The background of the slide is a detailed architectural line drawing of a multi-story building under construction. The drawing shows the steel framework, including columns, beams, and floor slabs. A large tower crane is positioned to the right of the building, with its jib extending over the top. In the background, other buildings and construction equipment are visible, suggesting an urban construction site. The drawing is rendered in a fine-line, etched style.

Study On Basic Structural System

Submitted By:

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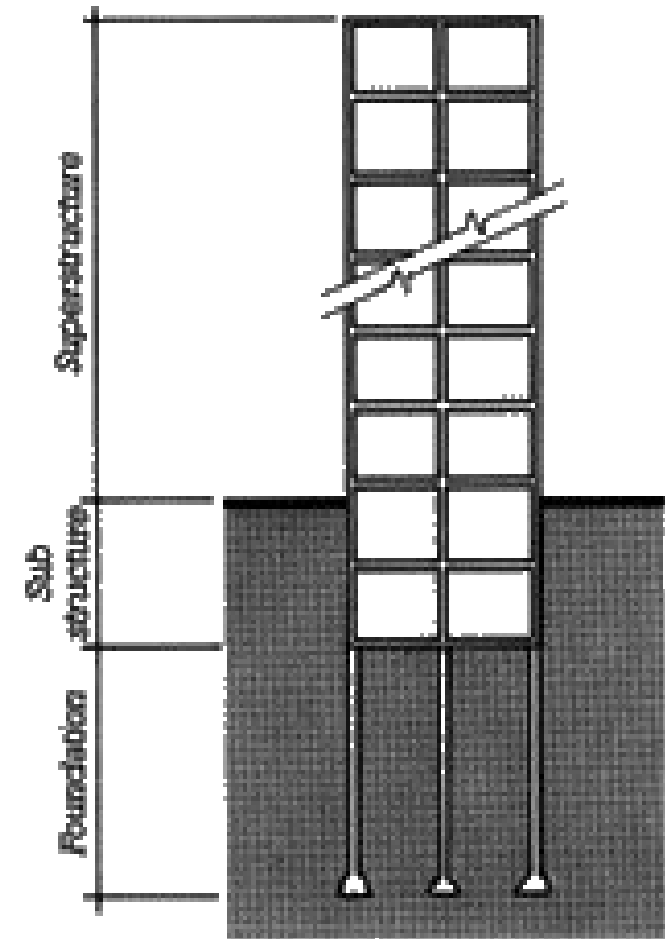
Introduction

Structure

Structure is a fundamental, tangible or intangible notion
Construction or framework of identifiable elements (components, entities, factors, members, parts, steps, etc.) which gives form and stability, and resists stresses and strains.

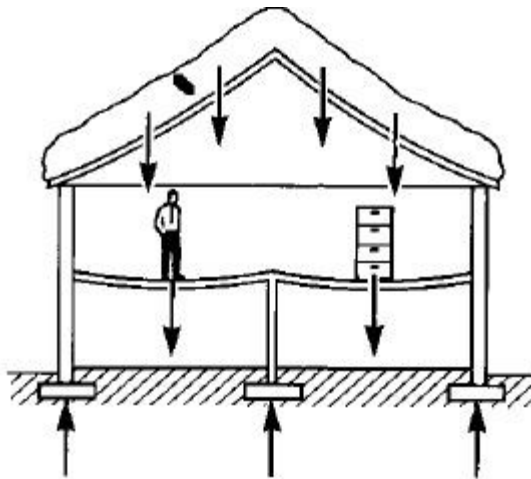
The basic frame work and skeleton provide for both erection and stability of any structure consist of two portion:

1. **substructure**
2. **superstructure**

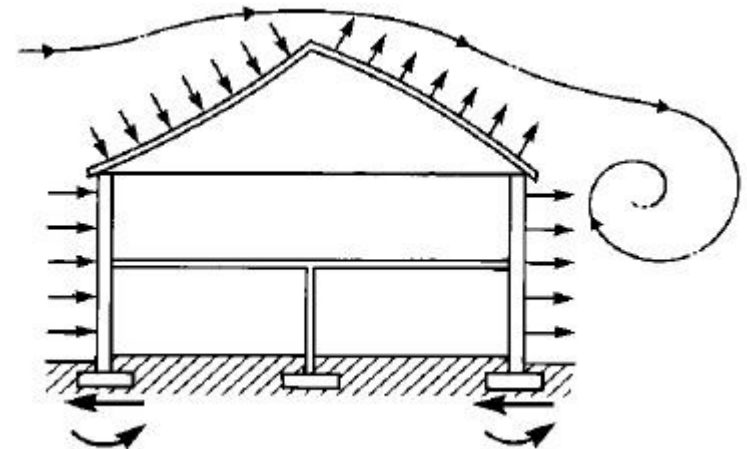


The relationship of structure to building

The simplest way of describing the function of structure is to say that it is the part of a building which resists the loads that are imposed on it. building may be regarded as simply an envelope which encloses and subdivides space in order to create a protected environment. The surfaces which form the envelope, that is the **walls**, the **floors** and the **roof** of the building, are subjected to various types of loads.



floors are subjected to the gravitational loads of the occupants and their effects



external surfaces are exposed to the climatic loads.

Gravitational loads and the occupation of the building cause roof and floor structures to bend and induce compressive internal forces in walls. Wind causes pressure and suction loads to act on all external surfaces.

The relationship of structure to building

A building structure must be able to support two types of load.

1. **Static load.**
2. **Dynamic load.**

Static load: Assumed to be constant in nature. Its two type.

1. **Dead load**
2. **Live load**

Dead load:

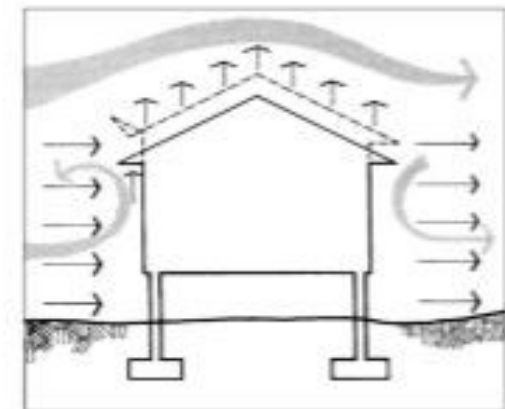
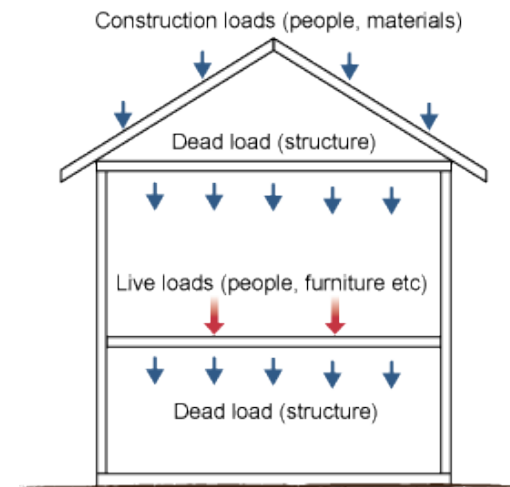
Dead loads are relatively fixed and include the weight of the building structure itself as well as the weight of any permanent elements within the building such as mechanical equipment.

Live load:

Live loads are moveable loads which may not be present all of the time. They include the weight of a building occupants and, furnishing as well as snow loads on roof.

Dynamic load:

Can be applied to a structure suddenly and vary in magnitude and location.



Dynamic load

Structural requirements

To perform its function of supporting a building in response to whatever loads may be applied to it, a structure must possess four properties:

- ❑ it must be capable of achieving a state of **equilibrium**.

This requires that the internal configuration of the structure together with the means by which it is connected to its foundations must be such that all applied loads are balanced exactly by reactions generated at its foundations.

- ❑ it must have adequate **strength**.

The requirement for adequate strength is satisfied by ensuring that the levels of stress which occur in the various elements of a structure, when the peak loads are applied, are within acceptable limits.

- ❑ it must be **geometrically stable**.

Geometric stability is the property which preserves the geometry of a structure and allows its elements to act together to resist load. The distinction between stability and equilibrium is illustrated by the framework

- ❑ it must have **adequate rigidity**.

Structural calculations allow the and rigidity of structures to be controlled precisely. They are preceded by an assessment of the load which a structure will be required to carry.

Structural Development in Architectural History

Time period: 6000 BC

Pre-Historic period:

- Man came from **cave** for hunting.
- Use of timber for building materials.
- The structural system was post and lintel type.
- Materials were clay, timber and stone.



Time period: (3000-2750) BC

Stone henge:

- The massive stones that made up the monuments of stone henge.
- Trabiated structural system.
- Load is transferred from beam to column.
- Accurate structural system is since unknown.



Time period: (3200 BC 14 AD)

Egyptian Architecture:

- Huge structure to show their power.
- Use of timber beam.
- Works of monolithic stone masonry.
- Columns made by single rock.
- The structural system was post lintel or post slab.
- Massive walls and lintels was supported by flat roof.



Time period: (2371-325BC)

Aesian Architecture:

- Stone was rarely used as building materials as it was not available.
- Sun dried or kiln burnt bricks were used as building materials.
- Use of timber as a column and logs as main roofing materials.
- Flat timber roof was used to cover a larger span and it allowed columns to be slender and graceful.

Time period: (1700-1380)

Crete Architecture:

Structural system was post lintel ,
it was mostly flat roof which were supported by
walls constructed of stone blocks , rubbles and
mud brick with reinforced.



Time period: (1250-300)BC

West Asiatic Architecture:

Trabiated structural system.
Columns were well ornamented.



Time period: (600-30)BC

Greek Architecture:

Stone was the main construction materials
Trabiated structural system.
Stablishment of post lintel system.
Columns were used in Greek pattern.
Columns are set as vertical supporting element of
the main structure.
Acropolis: Great example of Greek Architecture.



Time period: (300BC-365AD)**Roman Architecture:**

The Architecture was that of Greek but they developed the post and lintel system.

Structural system was post slab and post lintel.

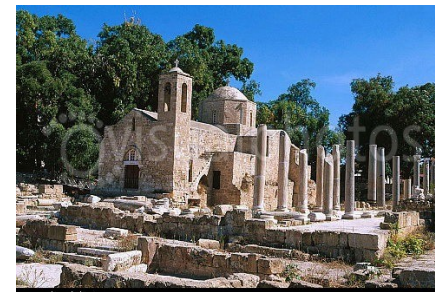
Post lintel system developed as column are used in circular and rectangular way.

Stability of Structure was easily ensured.

**Time period: (313-800AD)****Early christian:**

Handmaid rubble, concrete brick or stone were main building materials.

Construction system was archuated and trabeated.



C55-234502 [RM] (c) www.visualphotos.com

Time period: (330-1453AD)**Byzantine architecture:**

Construction material was limestone and sand mortar.

Construction system was wall slab.



Time period: (12th-16th century)

Gothic architecture:

Structural system was mainly post-lintel.

