Study On Basic Structural System

(Studi : Sistem Struktural Dasar)

STRUKTUR BANGUNAN RENDAH

Submitted By:

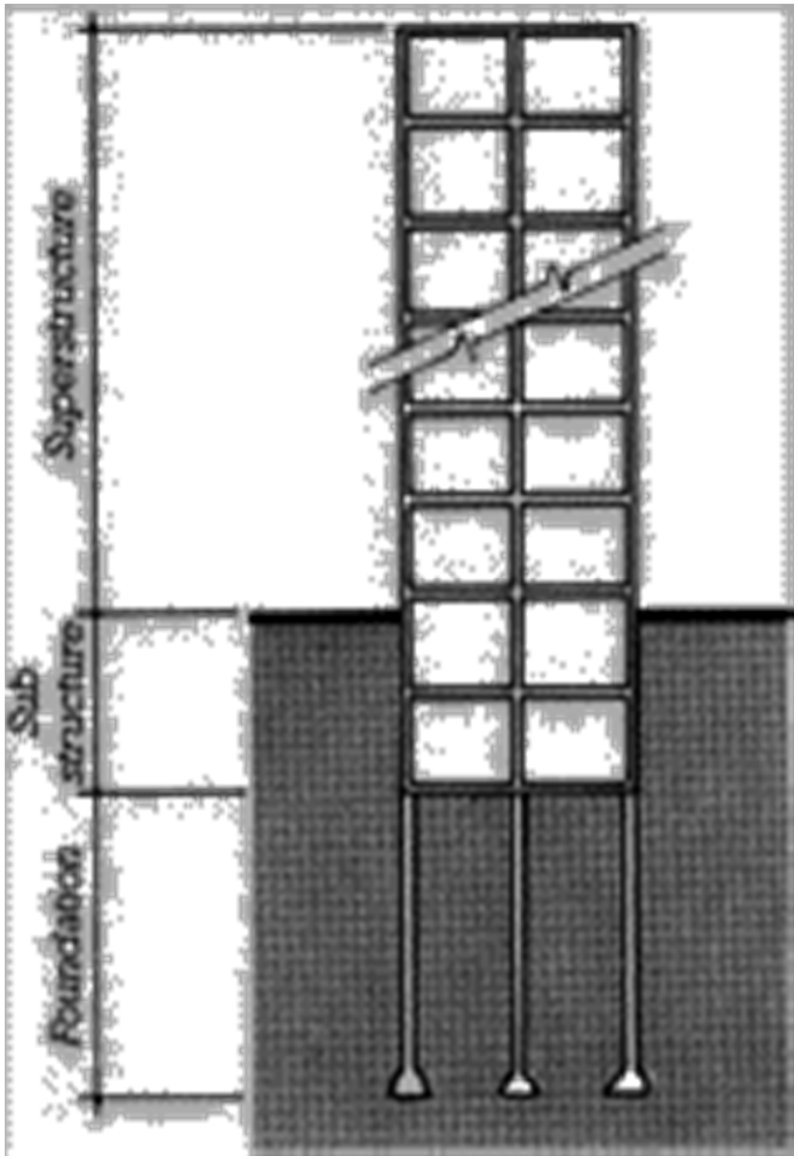
CONTENT

Introduction

Structure / Struktur

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.

Struktur adalah gagasan fundamental, berwujud atau tidak berwujud Konstruksi atau kerangka elemen yang dapat diidentifikasi (komponen, entitas, faktor, anggota, bagian, langkah, dll.) Yang memberi bentuk dan stabilitas, dan menahan tekanan dan ketegangan.



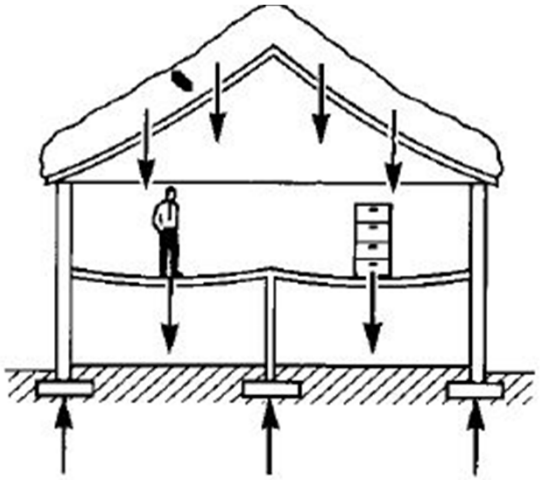
The basic frame work and skeleton provide for both erection and stability of any structure consist of two portion:

Pekerjaan rangka dan kerangka dasar menyediakan baik ereksi dan stabilitas struktur apapun terdiri dari dua bagian:

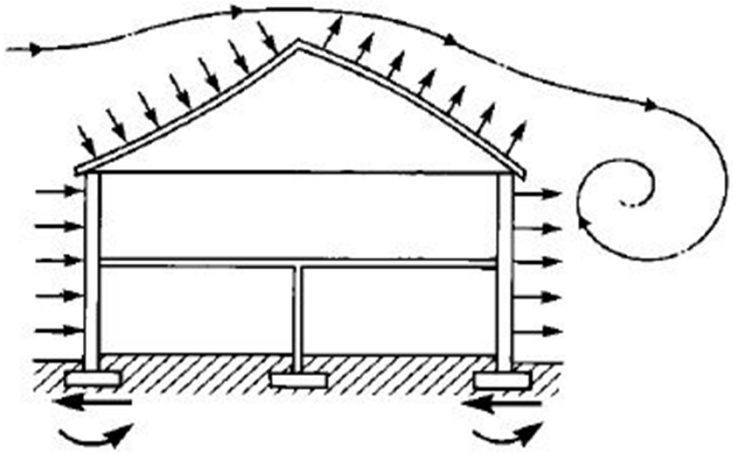
1. substructure
2. superstructure

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

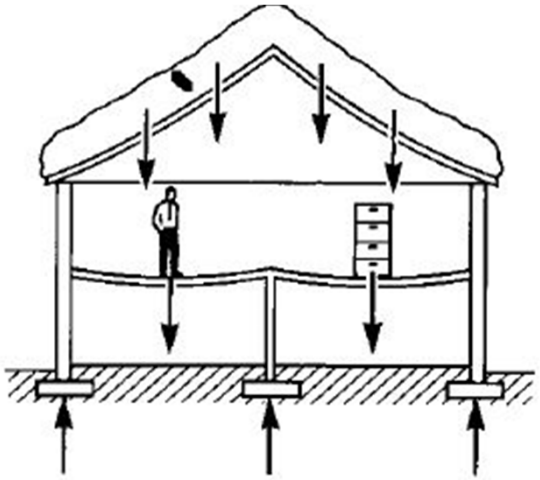


external surfaces are exposed to the climatic loads.

