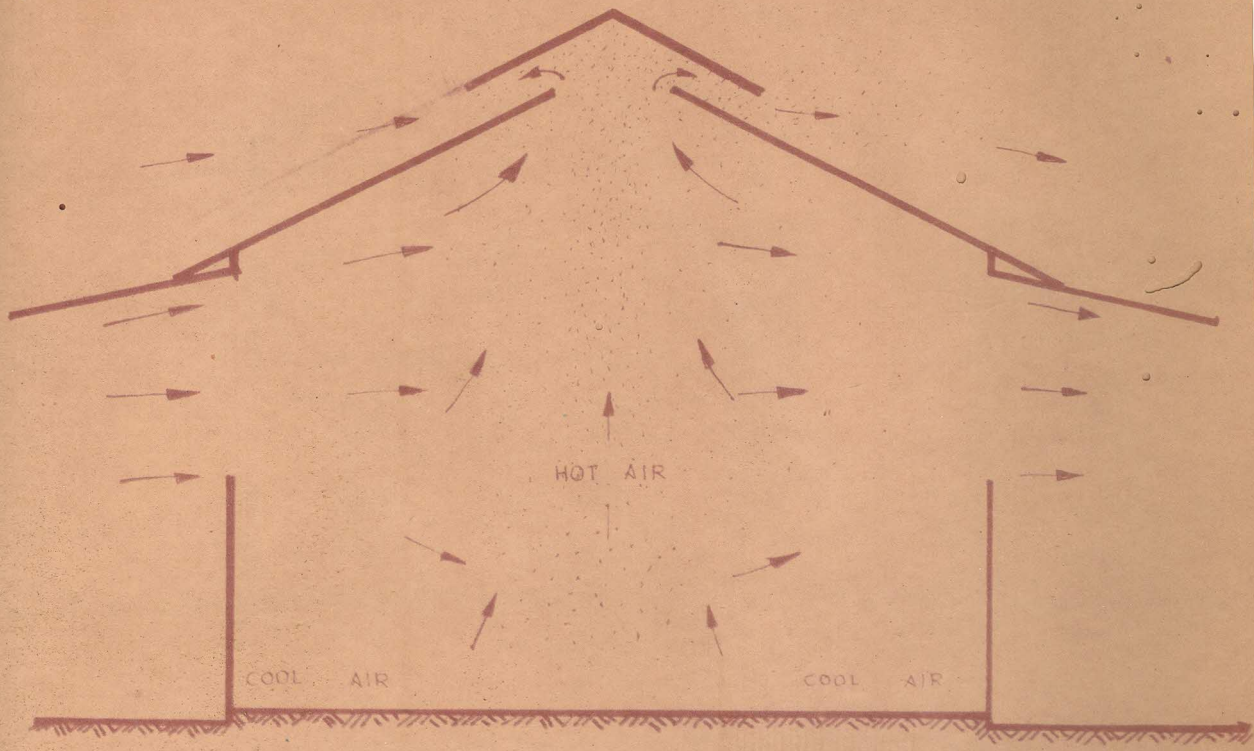
A) Ventilation problem has been solved by providing 2 windows and one door and aided by top ventilation.

B) Lighting problem is also solved by the windows anddoor.

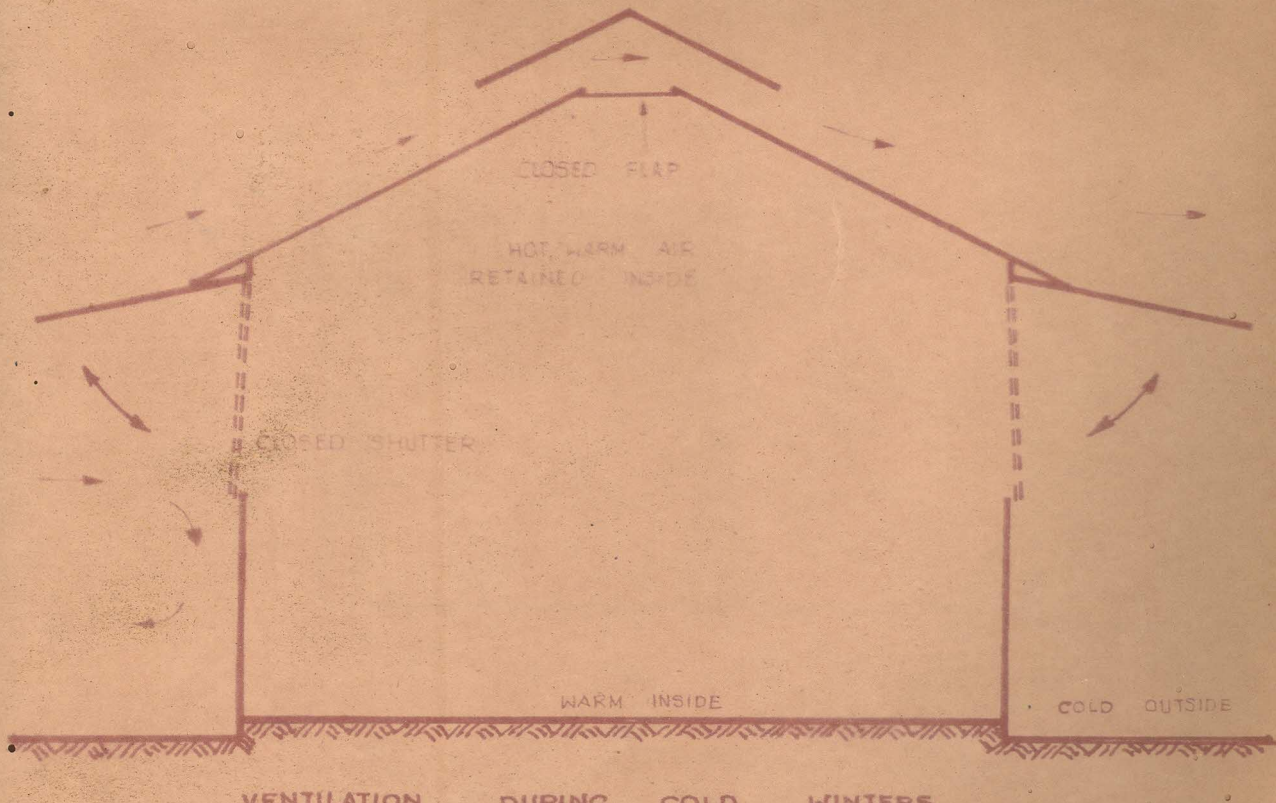
C) Cooking problem has been solved upto a certain extent. One of the storage spaces has a tin covering. The corner space below also has a tin or asbestos covering on which one can cook. During rainy season the food can be cooked on the storage platform above. The problem of smoke and hot gases accumulation has been solved by top ventilation.

8. The covering material - Outer Skin.

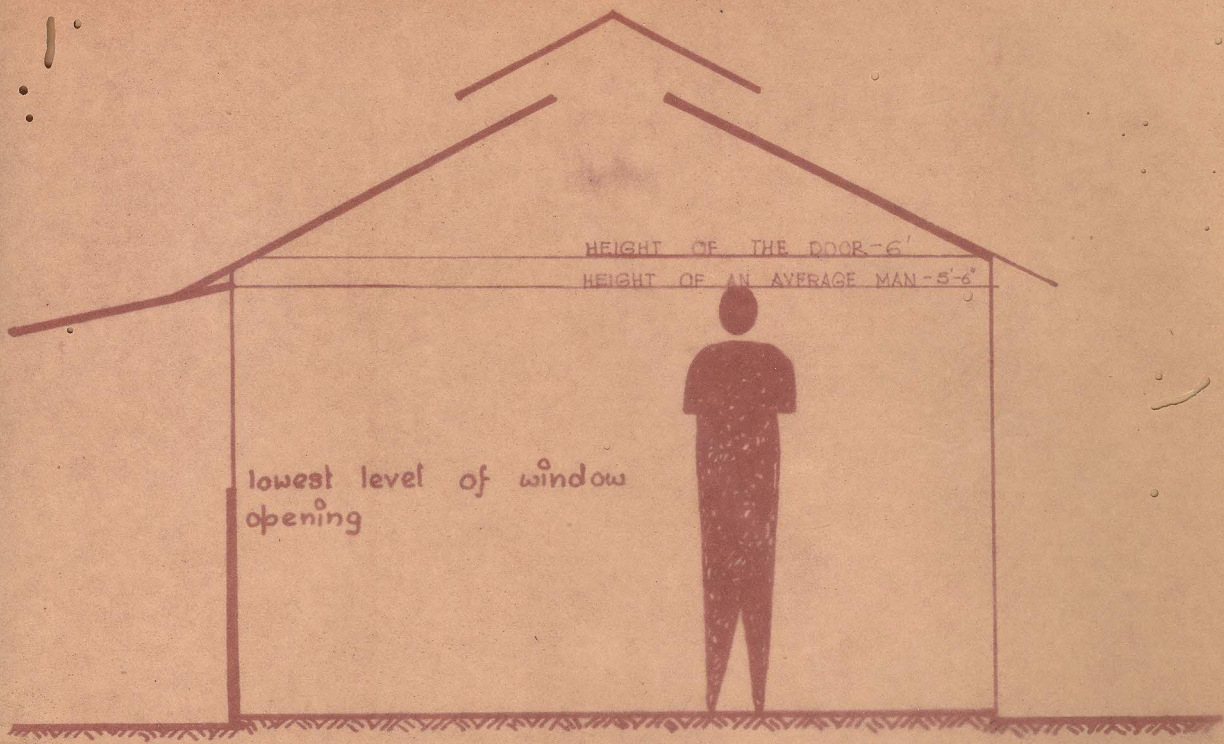
The covering material is P.V.C. Sheet sandwiched in between two layer of strong dute cloth.
The outer skin of the shelter can be folded together with the shelter itself or both of them can be separated and folded separately.