Use of tall structure.



Time period: (14th-17th century)

Renaissance architecture:

Symmetrical arrangement in free standing wall and support.

The wall thickness was lessened.

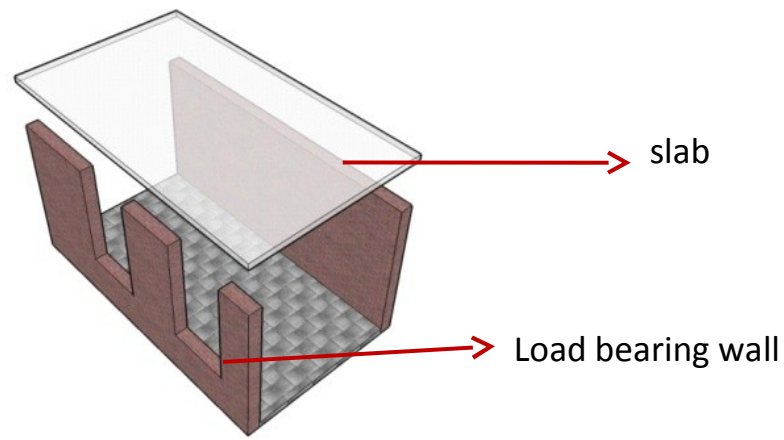
It diminished equally from the center.



Basic structural elements

Walls- Load Bearing:

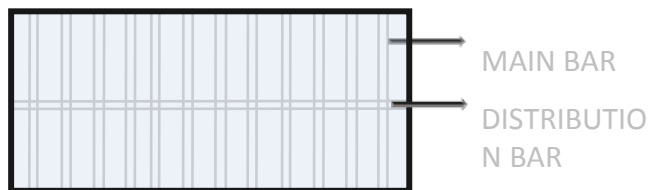
Structural walls are the vertical constructions of a building that enclose a building. Structural walls may also be internal partitions used for load-bearing conditions forming part of the structural framing system. There are two types of load bearing slab.



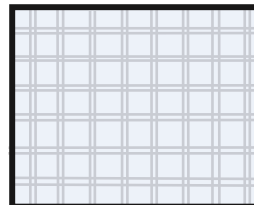
Slabs:

Slabs generally refer to various types of floor systems designed to support floor and sometimes roof loads.

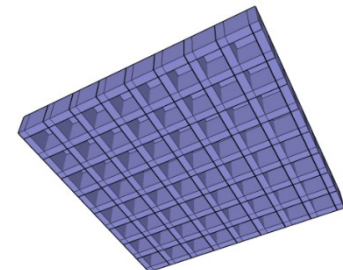
One Way Slab



Two Way Slab

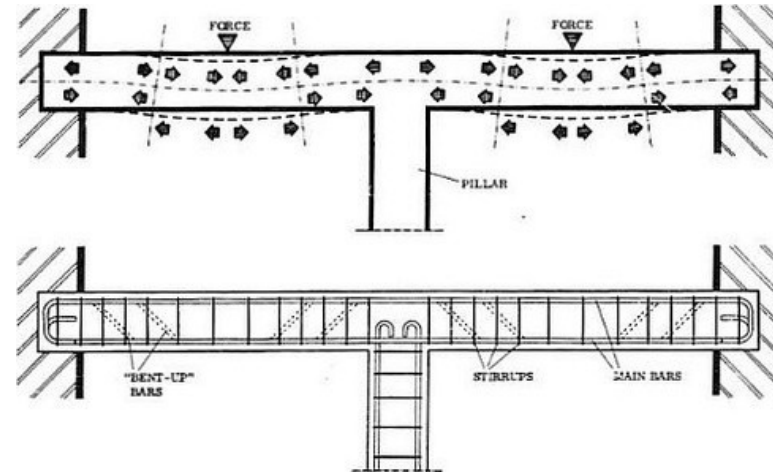


Waffle Slab

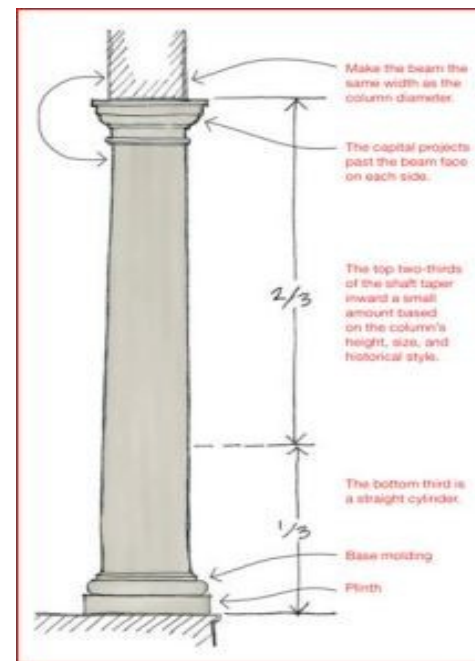


Beam:

Beams are typically horizontal structural members designed to carry a load. Steel is one of the most common materials used for beams, since it can withstand very heavy loads.

**Column:**

Are upright vertical structural members that support slabs, beams or trusses

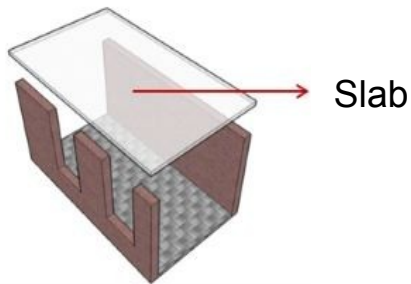


Analysis of Structural system:

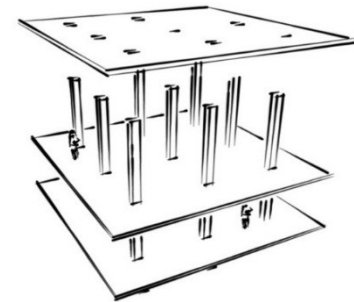
In strictly technical terms , structure may be considered as the means of translating external force into internal loads caring mechanism in order to support and reinforce an Architectural concept.

There are basic three types of structural system

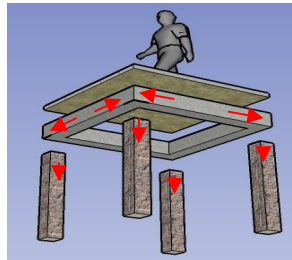
1.Wall slab structural system.



3.Post slab structural system.



2.Post-lintel structural system



WALL SLAB STRUCTURAL SYSTEM

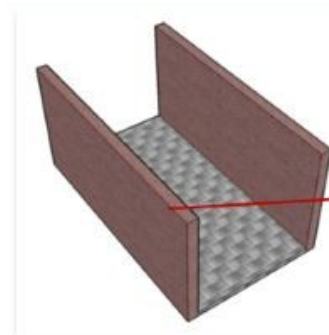
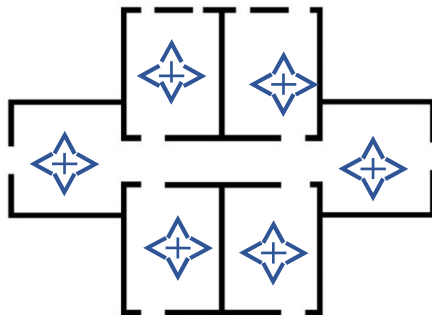
WALL SLAB

Continuous or linear support system to transfer the external loads to the ground with the help of wall and slab. A load bearing wall is a wall that bears a load resting upon it by conducting its weight to a foundation structure.

Structural Member

i. Wall (vertical load bearing member)

•Cellular wall arrangement :

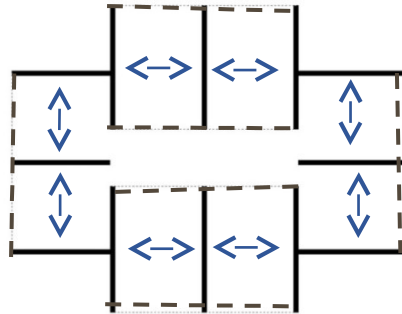


Vertical load bearing member

The structure consists of walls each joined to its neighbor. The external walls form the boundaries of the building and the internal walls divide the building into cells (rooms) making the building cellular.

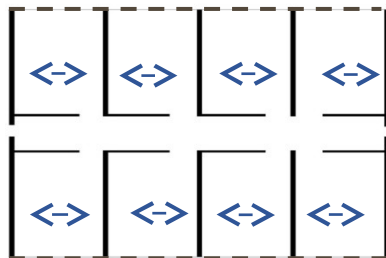
— Load bearing wall
- - Non load bearing wall

- Double cross wall structure:



If the rooms are to have effective day-lighting it will be observed that there is a limit to the depth of building which can be constructed on more complex system of cross walls set parallel to both major axes of the building.

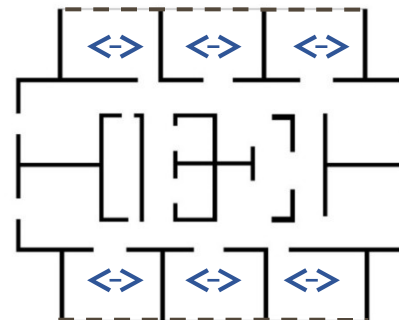
- Simple cross wall structure



This type of structure is suitable for a hostel or hotel building having a large number of identical rooms.

- Complex wall arrangement

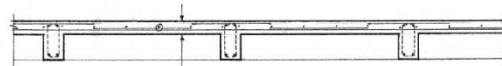
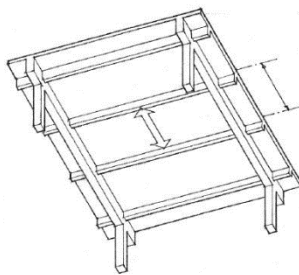
All kind of hybrids between cellular and cross-wall arrangements are included under the heading complex wall arrangement



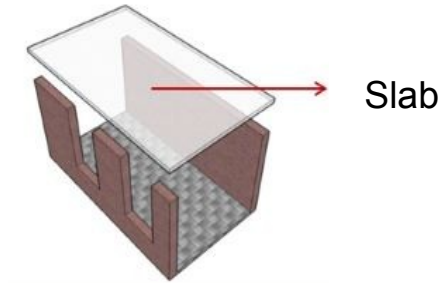
— Load bearing wall
- - Non load bearing wall

ii. Slab (horizontal load bearing member)

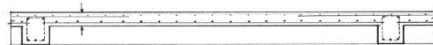
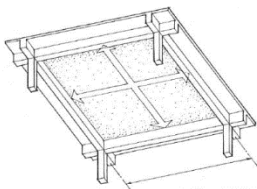
- One way slab