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

Cara termudah untuk mendeskripsikan fungsi struktur adalah mengatakan bahwa itu adalah bagian dari bangunan yang menolak muatan yang dikenakan padanya. Bangunan dapat dianggap hanya sebagai sebuah amplop yang membungkus dan membagi ruang untuk menciptakan lingkungan yang terlindungi. Permukaan yang membentuk amplop, yaitu dinding, lantai dan atap bangunan, dikenai berbagai jenis muatan.



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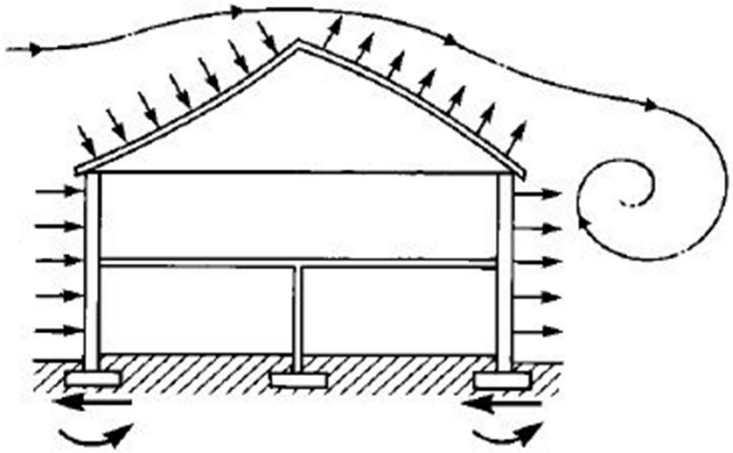


external surfaces are exposed to the climatic loads.

Beban gravitasi dan pendudukan bangunan menyebabkan struktur atap dan lantai menekuk dan mendorong gaya internal tekan di dinding. Angin menyebabkan tekanan dan beban isap bekerja pada semua permukaan luar.

The relationship of structure to building

A building structure must be able to support two types of load. (dua tipe beban: beban statis dan beban dinamis)

1. **S t a t i c l o a d .**
2. **D y n a m i c l o a d .**

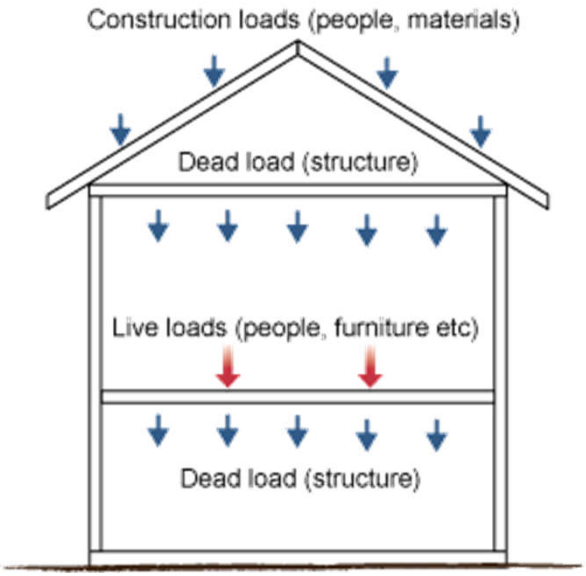
S t a t i c l o a d : Assumed to be constant in nature.
Its two type.

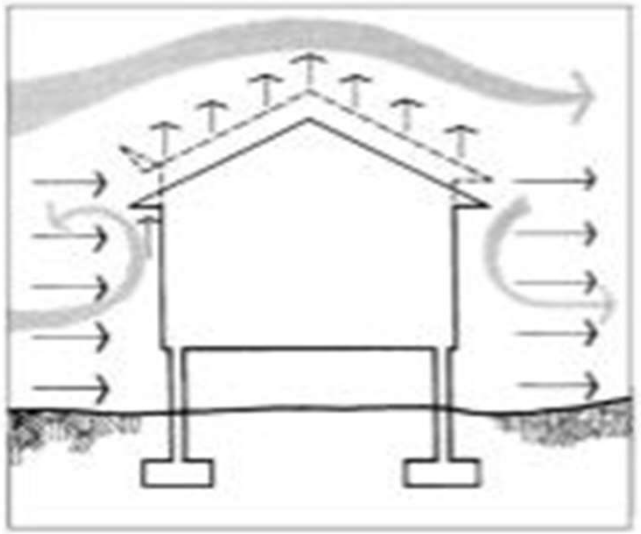
1. **Dead load**
2. **Live load**

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 with in 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 show loads no roof.

D y n a m i c l o a d :
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 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 **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 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 requirements (persyaratan struktural)

Untuk menjalankan fungsinya dalam mendukung bangunan sebagai respons terhadap muatan apapun yang mungkin diterapkan padanya, struktur harus memiliki empat sifat:

- it must be capable of achieving a state of **equilibrium**. ***Itu harus mampu mencapai keadaan kesetimbangan.***

  Ini mengharuskan konfigurasi internal struktur bersama dengan sarana yang dengannya terhubung ke fondasinya harus sedemikian rupa sehingga semua beban yang diterapkan setimbang persis dengan reaksi yang dihasilkan pada fondasinya.

- it must be **geometrically stable**. ***Itu harus stabil secara geometris.***

  Kestabilan geometrik adalah properti yang mempertahankan geometri suatu struktur dan memungkinkan elemen-elemennya untuk bertindak bersama untuk menahan beban. Perbedaan antara stabilitas dan ekuilibrium diilustrasikan oleh kerangka kerja

Structural requirements (persyaratan struktural)

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- it must have adequate **strength**. ***Itu harus memiliki kekuatan yang memadai***

  Persyaratan untuk kekuatan yang memadai dipenuhi dengan memastikan bahwa tingkat stres yang terjadi pada berbagai elemen struktur, ketika beban puncak diterapkan, berada dalam batas yang dapat diterima.