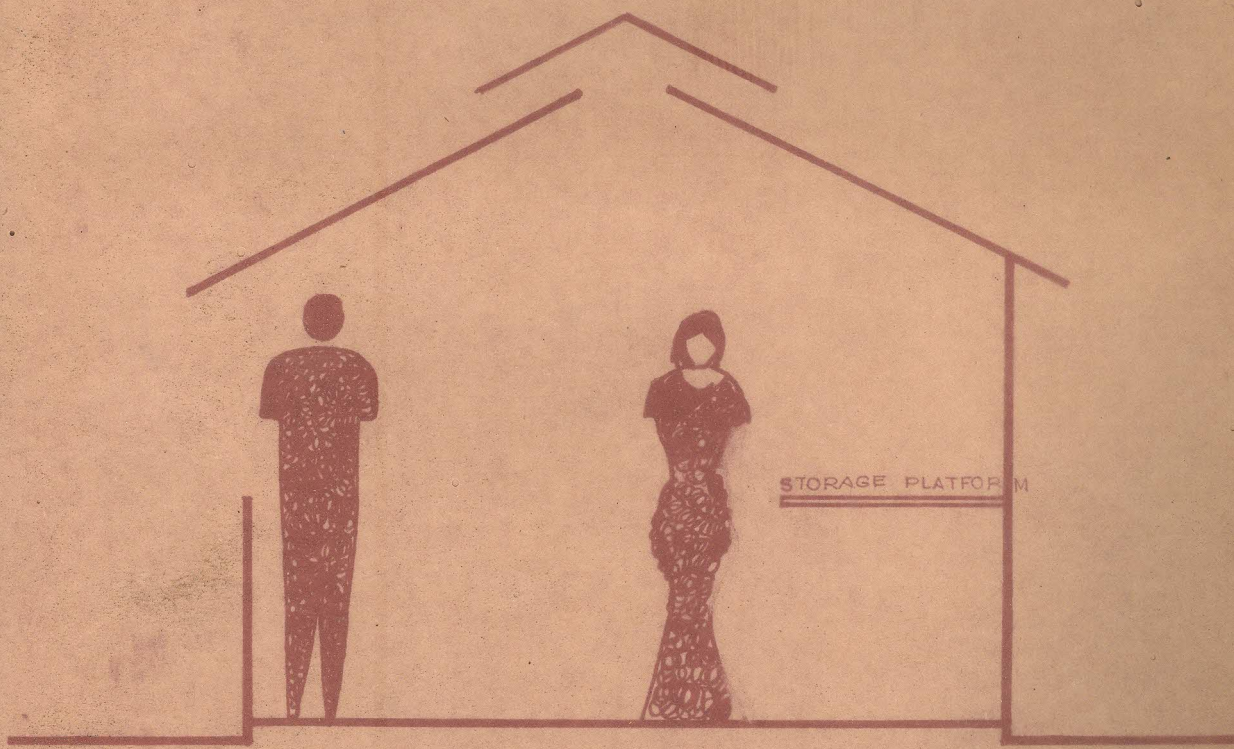
VENTILATION DURING HOT SUMMERS

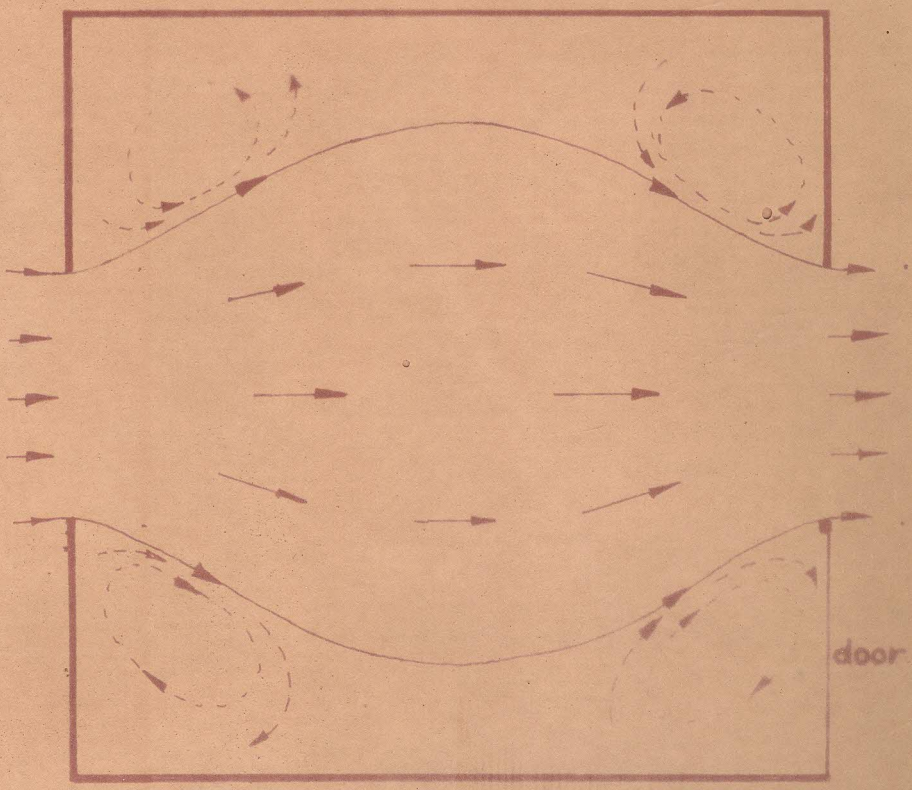


VENTILATION DURING COLD WINTERS

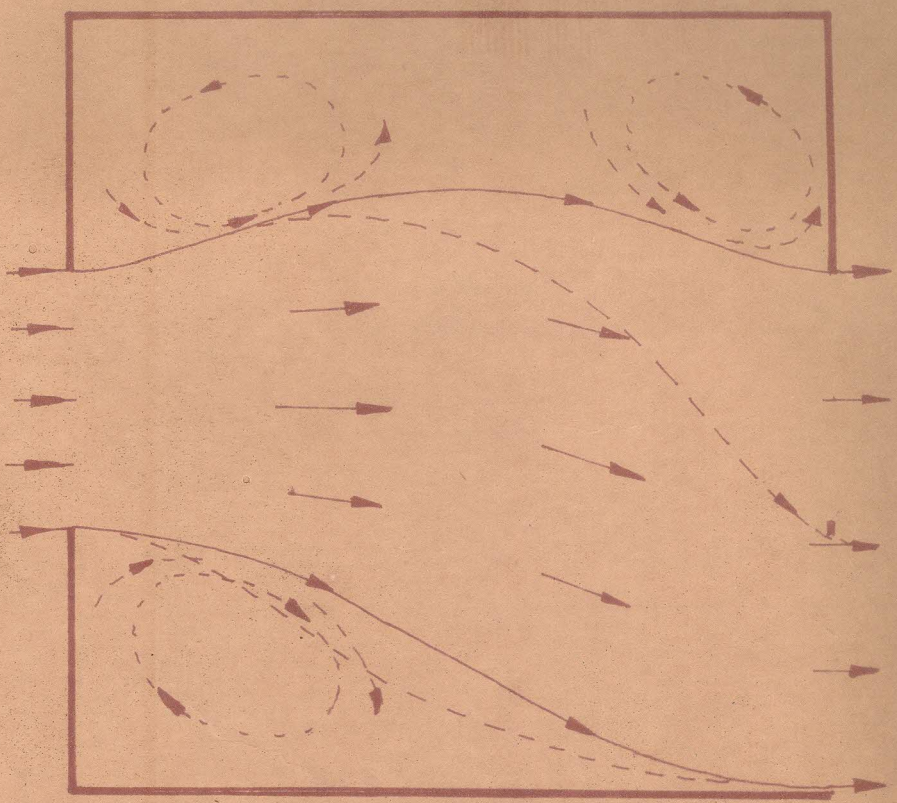


human scale comparison

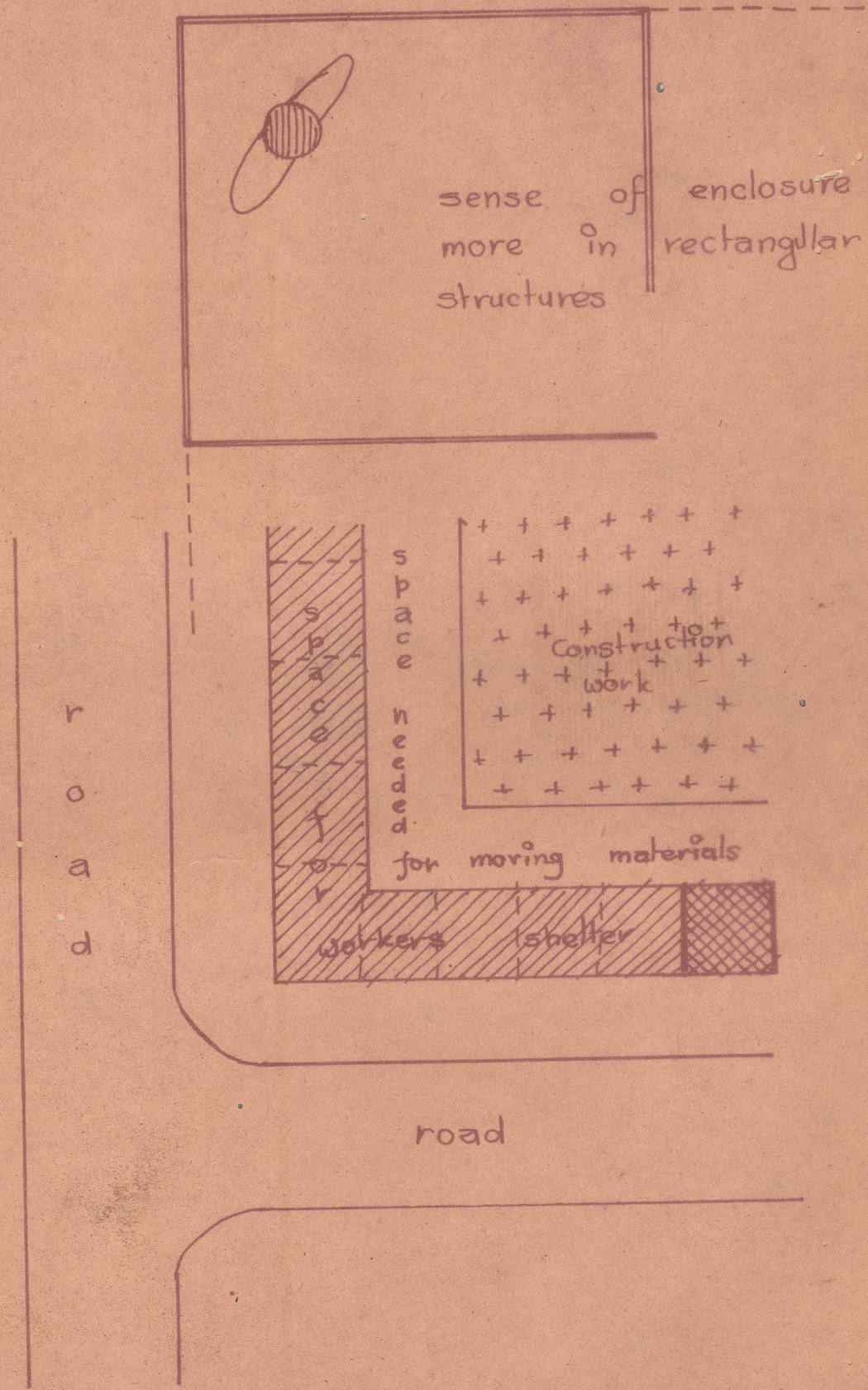




ventilation when door is not open



ventilation when the door is open

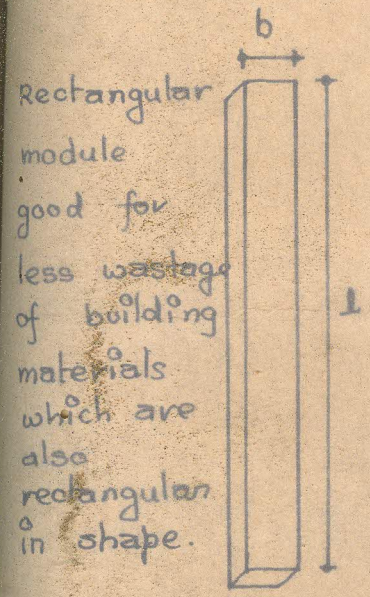

sense of enclosure more in rectangular structures
road
space needed for moving materials
Construction work
Workers shelter
road
road

SQUARE OR RECTANGULAR MODULE

BED itself a rectangular module

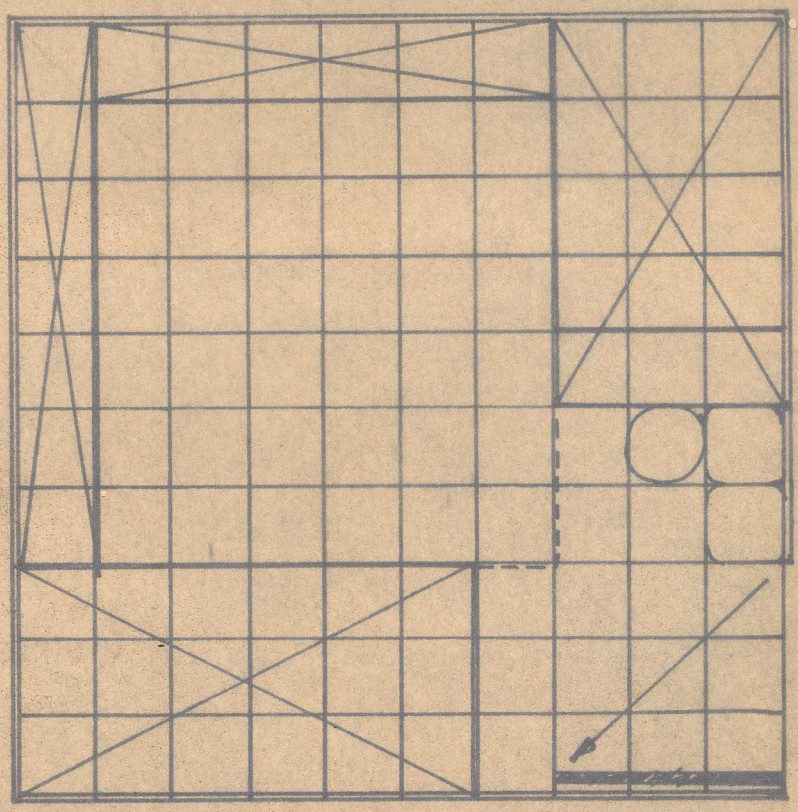
TABLE to be used as storage locker also rectangular m.

CHAIR OR STOOL square module



Rectangular module good for less wastage of building materials which are also rectangular in shape.

USUAL MODULAR ARRANGEMENT OF HUT



7.3.

SPACE FORM DESIGN.

A rectangular space preferred because of

1. Good sense of enclosure and privacy.
2. Higher space enveloped/surface ratio than the triangular or irregular space forms.
3. Our roads usually intersect at right angles and the building sites are also are rectangular in shape. Around them a strip is left on all sides in which a rectangular module fits in the best manner.
4. A rectangular module is easier to divide and repeat.
5. Almost all the furniture we use in rectangular in shape and so are most of the boxes etc. So they go well in a square or rectangular grid.
6. All the building material we get is in rectangular or square shapes and sizes (boards in particular). To avoid the wastage of material, the best way is to repeat it in the rectangular module.

7.4

Structural design

1) The roof design is based on the flat truss system, because this system employs simple joints with little need of sophistication using a simple principle of the triangle of forces.

2) The outward thrust of the members supporting the roof and forming the pyramid is prevented by the central swivel joint where members obstruct one another beyond a certain angle with the vertical plane. This is aiding by tie-tension cable which not only prevents the outward thrust but can also be used as clothes-line.

3) The pentograph mechanism used with equal arms of the parrellelogram thus formed ensures that the members in the top or secondary roof remain parallel in all position to the main roof members thus providing a constant gap for ventilating air.

4) The roof supporting members are of lenghts 5' and 4' and they can be folded together around a hinge joint. For making a straight vertical roof supporting member the stiffeners are to be fixed together with the strong members.

The stiffners are just hook type and members. Both the parts of the supporting system when folded make a bundle of 5' + 1' (stiffners) long.