Length / width ≥ 2 ...one way slab



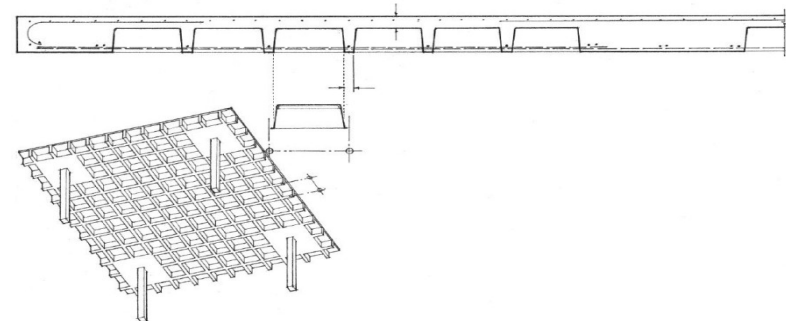
- Two way slab



Length / width ≤ 2 ...two way slab

- Waffle

For **Large Span** waffle slab constructed



Opening

- Not more than 30% of the load bearing wall
- Continuous horizontal opening avoided
- Arch framework or lintel is used
- Opening can be made from floor to wall
- Small opening
- Opening is of trabeated or arcuate system



First Unitarian church: Kahn



Massagno; Mario Botta

Load transfer method

Live load & dead load



Slab



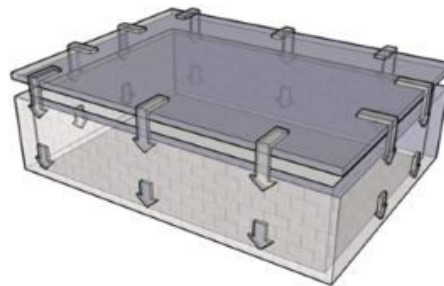
Wall



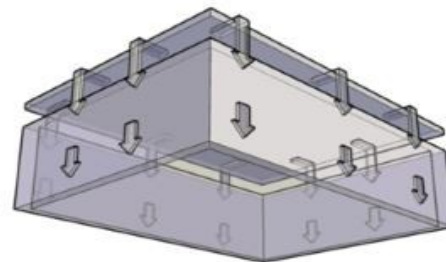
Footing



Ground

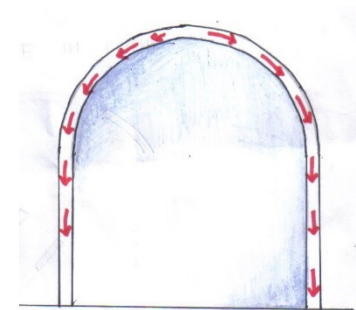


Load transferring system



Towards ground through wall

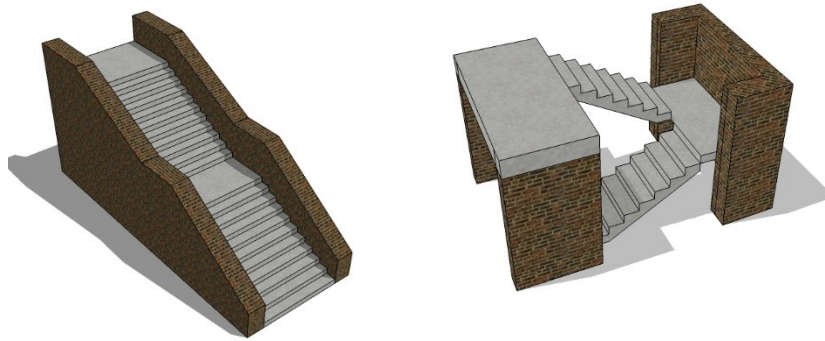
- Load transferring system towards ground through wall



- Load of the dome transfers with circular planned wall according to its periphery.
- Dome supported on squinches .

Position of stair

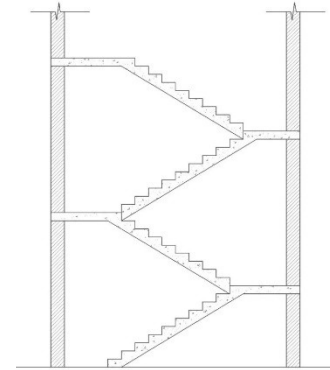
- Landing should be supported by load bearing wall
- The wall in both sides is the main structural member



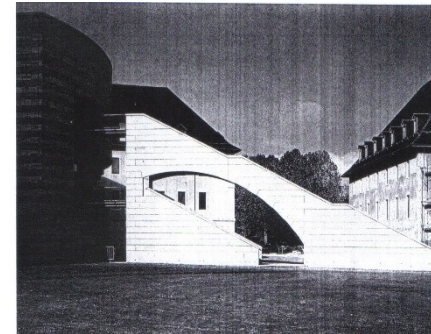
- Parallel walls on two sides can also provide support.
- Arch also can provide support for stair.
-

Span

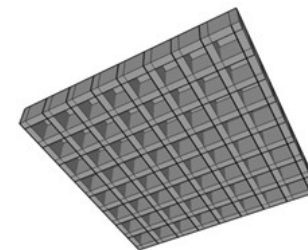
- 12'-15'
- Large span of roof is problem and it may be solved by waffle slab
- One way slab casting : $L=1.5W$



Stair case



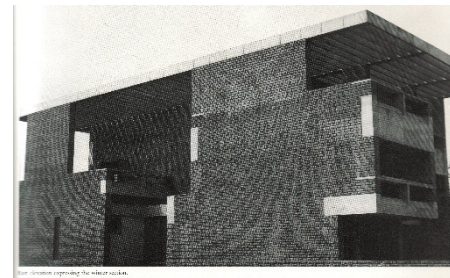
Theatre and Cultural Centre in Chambéry;
Mario Botta



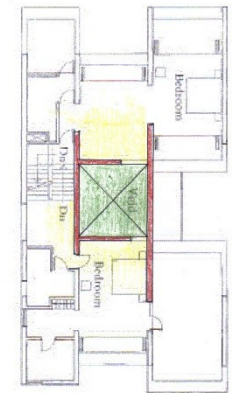
Waffle

Punch making method

- Generally punch can not be possible.
- Only a punch is appeared on first floor with respect to four walls around it.
- Punch can not be done 1/3 of the area of the roof



Parekh house



Cantilever

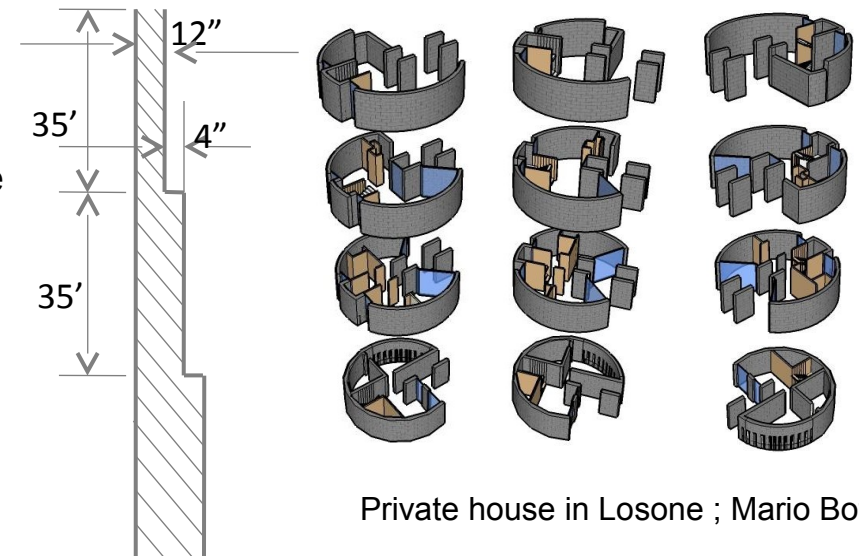
- Generally on cantilever is used

Material

- Reinforced concrete slab with wooden, brick, stone wall

Wall position/wall thickness

- Primarily 12" at six storey level and increases 4" at every one storey down
- For buildings not more than 3 stories or 35' in height, masonry walls may be 12" thick
- One stored solid masonry walls not more than 9' high may be 10" thick.
- Positions of walls are same.



Private house in Losone ; Mario Botta

Height

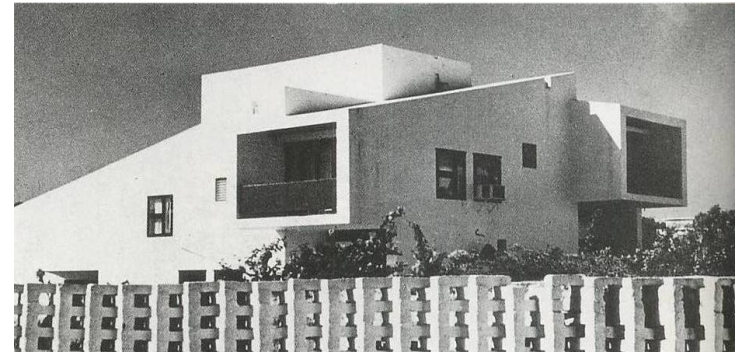
- Generally 6 storied

Cost and time

- Low rise building –this system represents economy
- Generally low cost construction
- Foundation –more shallow than other system
- Construction period –larger than any other system

Formal Expression

- Plan –no grid pattern, can be any desired shape
- Large ,unbroken plans could be expressed
- In elevation – small punches
- For large openings ,arches are provided
- Massive and bold
- Arch, dome, and vaults can be constructed in this type of structure
- Cantilevers can expressed as planes
- Solid void relation is boldly represented
- For hot dry climate this type of structure gives extra benefit.
- Screen wall can be added
- This type of structure lasted for thousand years.



Twin house, Charles Correa



Bangladesh Eye Hospital , Louis I Kahn



First Unitarian Church , Louis I Kahn

Case study : 1

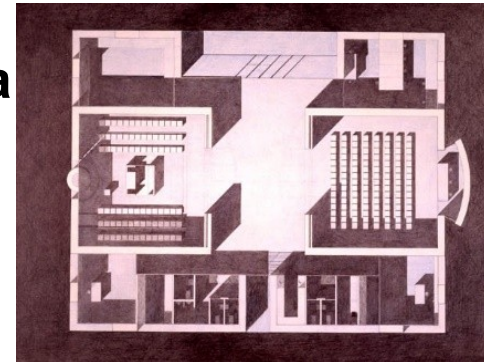
Cymbalista Synagogue ; Mario Botta

Plan- No grid pattern

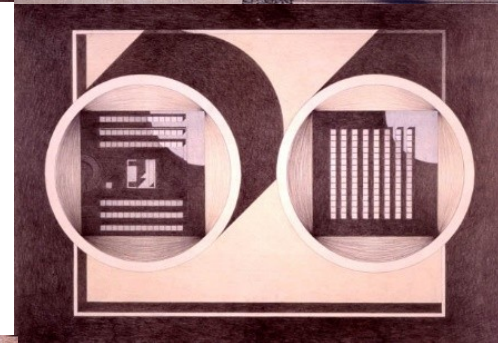
Section- clear referencing of load bearing wall