- it must have **adequate rigidity**. ***Itu harus memiliki kekakuan yang memadai.***

  Perhitungan struktural memungkinkan Dan kekakuan struktur yang harus dikontrol secara tepat. Mereka didahului oleh penilaian beban yang harus dibawa oleh sebuah struktur.

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 slander 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.

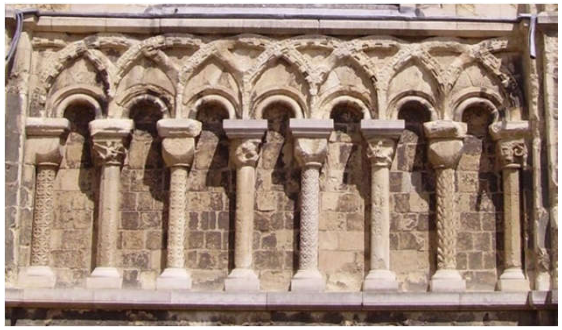
Time period: (600-30)BC
Greek Architecture:
Stone was the main construction materials
Trabiated structural system.
Stablishment of **post lintel** system.
Columns were used in Greek pattern.
Columns are set as vertical supporting element of the main structure.
Acropolis: Great example of Greek Architecture.

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.

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**.



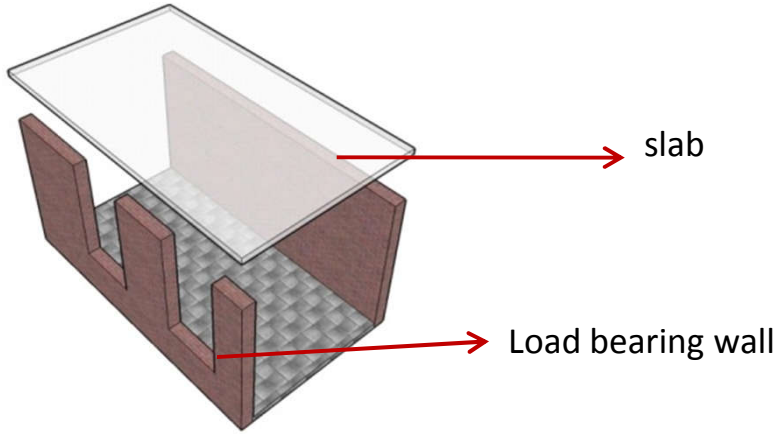
Time period: (14th-17th century)
Renaissance architecture:
Symmetrical arrangement in **free standing wall** and support.
The wall thickness was lessened.
It diminished equally from the center.

BEARING WALL

BEARING WALL

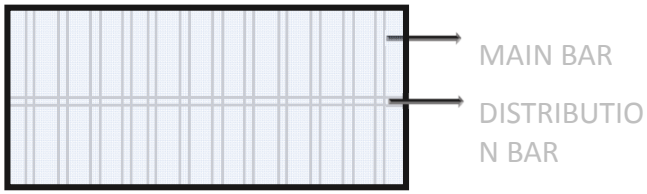
Walls- Load Bearing:
Structural walls are the vertical constructions of a building that enclose a building. Structural
walls may also be internal partitions used for load-bearing conditions forming part of the
structural framing system. There are two types of load bearing slab.

Basic structural elements

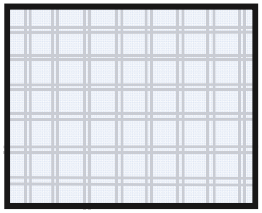


Slabs:
Slabs generally refer to various types of floor systems designed to support floor and sometimes roof loads.

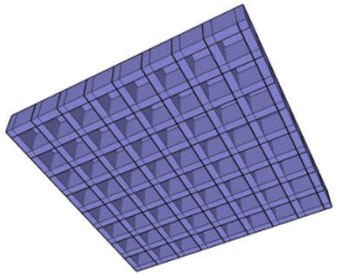
One Way Slab



Two Way Slab



Waffle Slab



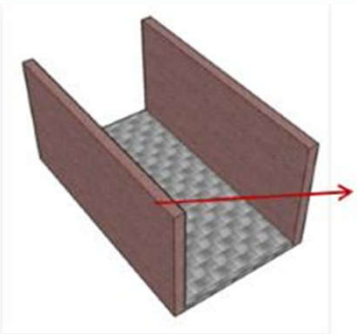
WALL SLAB STRUCTURAL SYSTEM

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.

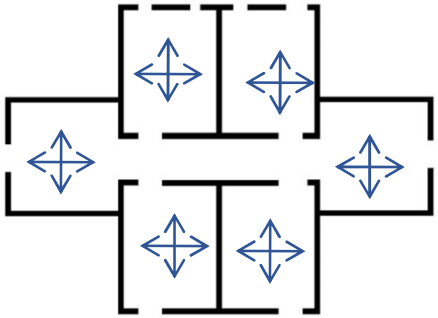
Structural Member

i. Wall (vertical load bearing member)



Vertical load bearing member

- Cellular wall arrangement :

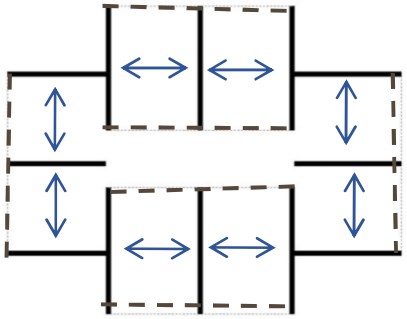


The structure consists of walls each joined to its neighbor. The external walls form the boundaries of the building and the internal walls divide the building into cells (rooms) making the building cellular.

Load bearing wall
Non load bearing wall

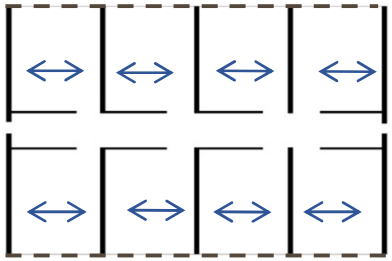
BEARING WALL

- 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.

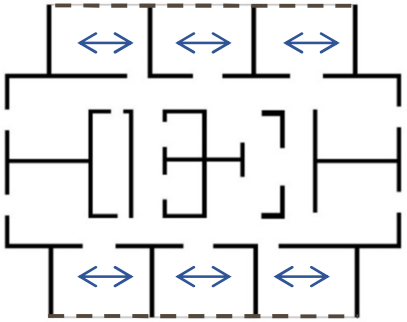
- Simple cross wall structure

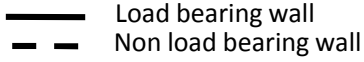


This type of structure is suitable for a hostel or hotel building having a large number of identical rooms.