5) When bamboos are to be used (indigenously available mats) they need not be cut and joined but used as 9' single pieces attached at the ends with 4 other pieces of bamboos to form a pentograph mechanism.

6) The vertical posts are held in position with the help of the spacers which themselves are foldable. The spacers' joints when properly operated are rigid.

7) The spacers in two opposite positions are connected by the window frame swivel joint.

8) The window frame can be folded together with the spacers. The door frame is a sliding folding type curtain shutter.

9) The storage spaces have been formed with the help of members spanning between two intermediate supports. The cross members stiffen the corners and give rigidity to the shelter.

10) The bottoms of the vertical posts rest on horizontal flat M.S.plates which are anchored in the ground.

Material economics

For aluminium

Hut size 9-1/2' x 9-1/2'

Height of hut vertical supports 6' + 6"

Aluminium sections are available in 12' lengths.

A) Four corner posts - 6' each

= 6' x 4 = 24' = 2 full pieces

B) Eight/six intermediate posts - 6' each

= 6'x8 = 48' = 4 pieces or

6' x 6 = 18' = 3 pieces

C) Horizontal spacers

a) Bottom spacers A - 4 Nos. - 4-1/2' each

2 x 3' used for one window shutter

= 3' horizontal + 3' vertical member.

b) Bottom spacers B - 6 Nos. - 3' each

+ 4 Nos. storage system supports

- 4-1/2' each

Therefore, 2(3'+4-1/2'+41/2)

= 2(12') = 2 full pieces

+ 3' x 4 = 12' = one full piece

(c) Top Spacers C - 6 Nos. - 4-1/2' each

3(4-1/2' x 2 = 9')- 3x3' left

= 3(12' - 9") = 3 x 3

- 3 x 3' used for 3 members of the secondary or top roof.

d) Top spacers D - 3 Nos. - 3' each

3x 3 = 9' - one 3' member left

12' - 9' = 3'

- 3' member used for the secondary or top roof's fourth member.

D) One door frame member - 6' long + top 3' long window shutter members = 6' + 2 (3') = 12' = one full piece.

E) Main roof members - 4 Nos.

5' + 4 Nos. - 4'

4 x(5' + 4') = 4 x(9')

∴ 4 x 3' left

- Roof members stiffening members - 4 Nos. - 1' each

4(3' - 1') = 4 x 2' left

- four 2' members used as axiliary supports to storage system.

F) 16 members - 1', - 10" long, (to be cut for the whole assignment and not for a separate hut)
6 members x 1' - 10" = 11

= 1' wastage per 6 members or 11'

1' to be used in joints at the door e.g. sliding tube at the bottom etc.

For bamboos and ballies -

No exact calculation can be made for these since bamboos are available for lengths from 6' to 12'. However, for a semirigid type of structure full 10' long bamboos can be used cut from a 20' long piece as spacers. Similar 10' pieces can be used for roofs (4 x 10' = 40' = 2 x 20' pieces) as shown in the system.

The covering cloth - It is made of two layers of Jute cloth sandwiching between them one layer of P.V.C. cloth.