Elevation- clear expression of wall slab structure in opening

Opening- small openings



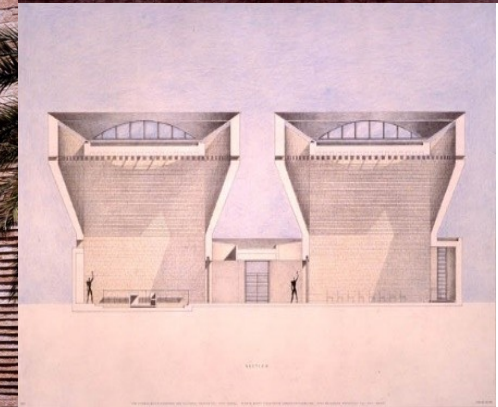
Plan



Top view



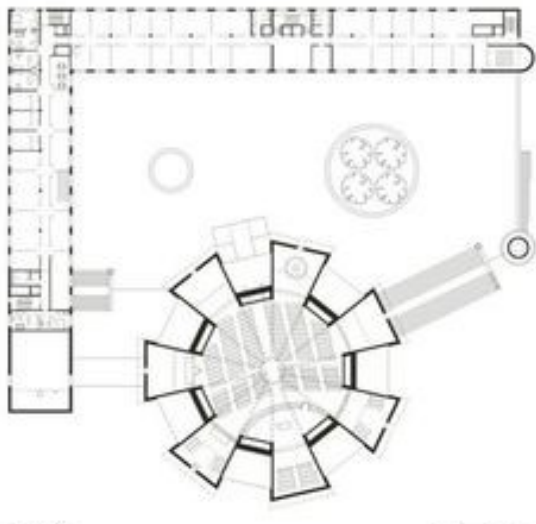
Elevation



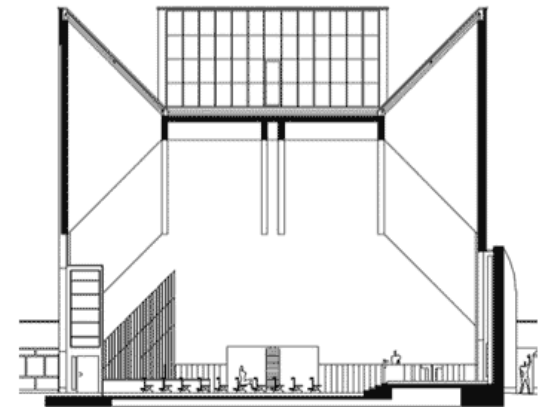
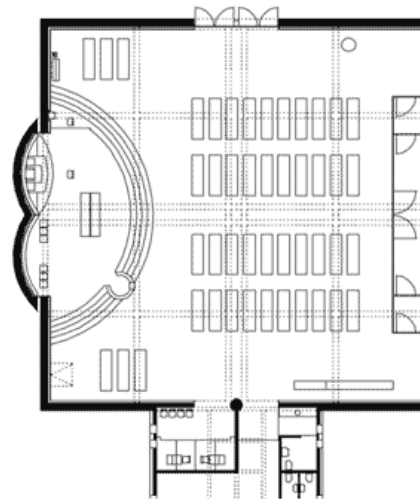
Section

Case study : 2

Church of Santo Volto ; Mario Botta



Brick wall is used which carries the load.
No expression continuous opening.
Solid void relationship is in pleasing condition
No grid pattern in plan
Vertical linear opening
No cantilever space.



Wall slab structural system

Strength

- For low storied structures this system is economical.
- Foundation is shallower than other systems, so foundation cost is the least of all.
- This type of construction lasted for thousands of years. The construction of Mohenjo-Daro built about 2500 B.C can be still identified
- Arches, Domes and Vaults are used in this system.
- Post does not disturb the free space.

Opportunity

- Screen wall can be used.
- Natural color can be obtained in the building surface, by different exposed brick of different hue.
- For hot dry climate this type of structure gives extra benefit.
- Wall thickness sometimes is extra beneficial for shading.
- This system could expresses the composition of Horizontal and vertical plane.

Weakness

- Span of the area is not enough. Maximum 12'.
- Limitation of structure height 6-7 storied.
- Walls must be built over a wall.
- More time is required
- Small space over a big space is not possible.
- Continuous opening can not possible

Threat

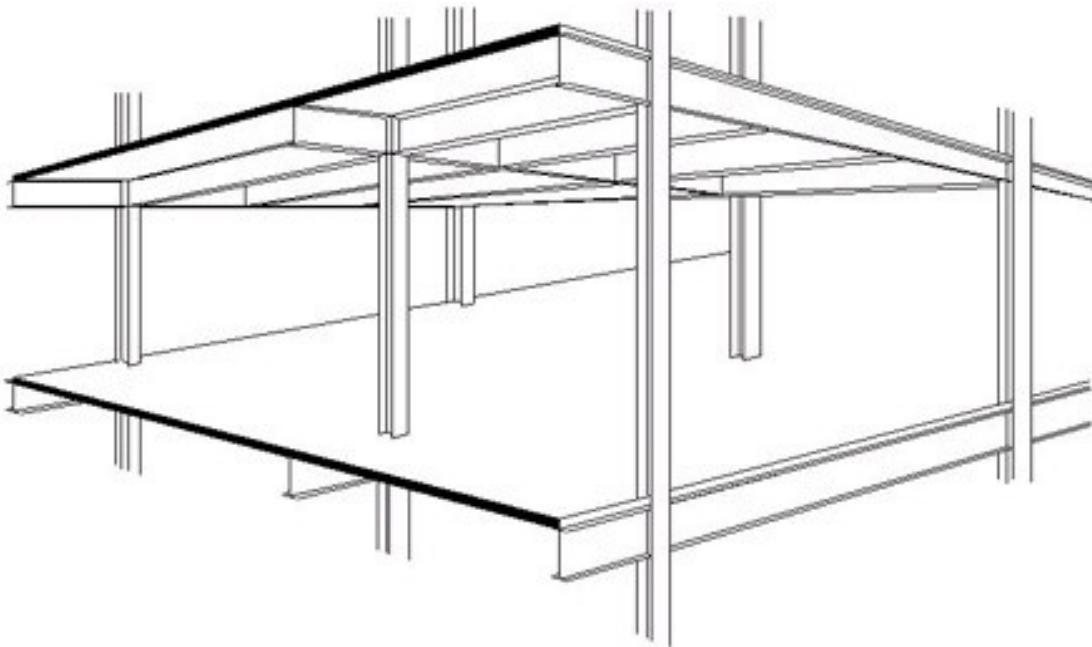
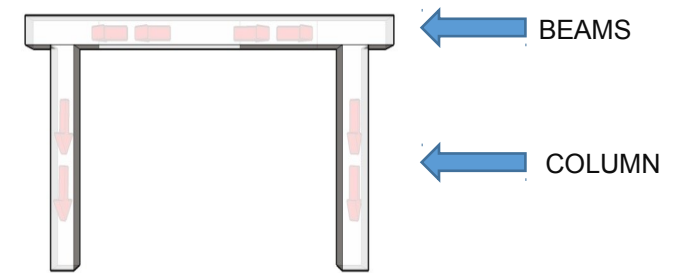
- This type of construction is not possible with out good load bearing capacity of earth.
- Flexibility of massing is very small floors can taper & up-ward.
- Dampness is also greater problem.

Post lintel

In Architecture post and lintel structural system is a simple construction technique also called column and beam, horizontal member is supported by two vertical posts at either end. All structural opening have evolved from this.

Post-and-beam structures are either loadbearing wall structures or frame structures.

A large range of spans is also possible depending on the types of element which are used.



Parthenon, GREEK



LOAD BEARING SYSTEM OF POST LINTEL

Load Dead load and Live load



Lintel



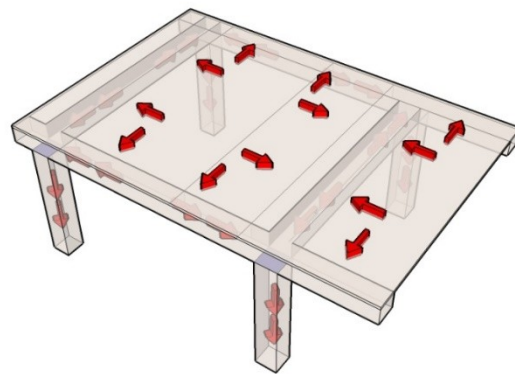
Columns



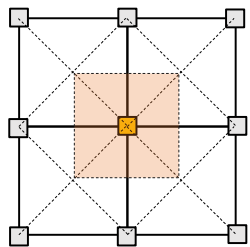
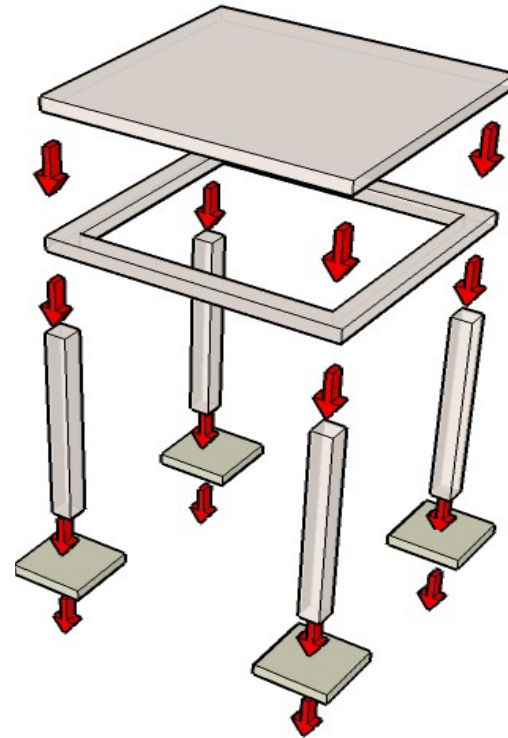
Footings