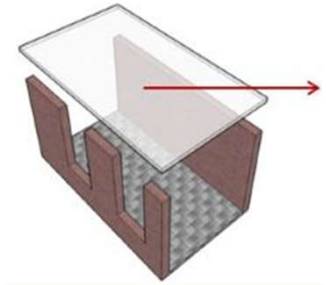
- Complex wall arrangement

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

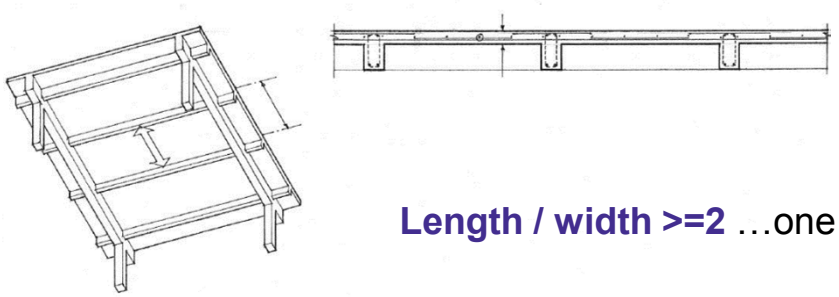




ii. Slab (horizontal load bearing member)

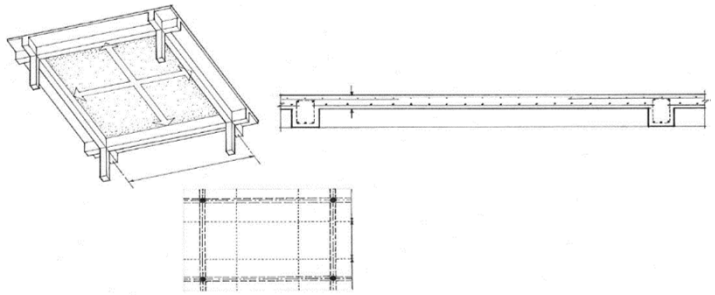


- One way slab



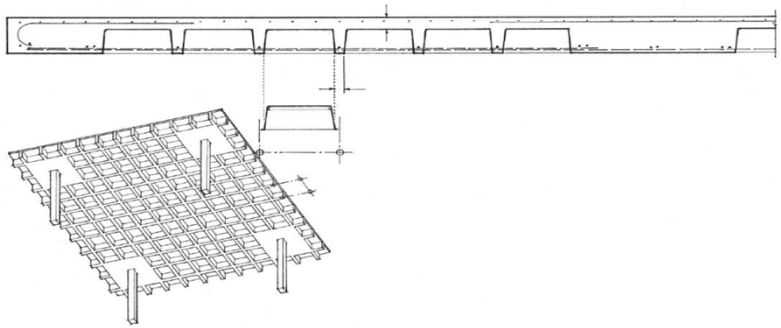
Length / width >=2 …one way slab

- Two way slab



Length / width <=2…two way slab

- Waffle



For **Large Span** waffle slab constructed

BEARING WALL

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

⬇

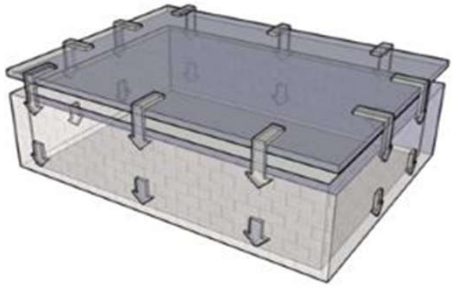
Wall

⬇

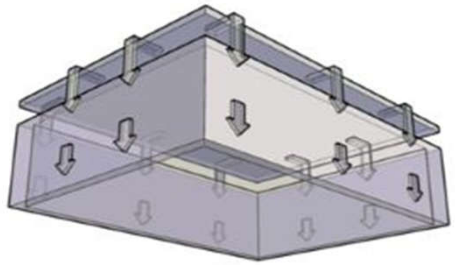
Footing

⬇

Ground

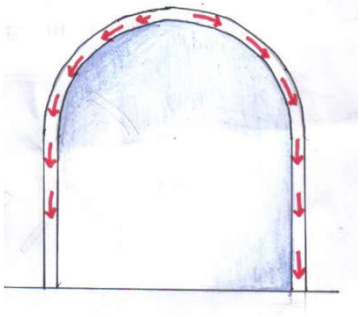


Load transferring system



Towards ground through wall

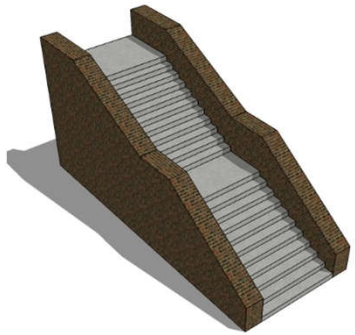
- Load transferring system towards ground through wall

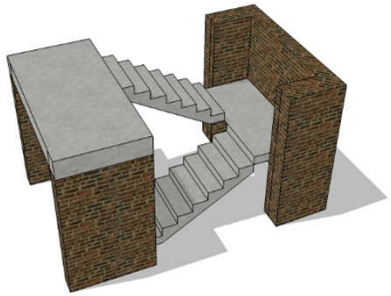


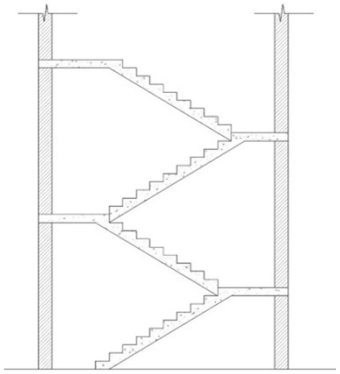
- Load of the dome transfers with circular planned wall according to its periphery.
- Dome supported on squinches .