REFERENCES:

1. Anthropode, New design futures by Jim Burns - Academy editions London.
2. Shelter, by shelter publications, California, 1973
3. Slums, by Dr.Venkatrayappa, Sterling publishers Ltd., New Delhi, 1972.
4. Kinetic architecture, by Zuk & Clerk, Van Nostrand Reinhold Company, New York, 1970.
5. Climate & architecture by Jeffrey Aronin,Reinhold publishing corporation, New York, 1953
6. Environmental design by Dober, Van Nostrand Reinhold Company, New York, 1969
7. Structure & form in modern architecture by Curt Seigel Crosby Lockwood & Son Ltd.,London, 1962
8. Frei Otto, Tension structures by Conrad Roland Praeger publishers, New York, 1970
9. Design with climate by Victor Olgyay, Princeton University Press, Princeton, New Jersey
10. Three dimensional design by Richard Thomas, Van Nostrand Reinhold Company, U.S., 1969.
11. Graphic problem solving by Paul Leseau, Cahners p-ublishing Company incorporated, Boston,Massachusetts
12. Landscape architecture by John Simonds, Mcgraw-Hill book company, U.S. 1961

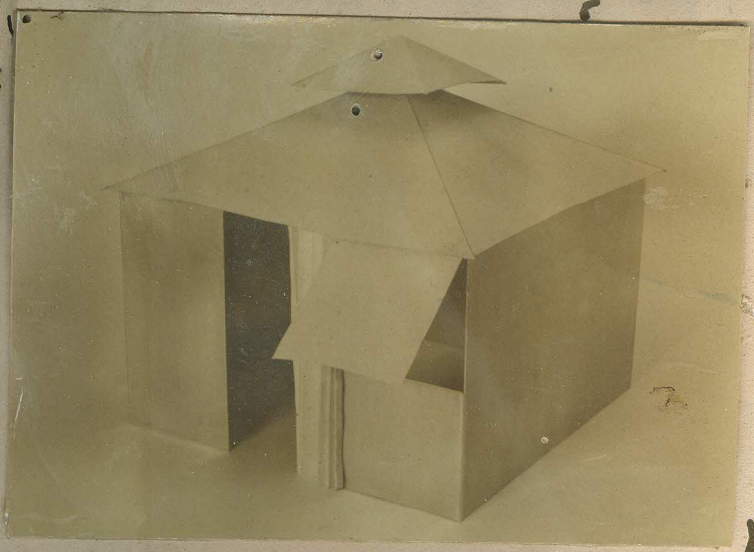
13. Planning by E, & O.E.

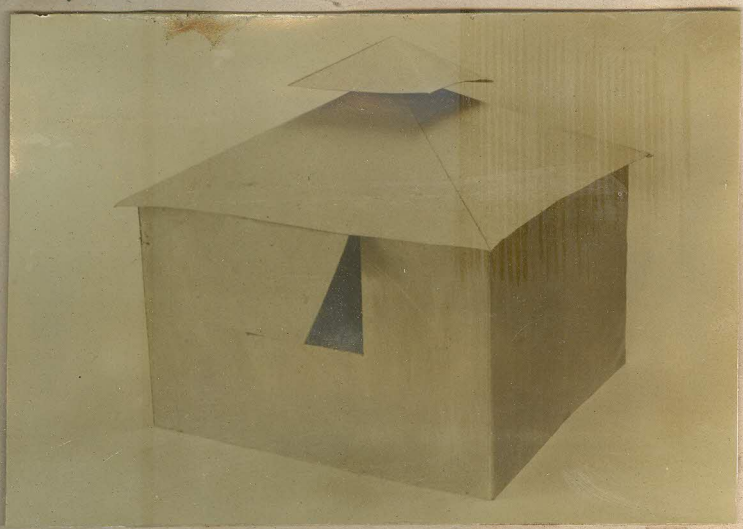
14, Architectural graphic standards

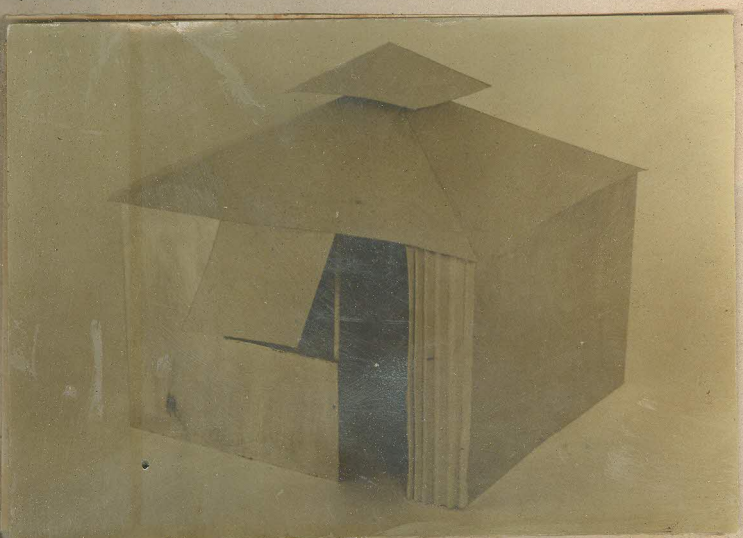
15. Time saver standards.

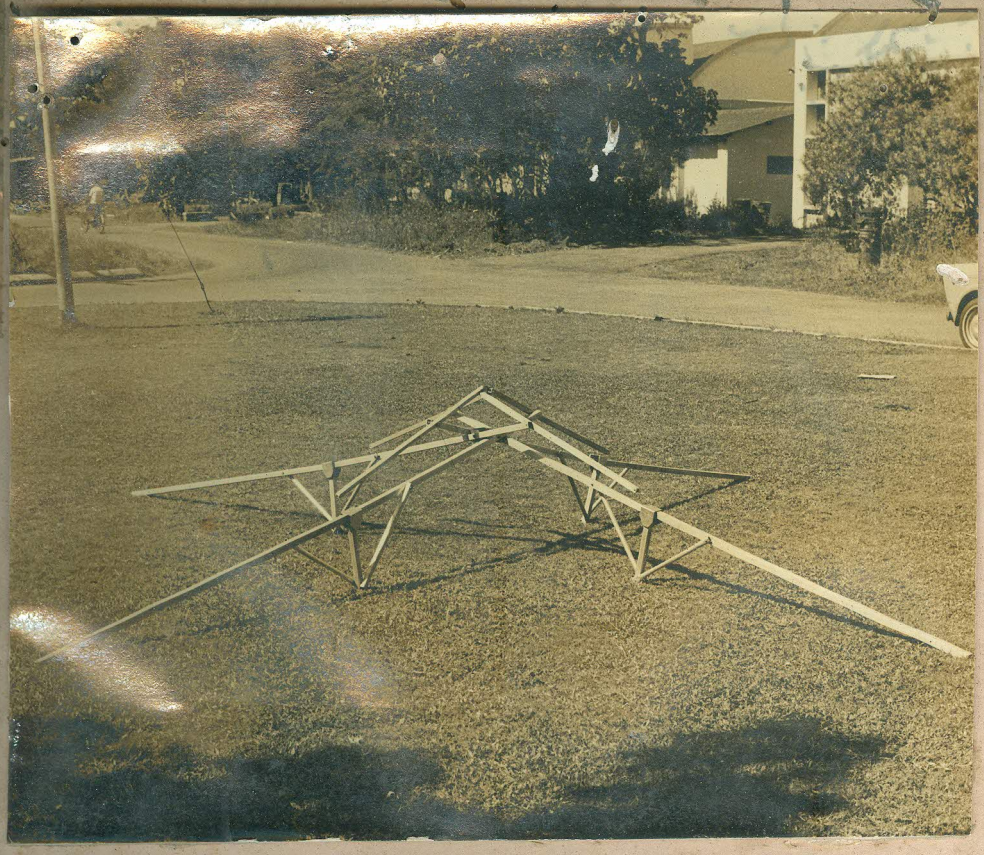
16. Structure systems by Engels - Reinhold - New York

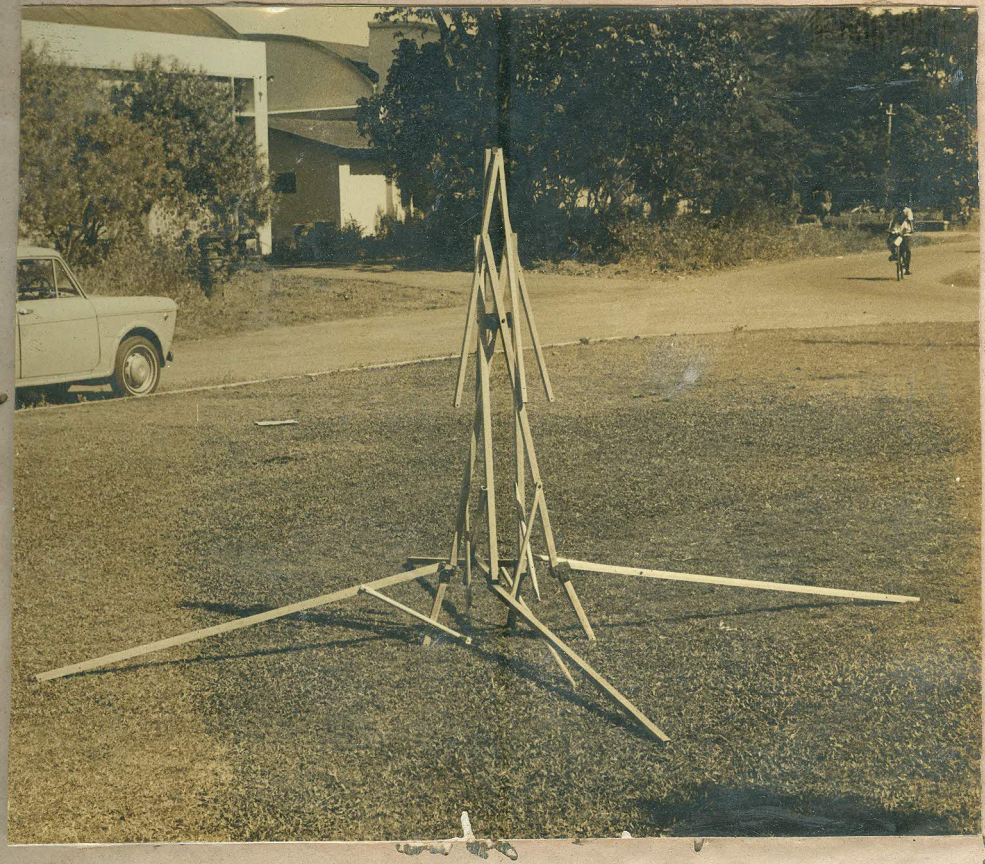
17. Architectural Design (A.D.)