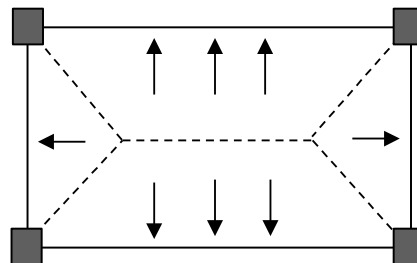
Ground



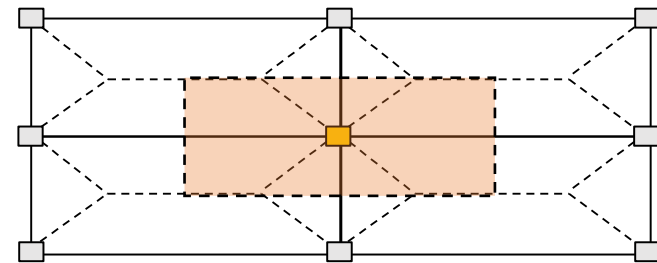
Single square grid



Multiple square grid

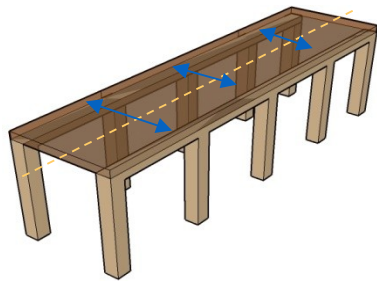


Single rectangular grid



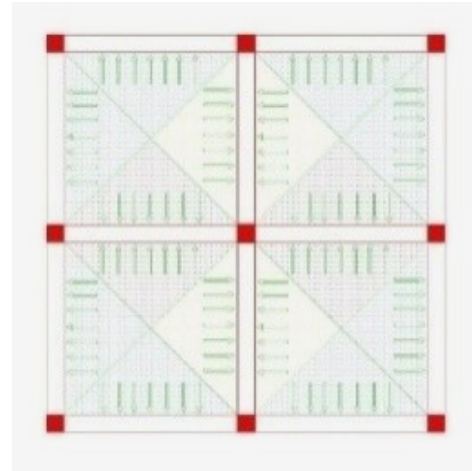
Multiple rectangular grid

One way slab

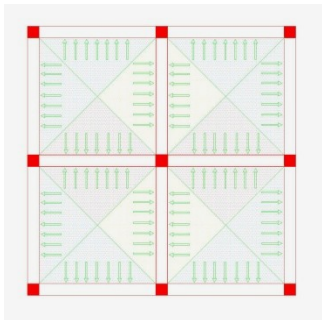


If Length = L Width = W, & $L/W > 2$
Then the slab works as a one way slab

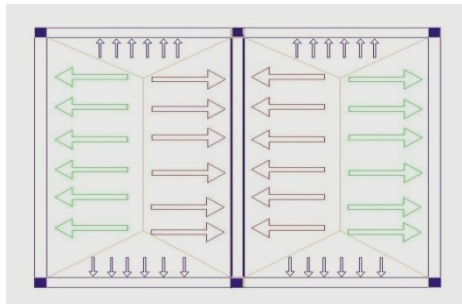
Two way slab



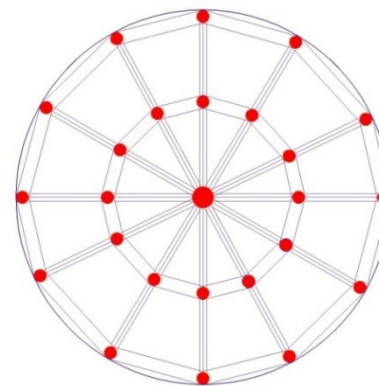
Orientation of members



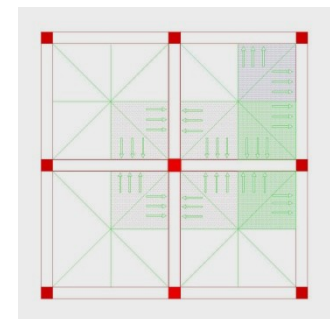
For Beam



RECTANGULAR PLAN



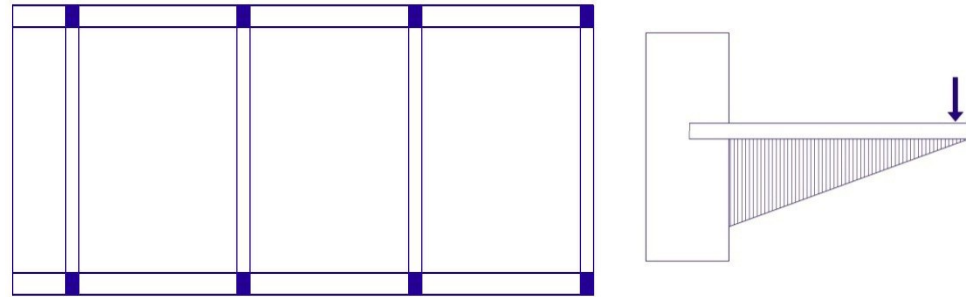
RADIAL GRID



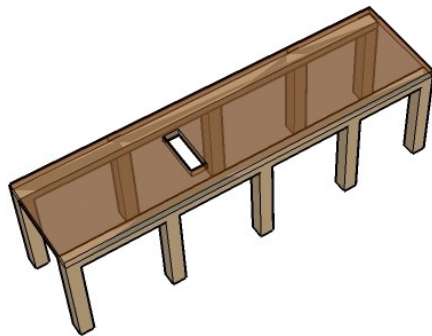
For Column

Span

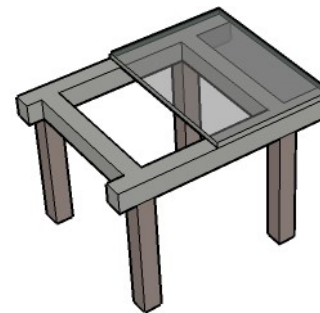
1. An overhang where one floor extends beyond and over a foundation wall.
2. Can be possible even more than 30-50% (economic)
3. Span is limited, 17'-22' is economical. Beam is proportional to span of slab. Such as span 40' than the width 40".



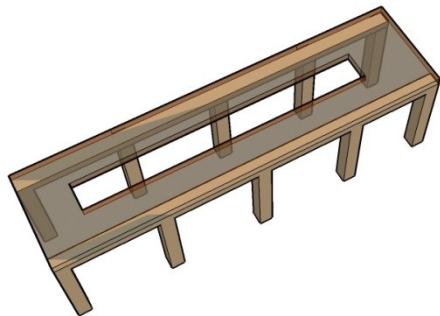
Punch



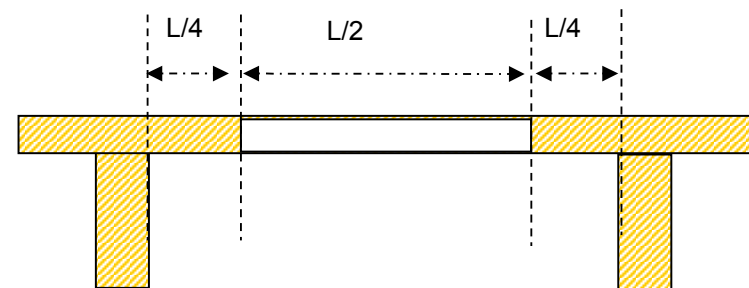
possible



possible



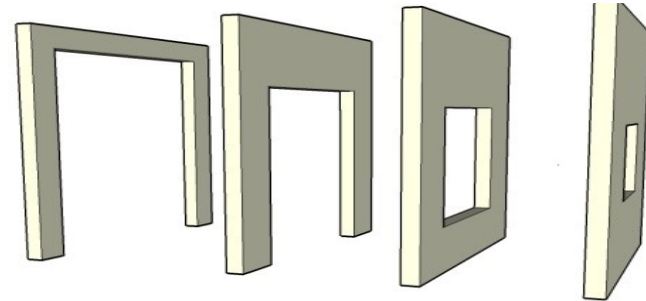
Not possible



Punched on the slab can be obtained without any disturbance.

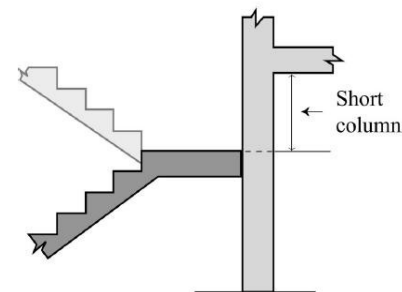
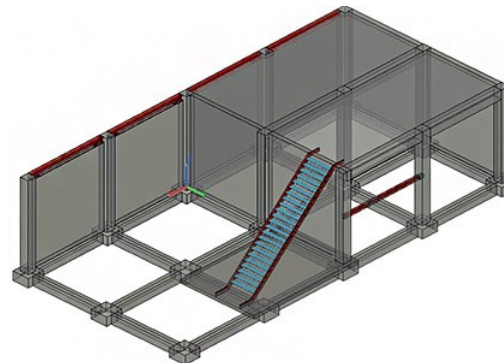
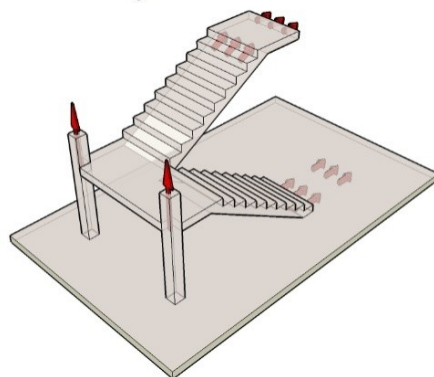
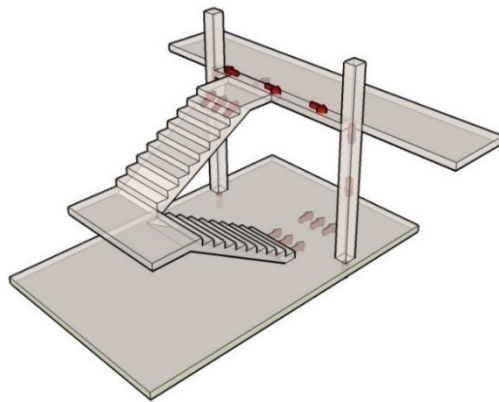
Wall

Wall must be placed over a beam. As wall does not carry any load opening can be created anywhere of the wall, 100% opening in wall surface is possible.



Stair

Stair must start with respect to a beam



Expression:

- Post and lintel are shown as a frame work.
- Beam can be shown under or over the roof as inverted beam.
- Column and beam can be identified.
- Columns are placed along the edge line of the building.
- Building height increase for the beam to get clear space.
- Unexpected lines can be formed in elevation.
- Unexpected beam can disturb the indoor spatial qualities.