Position of stair

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

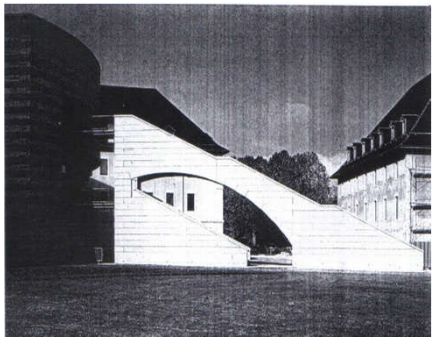






Stair case

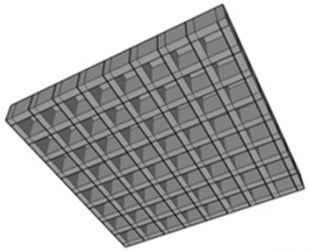
- Parallel walls on two sides can also provide support.
- Arch also can provide support for stair.
-



Theatre and Cultural Centre in Chambery; Mario Botta

Span

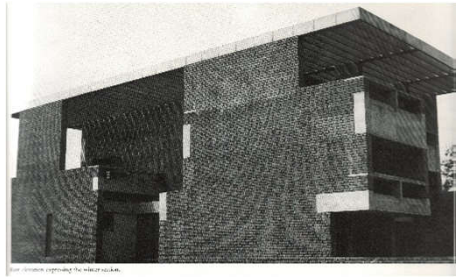
- 12’-15’
- Large span of roof Is problem and it may be solved by waffle slab
- One way slab casting : L=1.5W



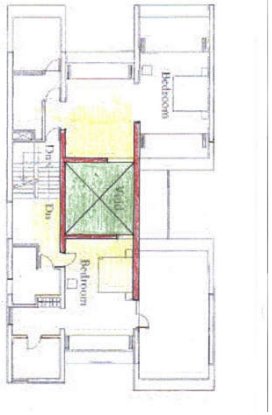
Waffle

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

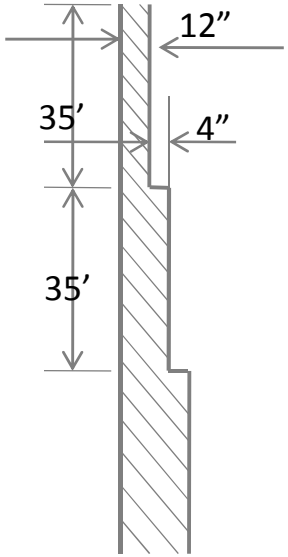
- Generally on cantilever is used

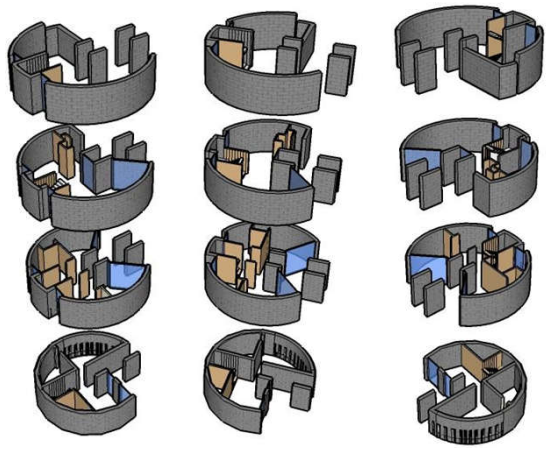
Material

- 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

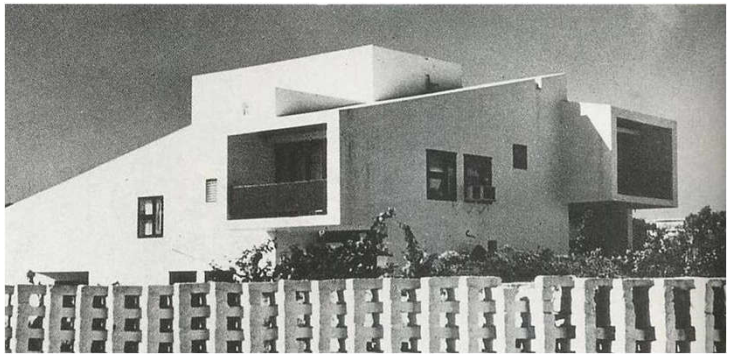
- Generally 6 storied

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

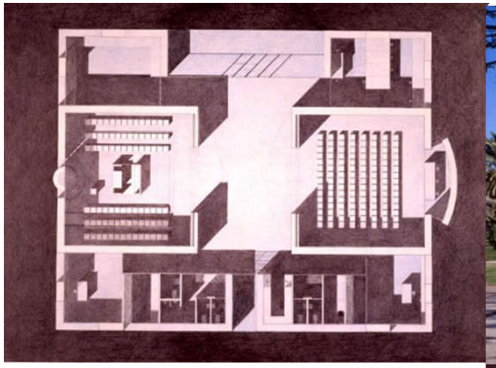
Bangladesh Eye Hospital , Louis I Kahn

First Unitarian Church , Louis I Kahn

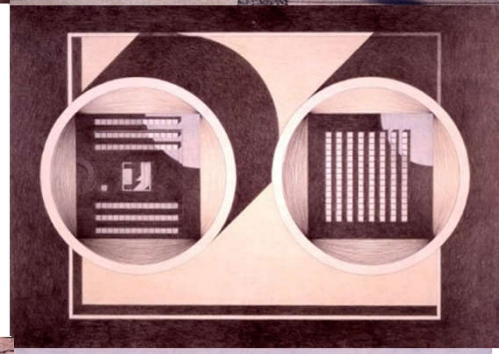
Case study : 1

Cymbalista Synagogue ; Mario Botta

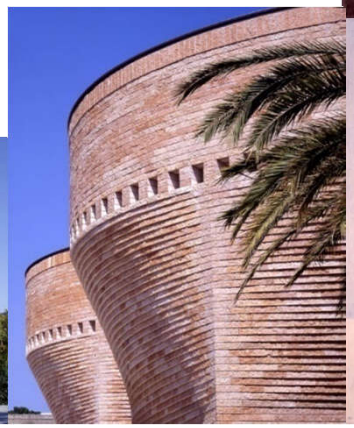
Plan- No grid pattern
Section- clear referencing of load bearing wall
Elevation- clear expression of wall slab structure in opening
Opening- small openings