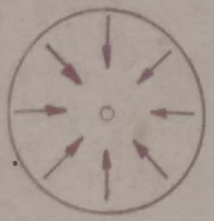








SPACE FORM DESIGN

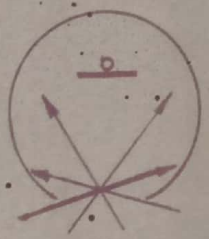


without an opening

circular space form

excellent enclosure

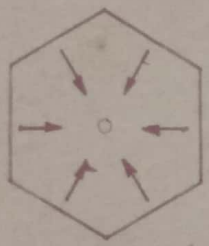
with an opening



space less intimate

(less privacy)

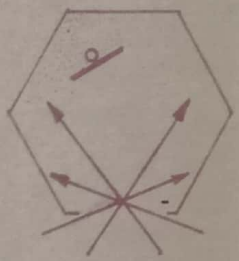
best functional space



Polygonal space form

less perfect enclosure

than a circular one

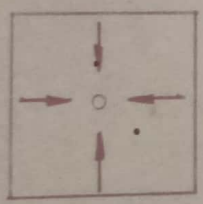


space more intimate

than the circular

space

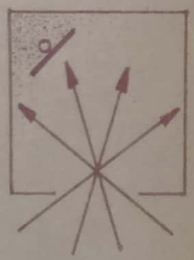
(better privacy)



square/rectangular space form

less perfect enclosure than

the circular one

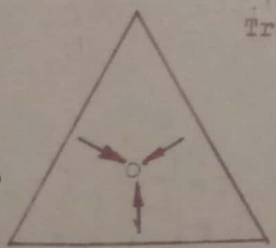


space more intimate

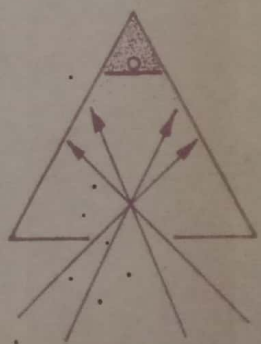
than the polygonal

space

(very good privacy)



Triangular space form



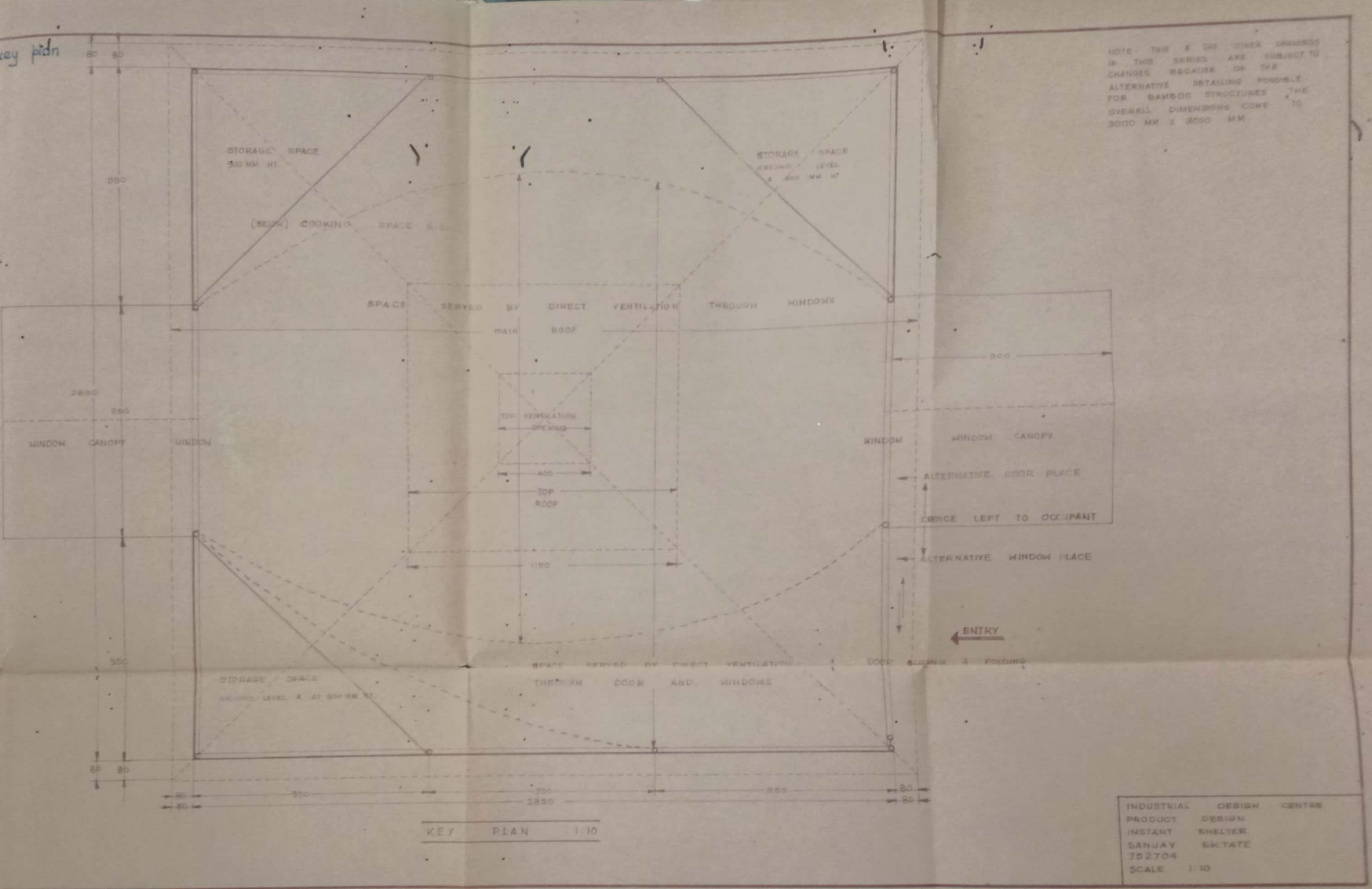
space most intimate

of the above four

(excellent privacy)

wastage of space

at corners

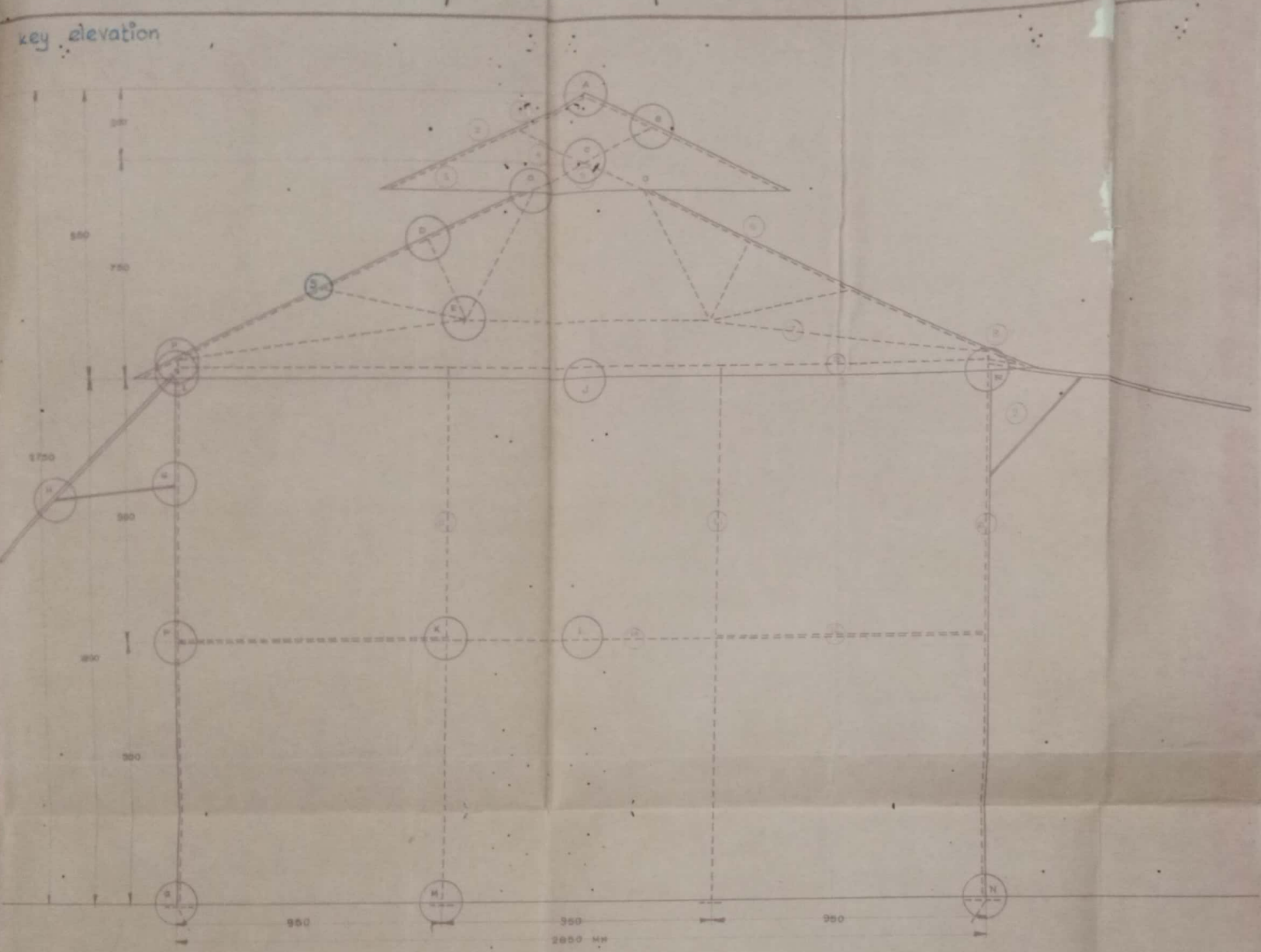


KEY PLAN 1:10

NOTE - THIS & THE OTHER DRAWINGS IN THIS SERIES ARE SUBJECT TO CHANGES BECAUSE OF THE ALTERNATIVE DETAILING POSSIBLE FOR BAMBOO STRUCTURES. THE OVERALL DIMENSIONS COME TO 3000 MM X 3000 MM.