Time and cost:

Time period less than wall slab system. More costly than wall slab(30% more for low rise than wall slab). Economical for large span building

Context:

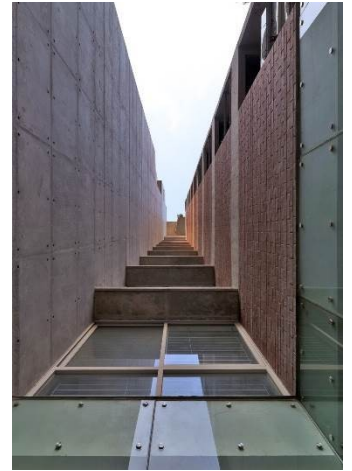
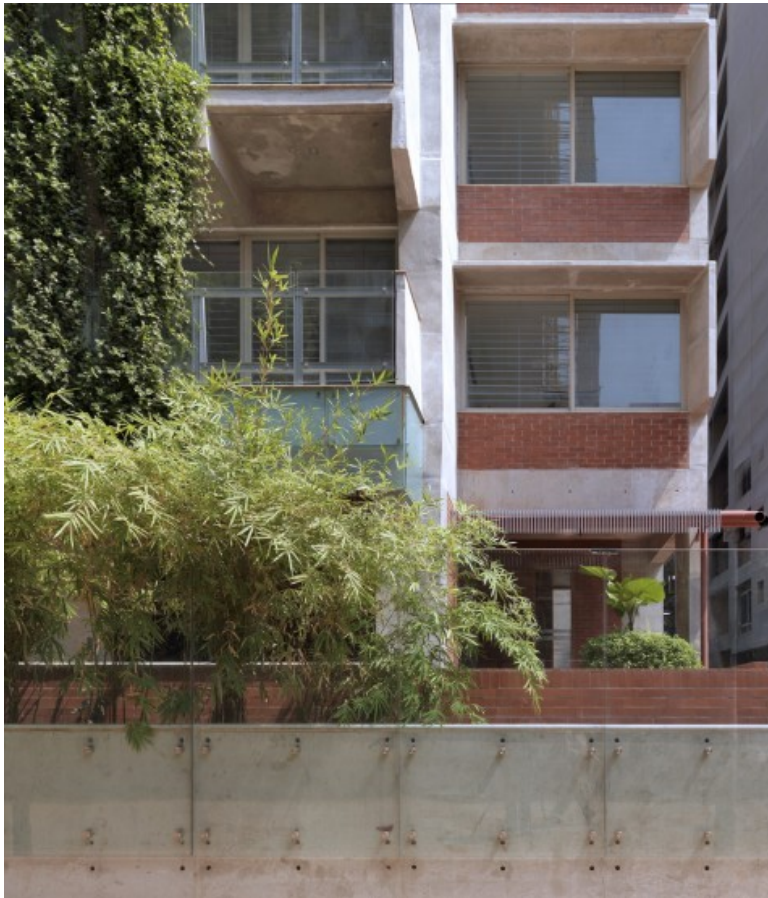
Suitable for composite climate

Material: R.C.C, iron, brick, timber, stone, steel



South 5053 Apartments

Designed by -shatotto



HMC Architects designed the Willow Elementary School, in the Los Angeles



Advantage

- Maximum column to column opening can be provided easily
- Roof can be provided flat, pitch or any other shape
- Punch in slab can be provided easily
- Aesthetic framework can be done

Disadvantage:

- The biggest disadvantage to a post and lintel construction is the limited weight that can be held up, and the small distances required between the posts.
- The tension induced by deformation of self-weight and the load above between the posts.

Post Lintel Structure System

Strength

- 50% cantilever system is applicable.

Opportunity

- Maximum column to column opening
- Any type of roof can be provided
- Aesthetic framework can be done

Weakness

- Unexpected beam hampers interior.
- Acoustic problem may occur.
- Stairs must be started with the reference of beam

Threat

- If beam is not strong enough, where large span, huge concentrated load may occur bending stress and deflection.
- Short span beams with large concentrated load near the posts will occur shear stress .

Post slab structural system:

Members: Column , Slab

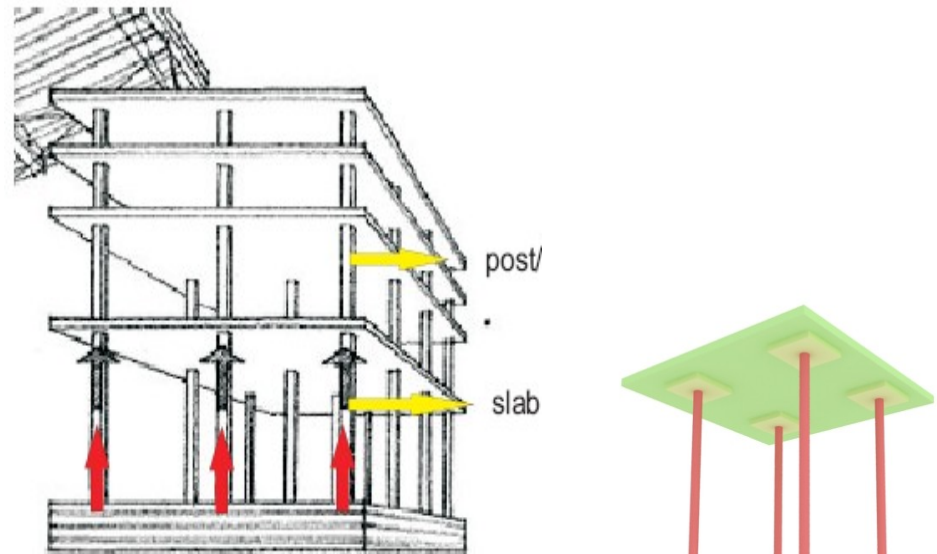
Slab_ Horizontal structural member

Post_ Vertical structural member

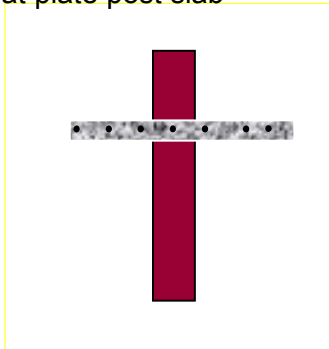
Classification of post slab:

A.flat plate

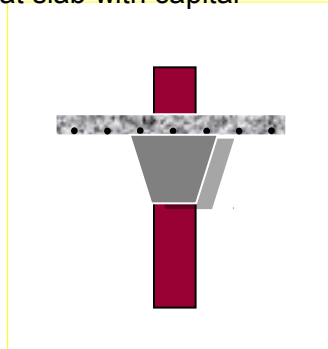
B. flat slab : with capital
with drop
with capital & drop



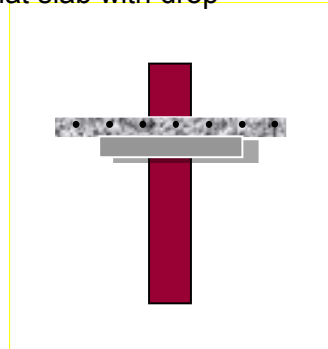
flat plate post slab



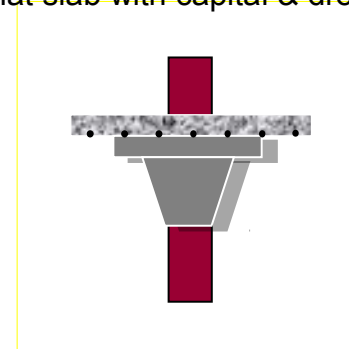
flat slab with capital



flat slab with drop



flat slab with capital & drop



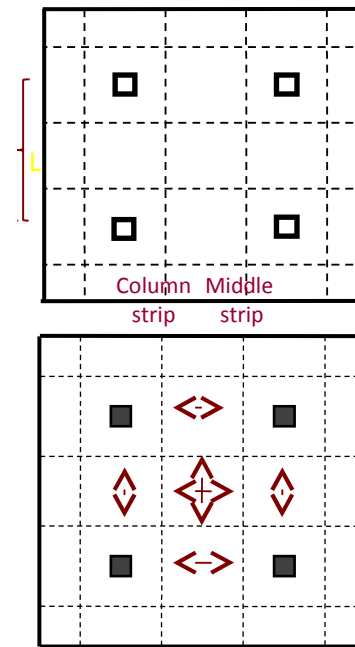
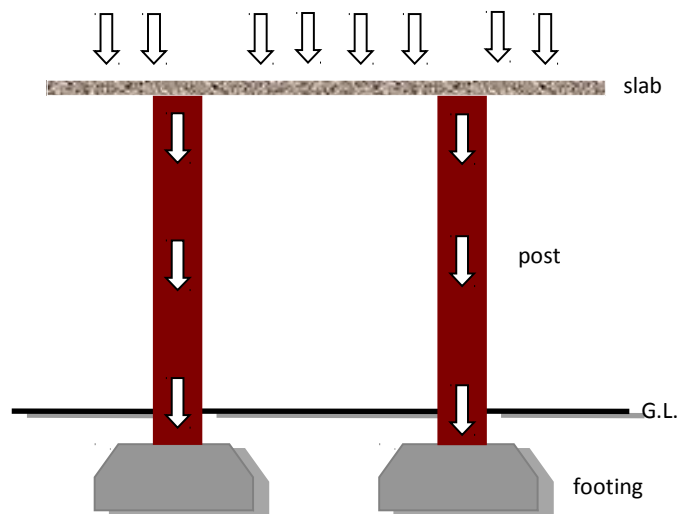
Materials:

R . C . C , iron

Load transfer system:

The load of the slab it self and other live load transfer to the post by the slab. both the dead load and live load which the post gets form the slab transfer to the ground by the post.

Load ▷ slab ▷ column ▷ ground



Span:

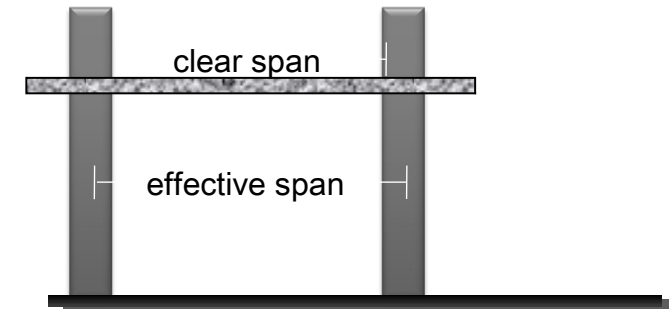
effective span

horizontal distance between center points of two vertical support.

clear span

horizontal distance between internal faces of two vertical support.

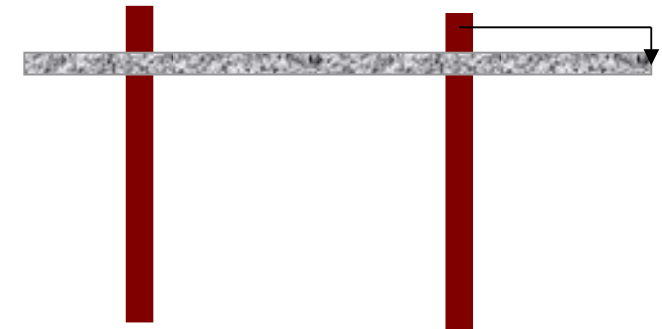
Economical 17'-22'



Cantilever:

Floor slab in all across must be cantilevered and it will be $\frac{1}{3}$ of the span of the post

maximum cantilever will be 33- 50% of the span.

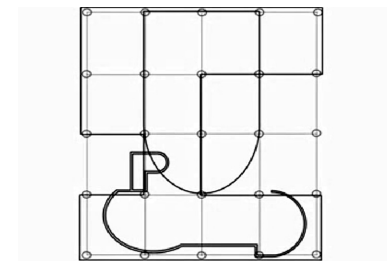
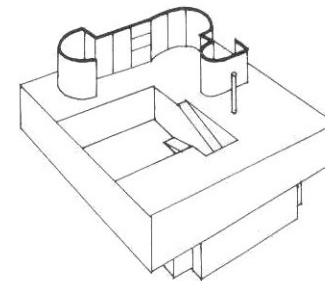


Position of wall:

Wall can be built freely as desired in different floors.

it is recommended to built walls on the column strips.

It is better to avoid the middle strips from first floor.