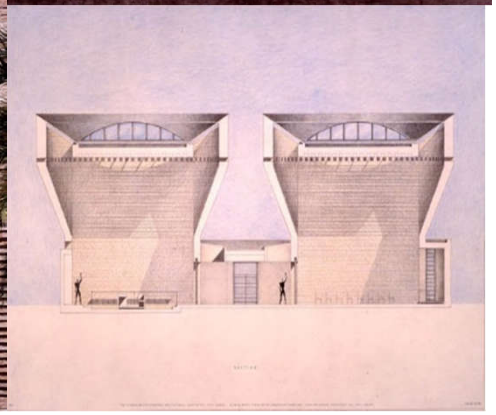
Plan



Top view



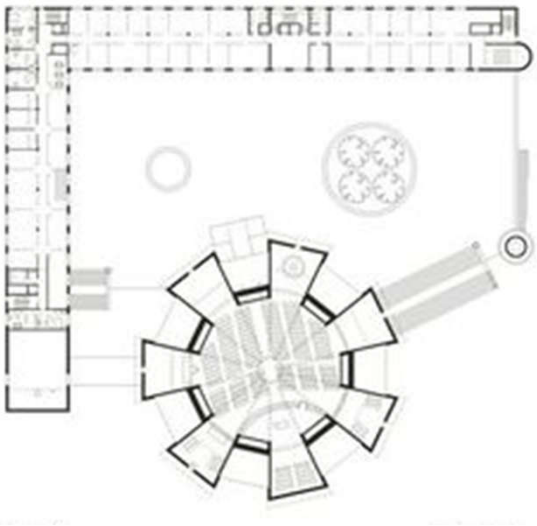
Elevation

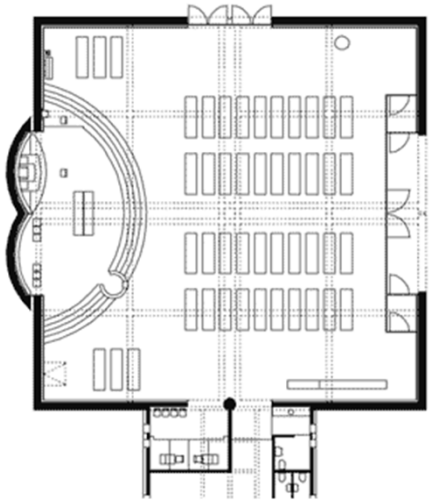


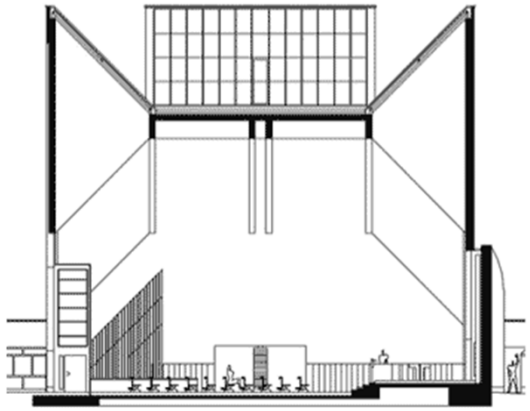
Section

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.

BEARING WALL (SWOT)

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.

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

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.

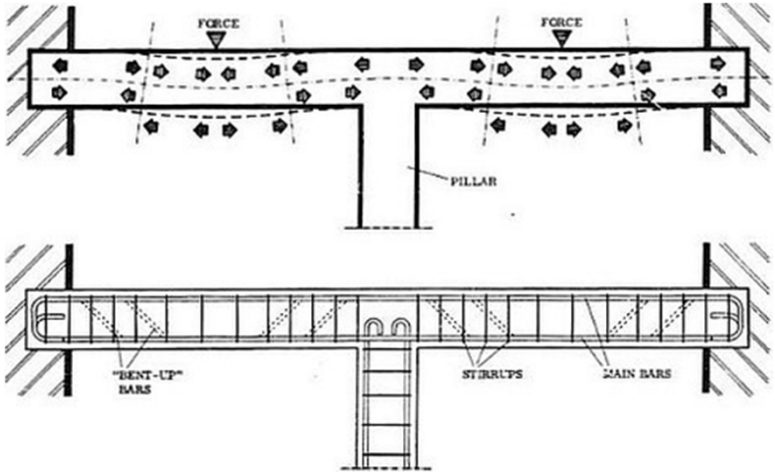
Threat

- 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.

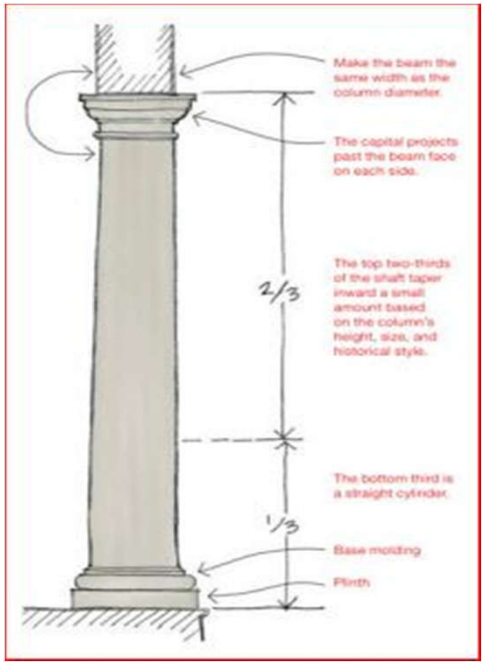
FRAME STRUCTURES

BEAM AND COLUMN

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



Post lintel

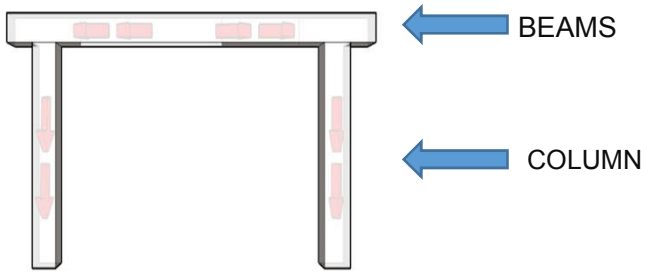
In Architecture post and lintel structural system is a simple construction technique also called column and beam,