INDUSTRIAL DESIGN CENTRE
PRODUCT DESIGN
INSTANT SHELTER
SANJAY ELKTATE
752704
SCALE 1:10

key elevation



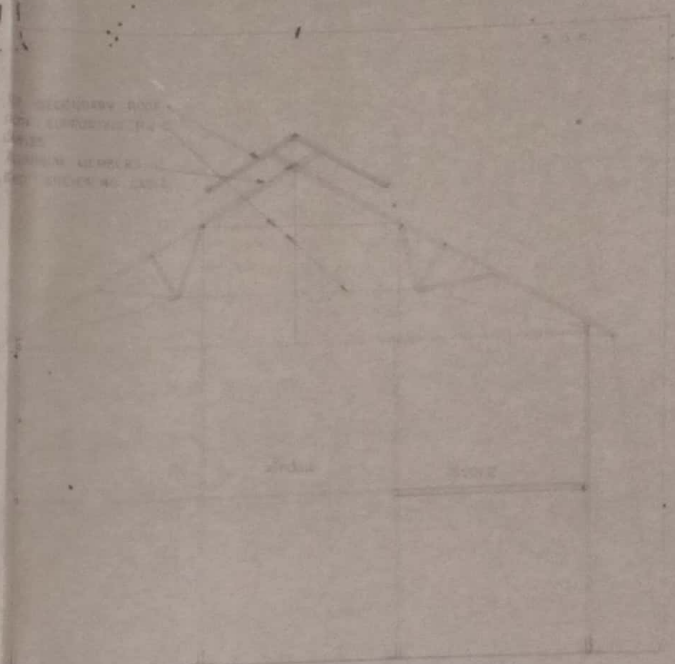
KEY ELEVATION 1:10

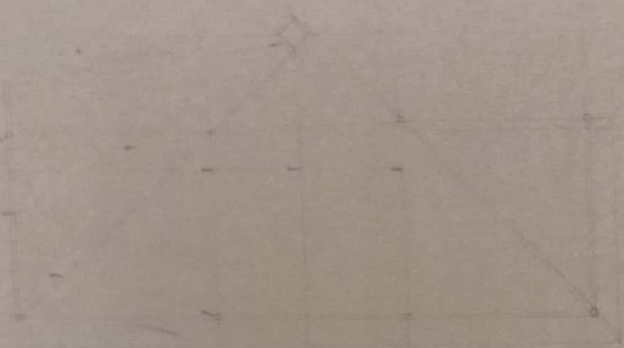
1. Waterproof cloth roof cover
2. Secondary or top roof pyramid
3. Members supporting top roof connected at hinge joint A
4. Extension of main roof supporting members joined to the top roof at joint B
5. Main roof members hinge jointed at C forming a pentograph mechanism structure
6. Top segment of main roof supporting members joined to its lower segment at G with the help of stiffners
7. Polythene or nylon tie cable
8. Main roof supporting member joined at H to the corner vertical post
9. Stay for window shutter
10. Main corner vertical posts
11. Intermediate vertical posts
12. Storage space members spanning between two intermediate posts
13. Top horizontal spacers holding the vertical posts
14. Bottom horizontal spacers

Final scheme - jt. & system details - 1

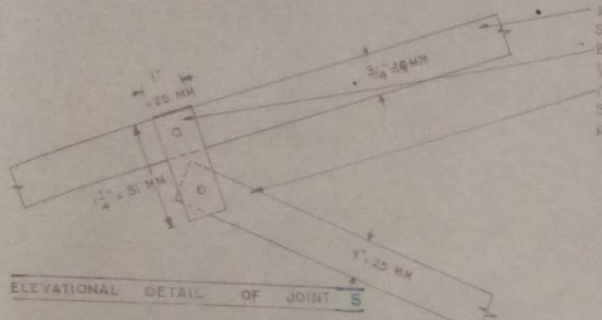
DETAIL AT F & R

DETAIL AT P



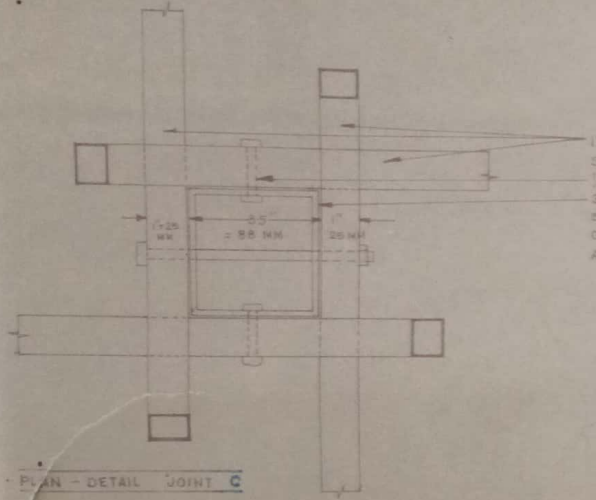


final scheme and joint details



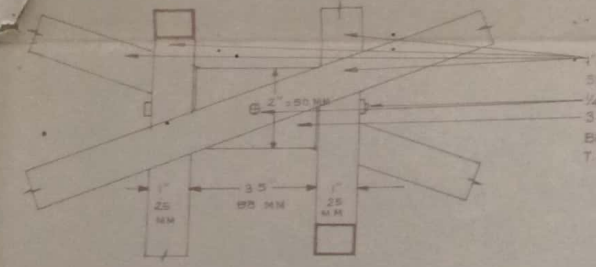
3/4" = 19 MM X 19 MM ALUMINIUM SQUARE SECTION - 3' LONG
BENT UP 25 MM WIDE M.S STRAP
1/4" Φ = 6 MM Φ - 1/2" LONG M.S SCREW
1" = 25 MM X 25 MM ALUMINIUM SQUARE SECTION [MAIN ROOF SUPPORTING MEMBER] 9' = 2700 MM LONG

ELEVATIONAL DETAIL OF JOINT S



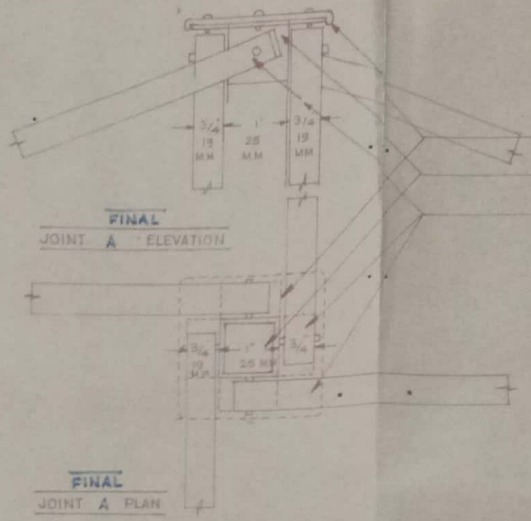
1" X 1" = 25 MM X 25 MM ALUMINIUM □ SECTIONS - 9" = 225 MM LONG EACH
1/4" = 6 MM Φ 1 1/2" LONG M.S SCREWS
3.5" X 3.5" or equivalent m.s sequoia section or bent up m.s straps or 3.5" X 3.5" ALL WOODEN BLOCK ACTING AS CENTRAL HINGE JOINT

PLAN - DETAIL JOINT C



1" X 1" = 25 MM X 25 MM ALUMINIUM SQUARE SECTIONS - 9" = 225 MM LONG EACH
1/4" = 6 MM Φ M.S SCREWS 1 1/2" LONG
3.5" X 3.5" M.S SQUARE SECTION OR BENT UP M.S PLATE OR 3.5" X 3.5" X 2" T.W BLOCK AS CENTRAL PIVOT JOINT

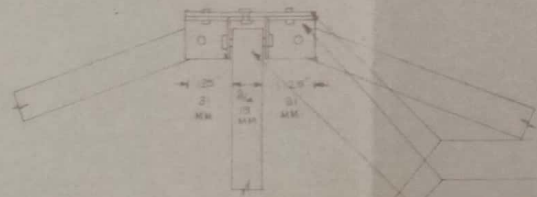
ELEVATIONAL DETAIL JOINT C



FINAL
JOINT A ELEVATION

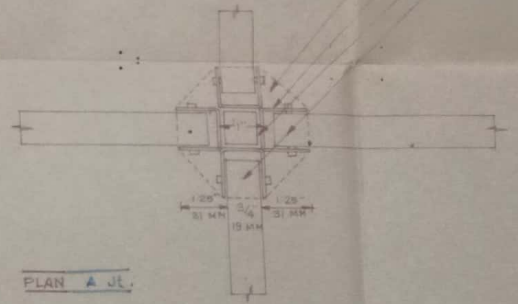
TOP M.S STRAP [FLAT PLATE] COVERING THE UPPER PORTION OF THE JOINT
1" X 1" = 25 MM X 25 MM M.S SQUARE SECTION WITH UPPER PART BENT
3/4" X 3/4" = 19 MM X 19 MM - 3' LONG ALUMINIUM SQUARE SECTIONS - 4 NOS