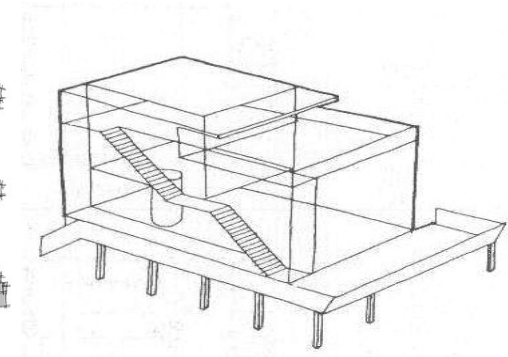
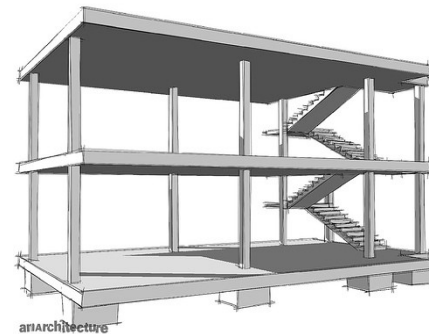


Stair position:

Stair can be created from middle strip.

Simply supported stair.

Stair can be created by using cantilever as landing.



Maison Citrohan
Le Corbusier

Opening:

Any kinds of opening of any size can be provided

Ribbon window –possible



Villa savoye; le corbusier



COTTBUS UNIVERSITY LIBRARY



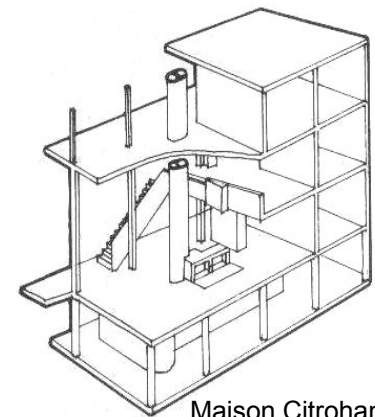
Villa Stein-De-Monzie
Le Corbusier

Punch in slab:

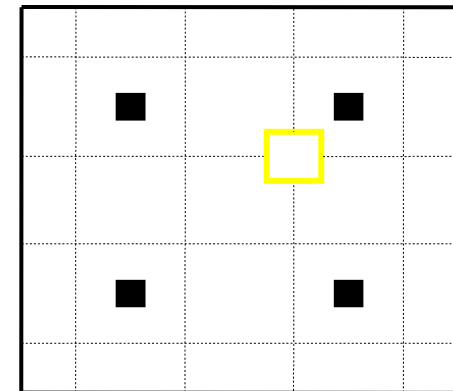
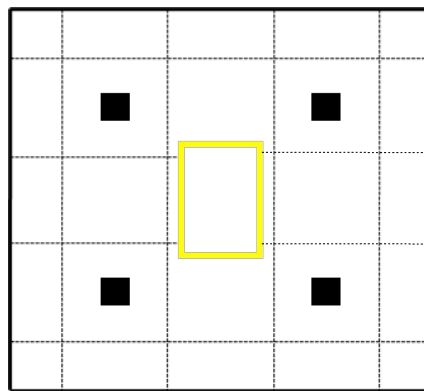
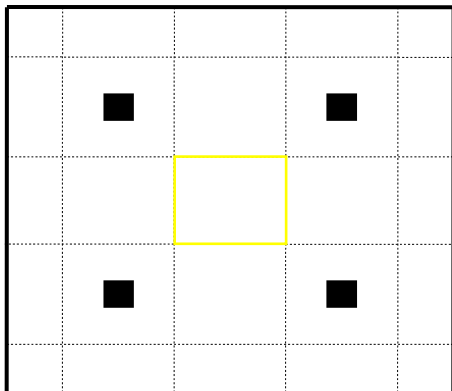
in the area common to the slab middle strips.

in the area common to two column strips, not more than one-eighth the width of the strip in either span should be interrupted by openings..

in the area common to one column strip and one middle strip, not more than one –fourth of the re-enforcement in either strip should be interrupted by the opening.



Maison Citrohan
Le Corbusier



Position of wall:

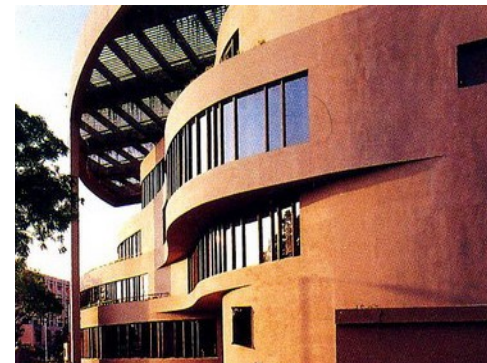
Wall can be built freely as desired in different floors.

it is recommended to built walls on the column strips

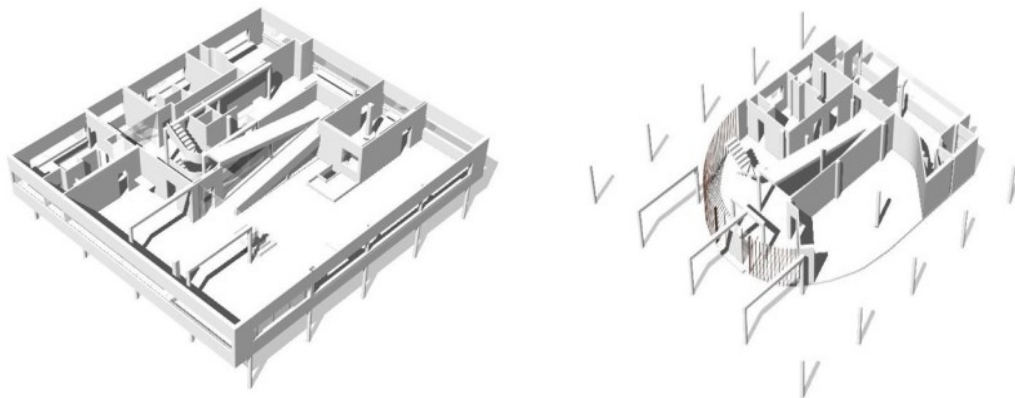
It is better to avoid the middle strips from first floor



Johnson Wax Administration Building
Frank Lloyd Wright



MRF Headquarter
Charles Correa



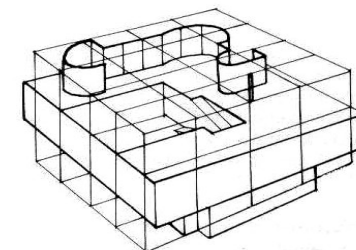
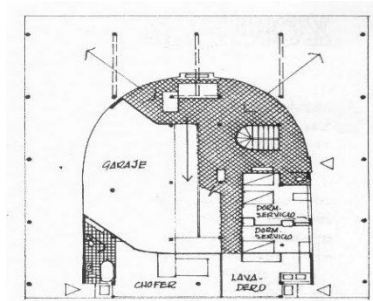
Expression:

The plan of the building of post and slab system is regular shaped and respect strong square grid pattern.

The slab is always cantilevered from the post.

Solid void relationship is strongly achieved

Vertical reference is maintained



Expression:

Massing constructed in post and slab system has an effect of floating

Continuous opening can be provided



Advantage:

Ribbon window or large opening is a greater opportunity

Cantilever 33%_50% possible

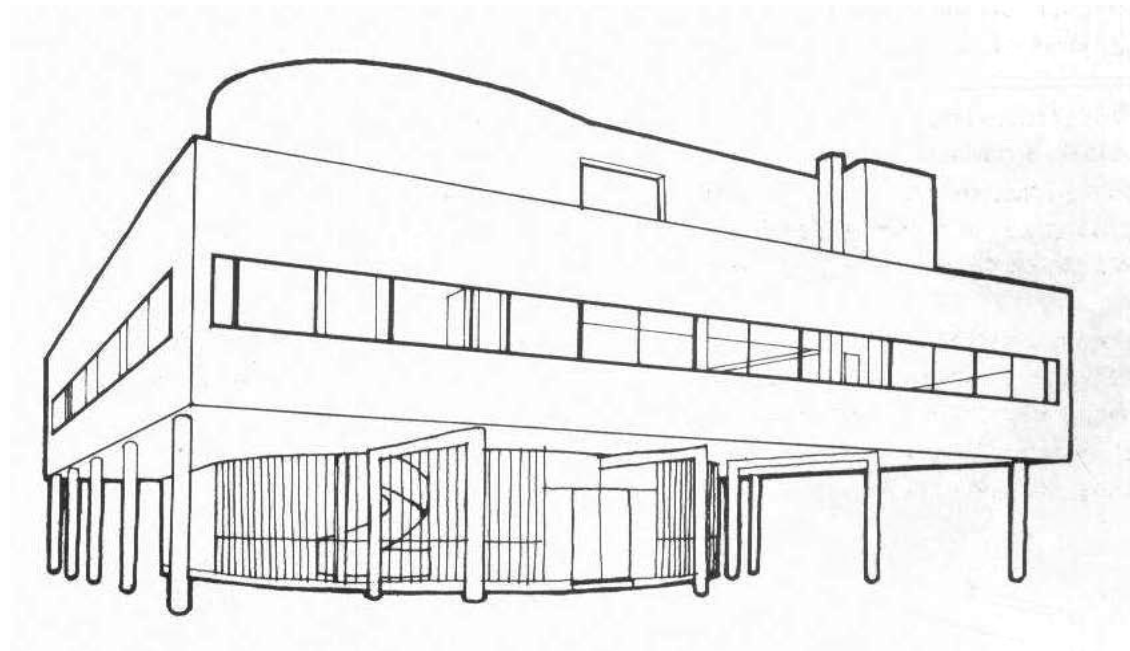
Slabs can be cut as freely as needed

Position of enclosing wall can be changed in different floor plan

Different types of shading device can be used

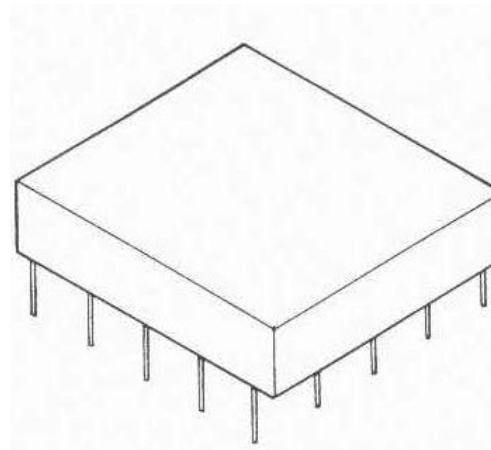
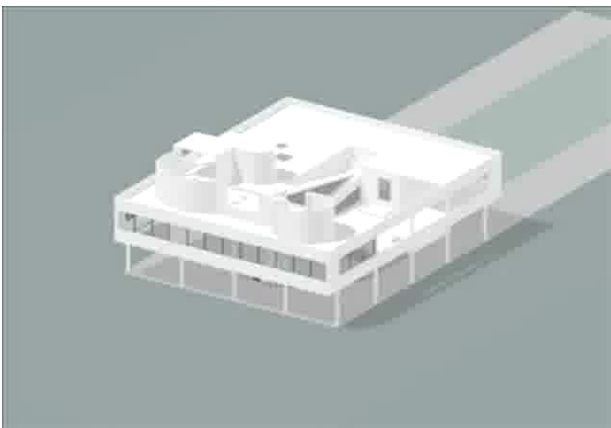
Partition wall can be use as required