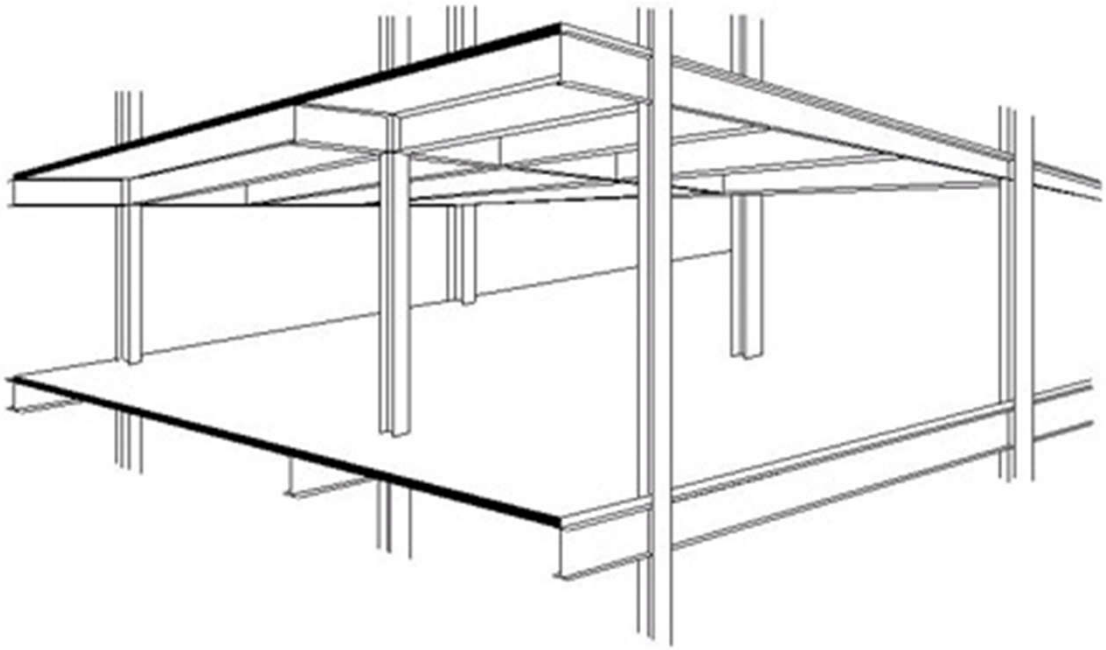
horizontal member is supported by two vertical posts at either end.