FINAL
JOINT A PLAN



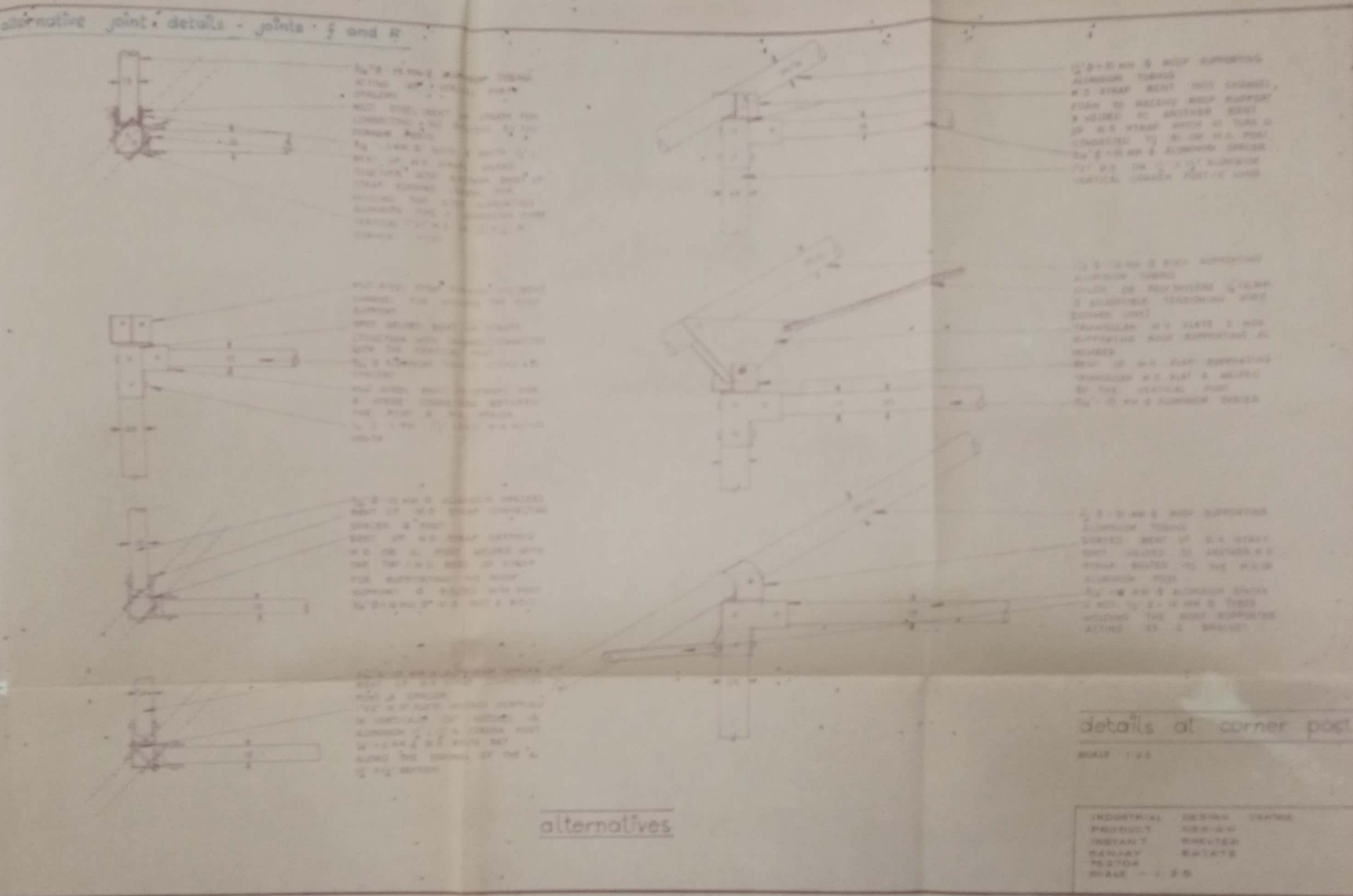
ALTERNATIVE JOINT. ELEVATION A

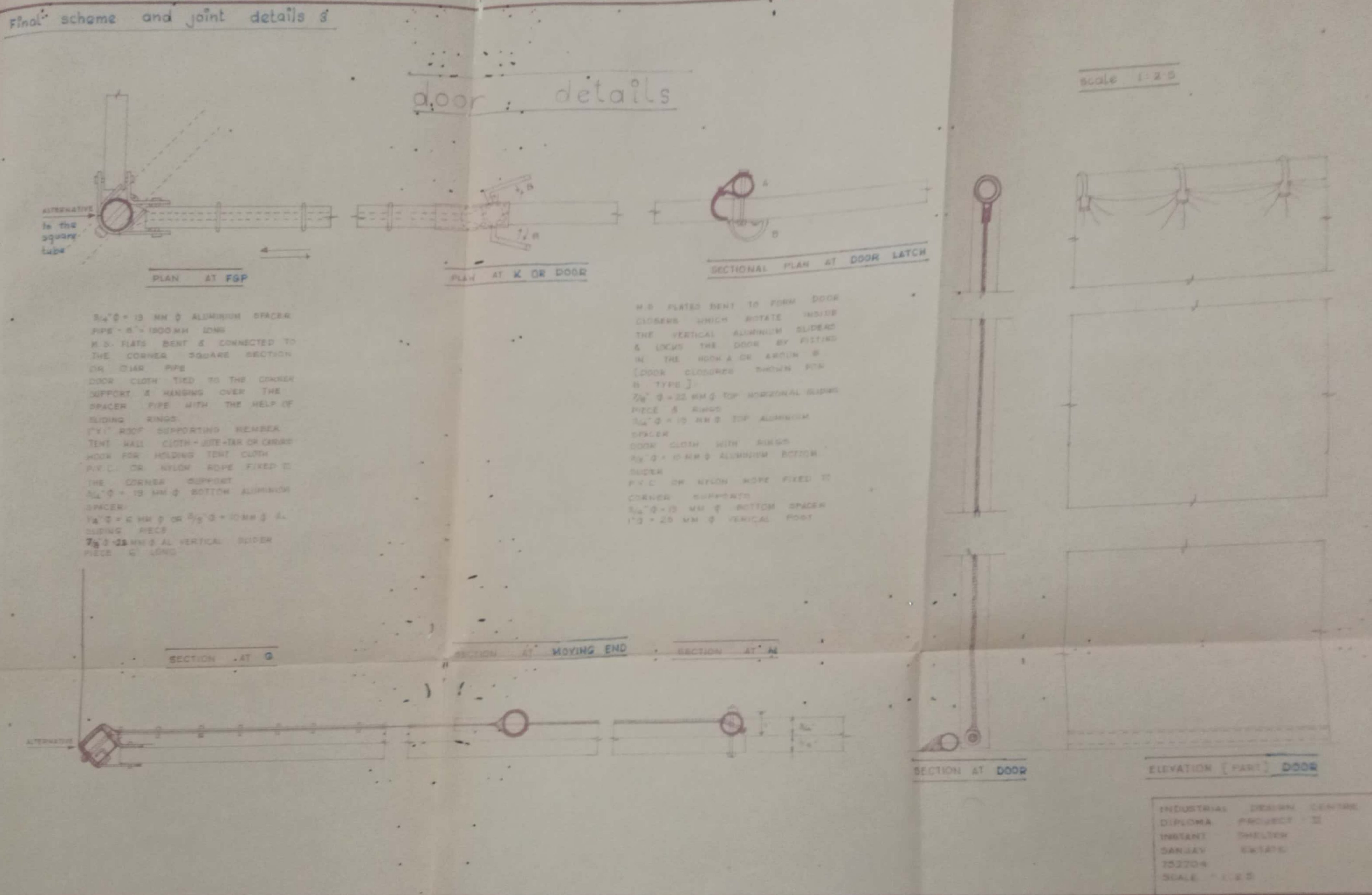
TOP M.S OCTAGONAL FLAT COVERING THE JOINT
BENT UP M.S STRAPS AT THE CENTRAL HINGE JOINT
1" X 1" ALUMINIUM SQUARE SECTION
3/4" X 3/4" - 19 MM X 19 MM ALUMINIUM SQUARE SECTION 8' LONG



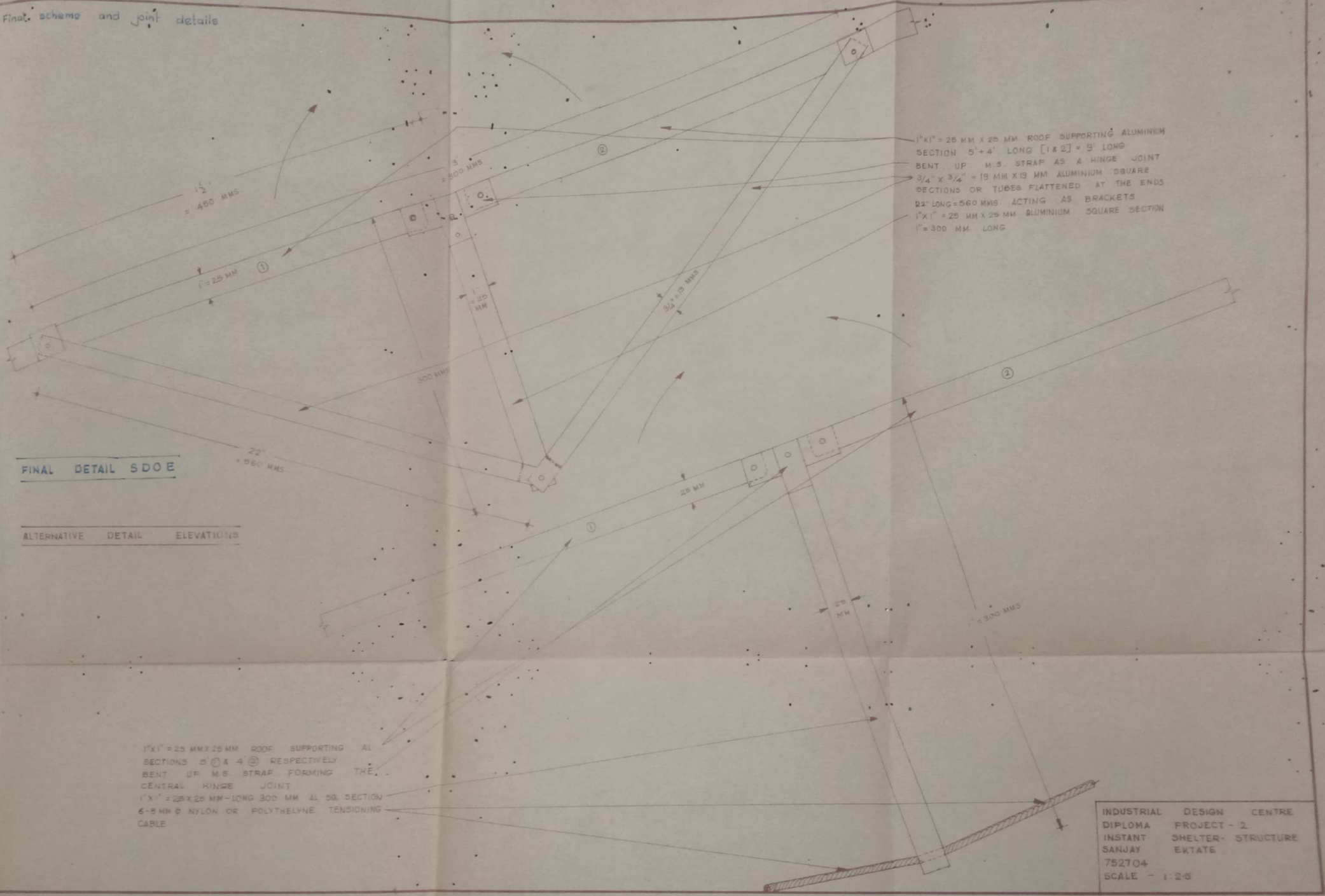
PLAN A Jt.