CASE STUDY:

Villa savoya
Le corbusier

Load transfer system:



slab/floor



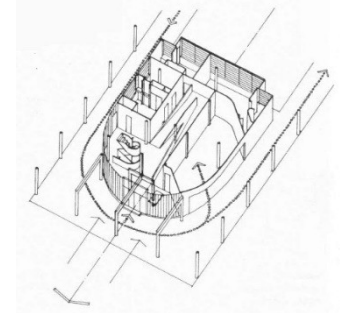
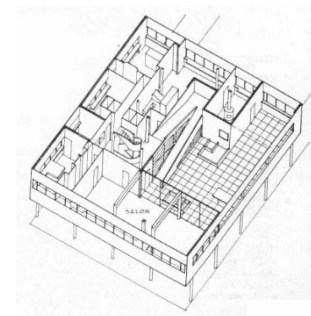
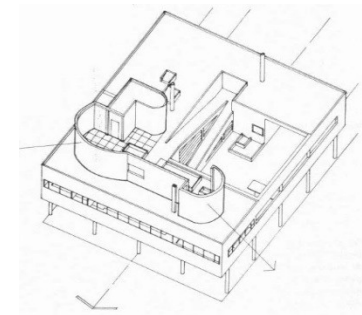
Column

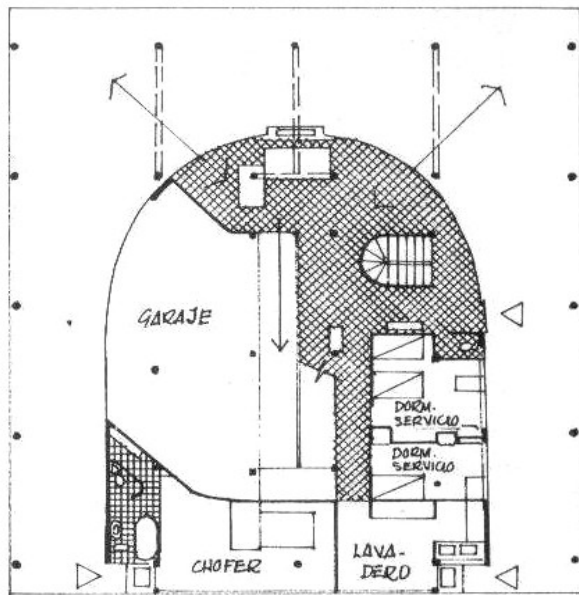


Footing

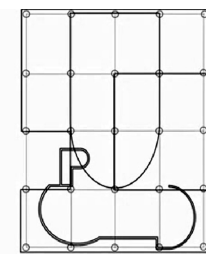
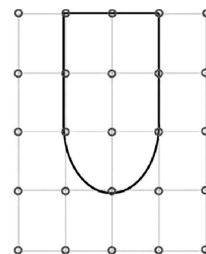
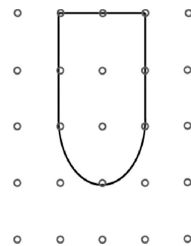
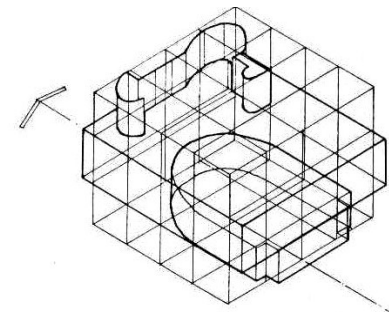
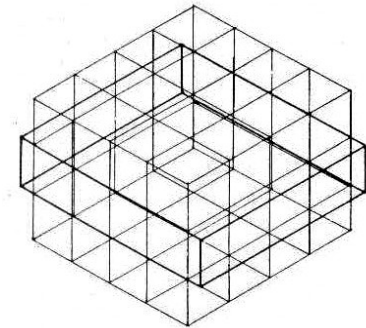


sub soil



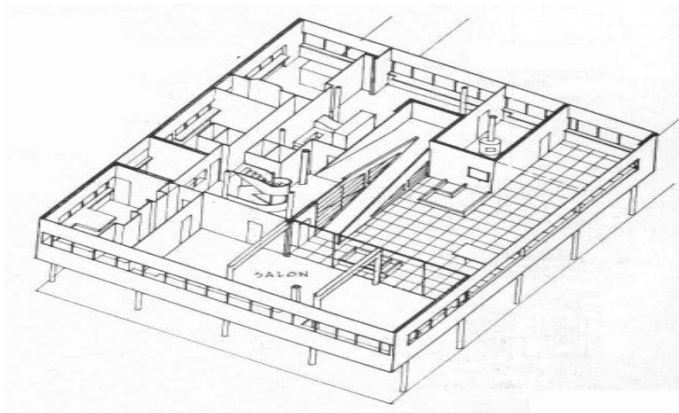
Orientation:

Square grid pattern

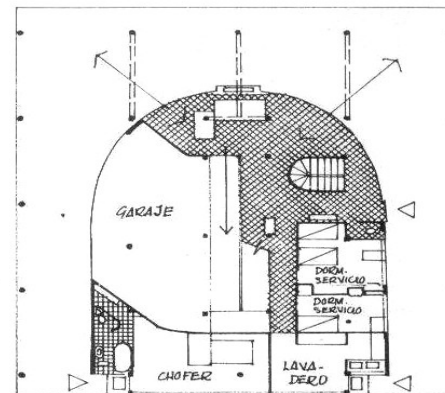


Opening:

Continuous opening, ribbon window

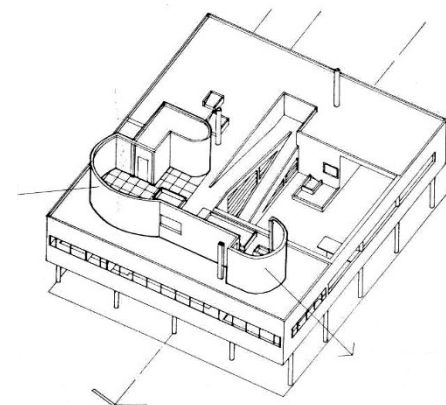
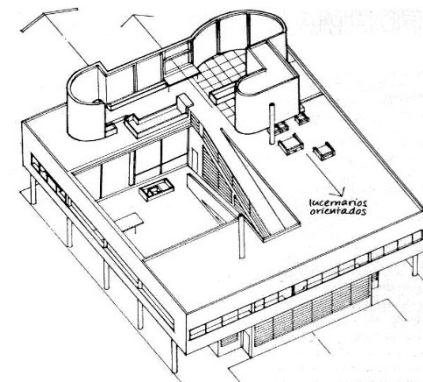
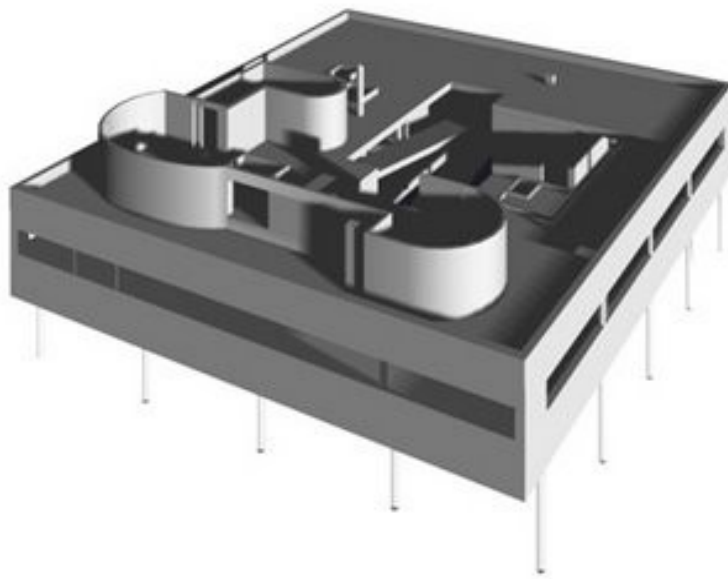


Cantilever:



Punch in slab:

Large Punch, without disturbance of beam



Stair in the middle strip

“.....From structural view point punches in the slabs are best located well away from the columns, preferably in the area common to the slab middle strip. Unfortunately architectural consideration usually cause them to be located close to the columns.”

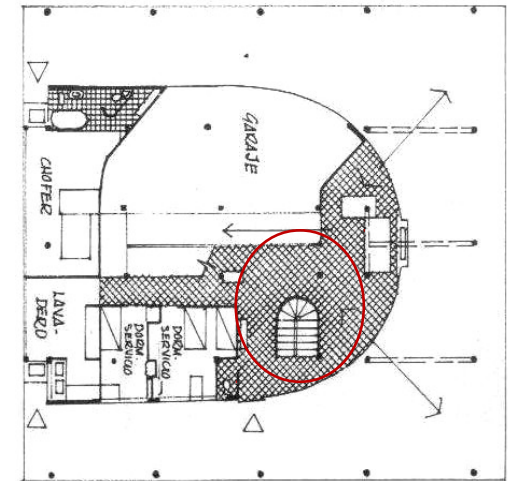
Expression:

Ground floor a band of column, and in the first floor strip of ribbon window.

The main body of the house is limited by four similar walls.

Solid void relationship found here.

Floating effect



Post slab structural system

Strength

- Economical for low storied structure
- Shallow Foundation
- Long lasting

Opportunity

- Plans follow no grid pattern; it can be of any desired shape.
- Large, unbroken plans could be formed.
- Extra benefit for hot dry climate
- Wall thickness sometimes extra beneficial for shading.
- Post does not disturb the free space.

Weakness

- Continuous ribbon window for panoramic view is impossible.
- Wall thickness is greater than in the other two systems.
- As for the poor opening ratio, it is not suitable for our climatic condition.
- Small space over a big space is not possible.
- Wall must be built over a wall.

Threat

- Not usually suitable for high-rise
- Span of the area is not large enough.
- Allowable amount of cantilever is limited
- Low Flexibility of massing

COMMON FEATURE

Topic	Wall slab	Post lintel	Post slab
Structural system	Load -slab-wall foundation-ground	Load-slab-beam post-ground	Load-slab-postground
Opening	Absence of continuous opening -Nearly 1/3 of the total floor slab area Can be made hollow.	-series of openings, ribbon Window can be possible. -post makes problem in Placing of windows	Continuous opening in the wall -Ribbon window can be provided.
Wall	-wall must be build one above another	-Must be build over the beam -wall does not carry any load -opening can be anywhere Of the wall	wall can be made anywhere

Reference

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Design of concrete structure 14

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DESIGN OF MASONRY STRUCTURE , A.W. HENDRY, B. P.

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