INDUSTRIAL DESIGN CENTRE
DIPLOMA PRODUCT - P.D II
INSTAT SHELTER - STRUCTURE
SANJAY ESTATE
752704
SCALE - 1" 25


alternative joint details - joints f and R
alternatives
details at corner post


Final scheme and joint details &
door details
scale 1:2.5
ALTERNATIVE
to the square tube
PLAN AT FGP
PLAN AT K OR DOOR
SECTIONAL PLAN AT DOOR LATCH
3/4" Φ = 19 MM Φ ALUMINIUM SPACER PIPE - 6' = 1800 MM LONG
M.S. FLATS BENT & CONNECTED TO THE CORNER SQUARE SECTION OR ◻ IAR PIPE
DOOR CLOTH TIED TO THE CORNER SUPPORT & HANGING OVER THE SPACER PIPE WITH THE HELP OF SLIDING RINGS
1"x1" ROOF SUPPORTING MEMBER
TENT WALL CLOTH - JUTE - TAR OR CANVAS
HOOK FOR HOLDING TENT CLOTH
P.V.C. OR NYLON ROPE FIXED TO THE CORNER SUPPORT
3/4" Φ = 19 MM Φ BOTTOM ALUMINIUM SPACER
1/4" Φ = 6 MM Φ OR 3/8" Φ = 10 MM Φ AL SLIDING PIECE
7/8" Φ = 22 MM Φ AL VERTICAL SLIDER PIECE 6" LONG
M.S. PLATES BENT TO FORM DOOR CLOSERS WHICH ROTATE INSIDE THE VERTICAL ALUMINIUM SLIDERS & LOCKS THE DOOR BY FITTING IN THE HOOK A OR AROUND B [DOOR CLOSURES SHOWN FOR B TYPE]
7/8" Φ = 22 MM Φ TOP HORIZONTAL SLIDING PIECE & RINGS
3/4" Φ = 19 MM Φ TOP ALUMINIUM SPACER
DOOR CLOTH WITH RINGS
3/8" Φ = 10 MM Φ ALUMINIUM BOTTOM SLIDER
P.V.C. OR NYLON ROPE FIXED TO CORNER SUPPORTS
3/4" Φ = 19 MM Φ BOTTOM SPACER
1" Φ = 25 MM Φ VERTICAL POST
SECTION AT G
SECTION AT MOVING END
SECTION AT M
SECTION AT DOOR
ELEVATION [PART] DOOR
INDUSTRIAL DESIGN CENTRE
DIPLOMA PROJECT II
INSTANT SHELTER
SANJAY
752204
SCALE 1:2.5

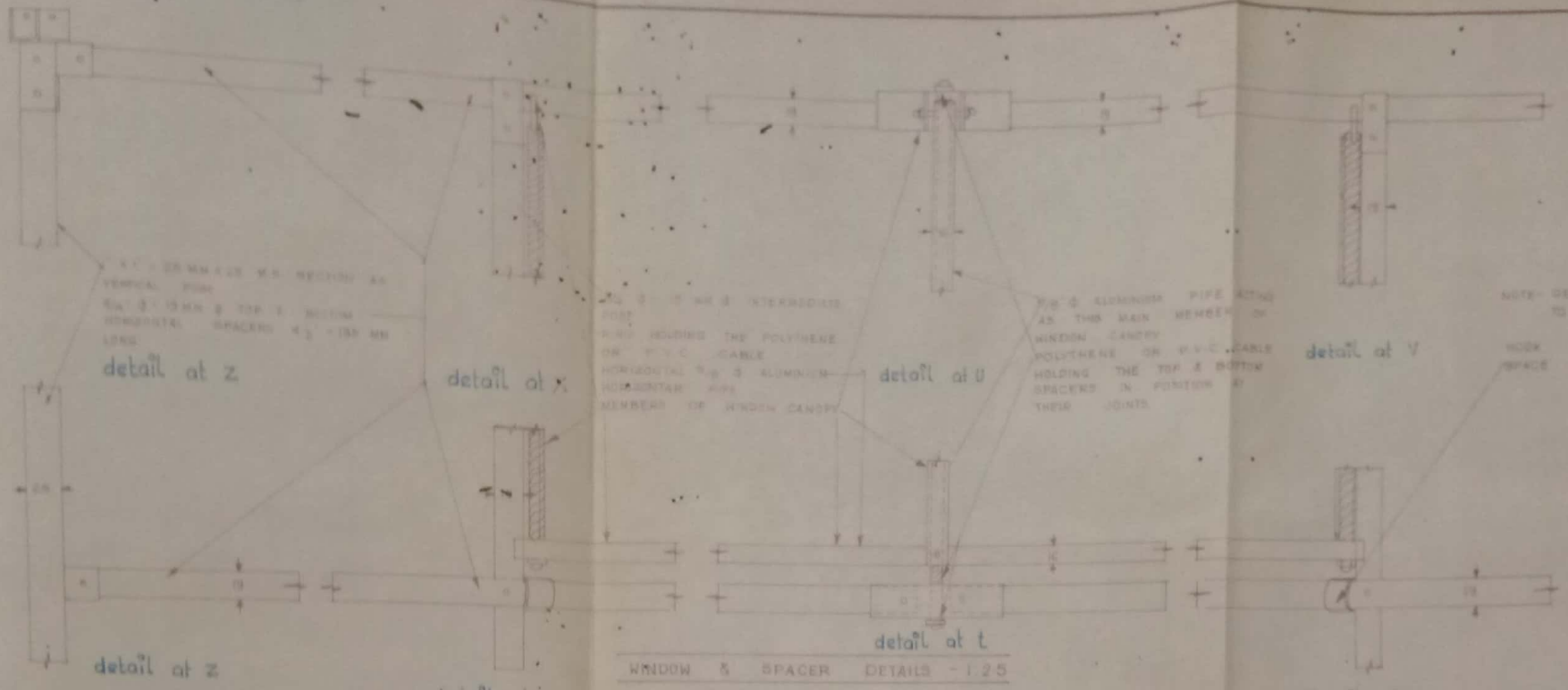
Final scheme and joint details



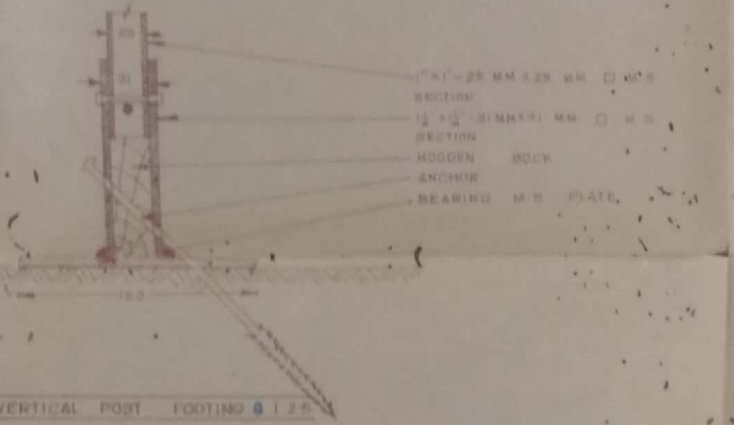
FINAL DETAIL SDOE

ALTERNATIVE DETAIL ELEVATIONS

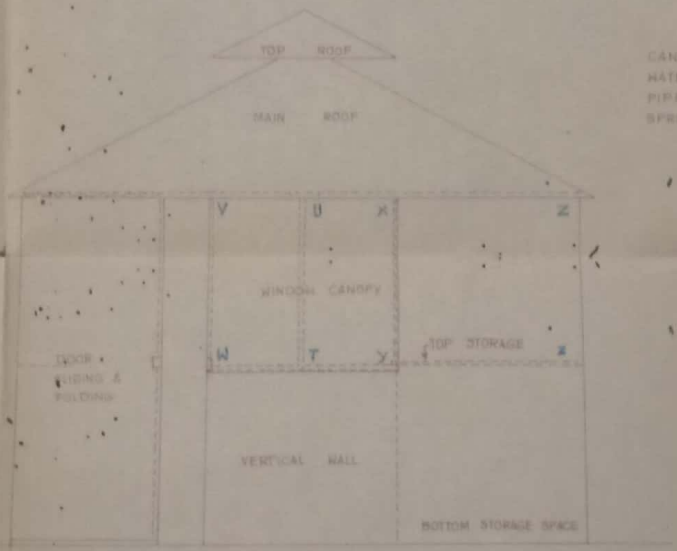
INDUSTRIAL DESIGN CENTRE
DIPLOMA PROJECT - 2
INSTANT SHELTER- STRUCTURE
SANJAY EKTATE
752704
SCALE - 1:2·5



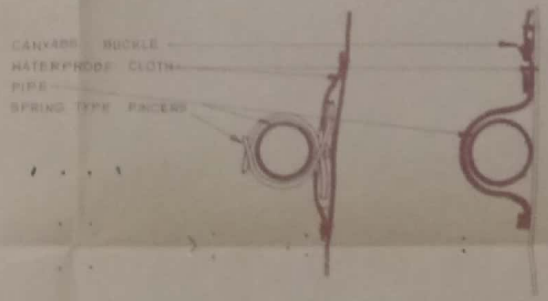
WINDOW & SPACER DETAILS - 1:25



VERTICAL POST FOOTING @ 1:25



KEY ELEVATION 1:20



INDUSTRIAL DESIGN CENTRE
PRODUCT DESIGN
INSTANT SHELTER
SANJAY EXTATE
752704
SCALE - 1:25 & 1:20