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

↓

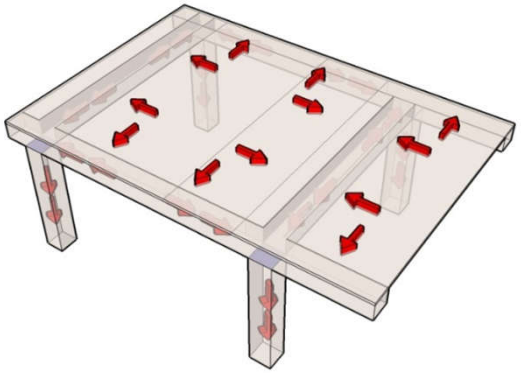
Columns

↓

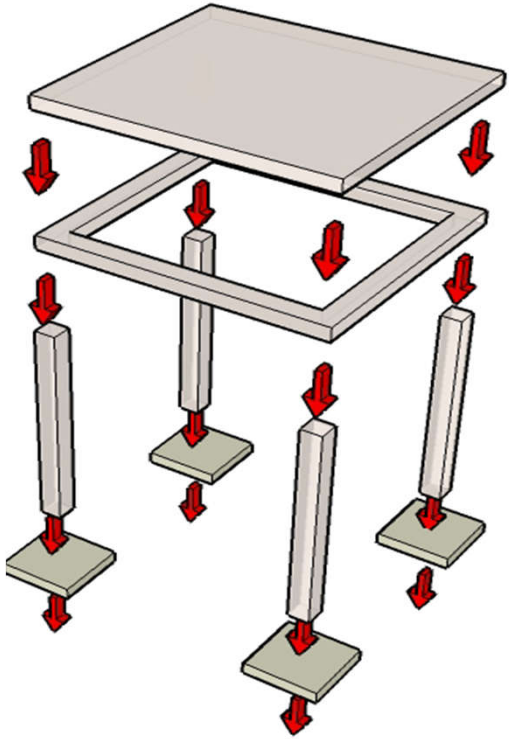
Footings

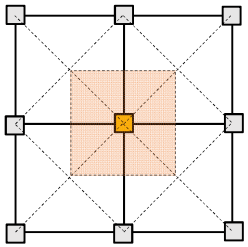
↓

Ground

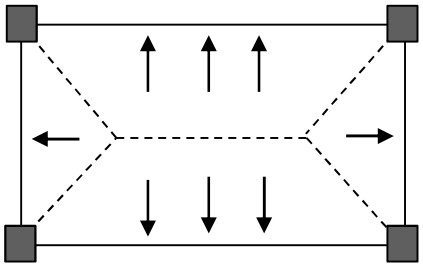


Single square grid

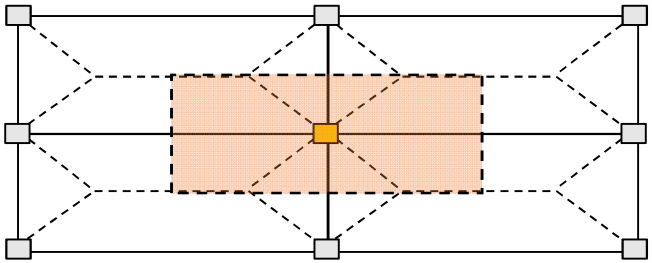




Multiple square grid



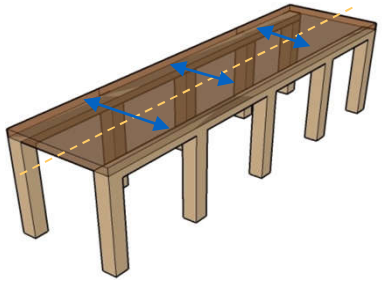
Single rectangular grid



Multiple rectangular grid

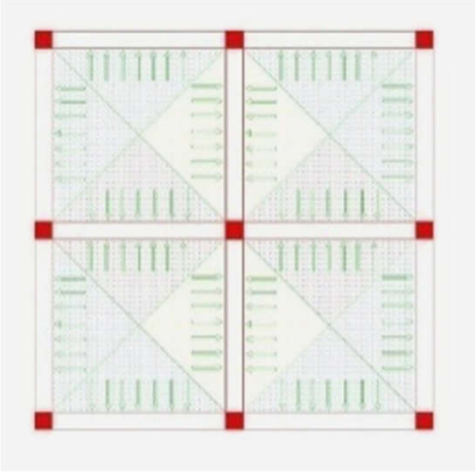
FRAME STRUCTURES

One way slab

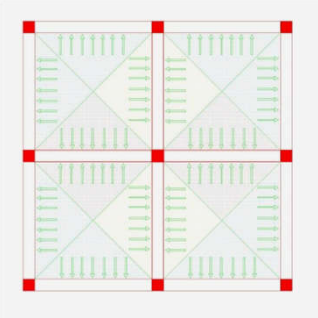


If Length = L Width = W, & L/W > 2
Then the slab works as a one way slab

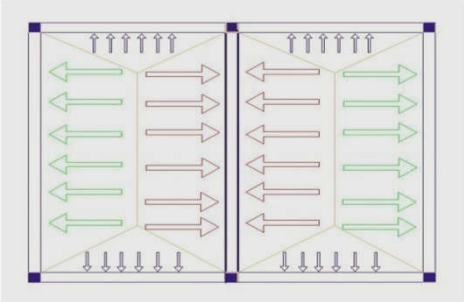
Two way slab



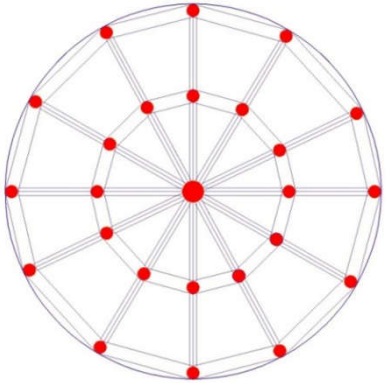
Orientation of members



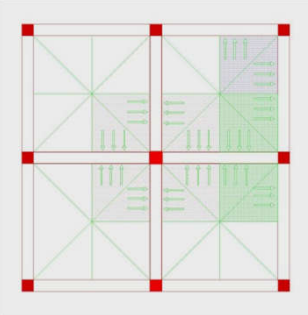
For Beam



RECTANGULAR PLAN



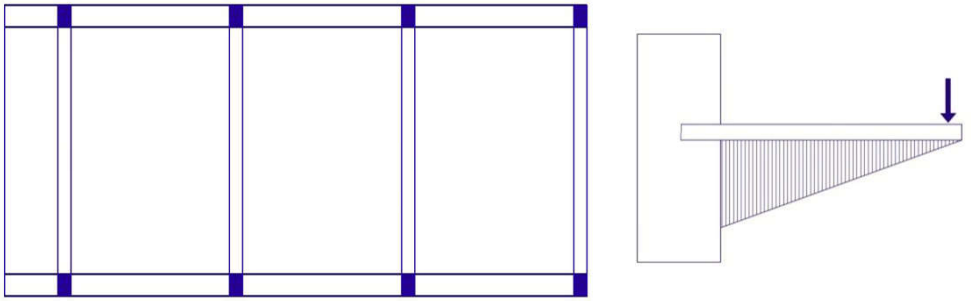
RADIAL GRID



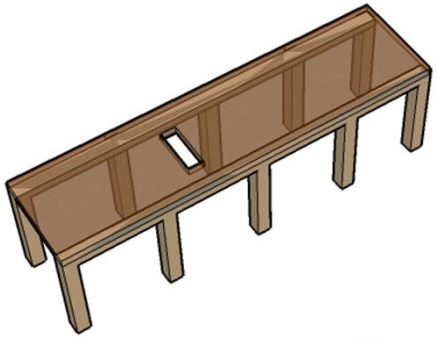
For Column

Span

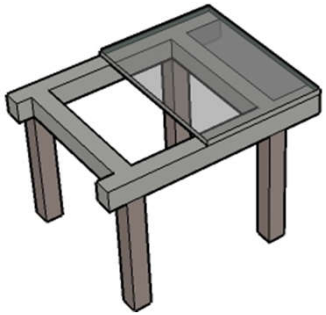
1. An overhang where one floor extends beyond and over a foundation wall.
2. Can be possible even more than 30-50%(economic)
3. Span is limited,17'-22' is economical. Beam is proportional to span of slab. Such as span40' than the width40''.



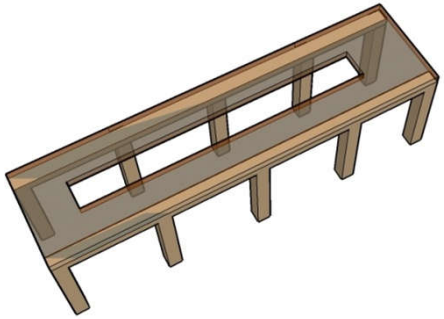
Punch



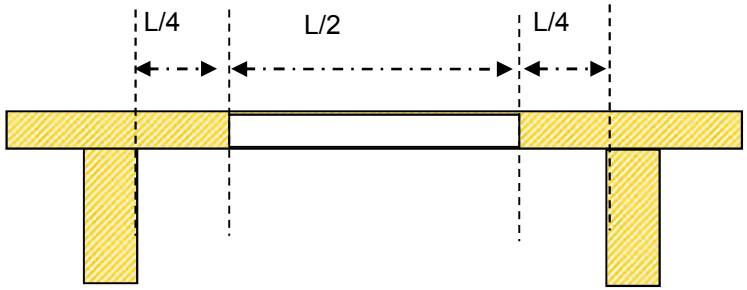
possible



possible



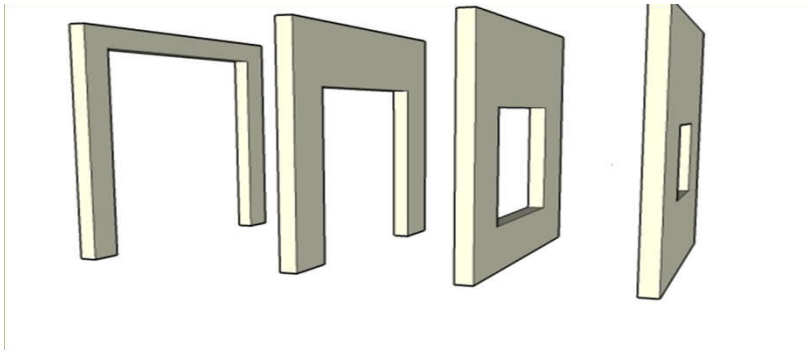
Not possible



Punched on the slab can be obtained without any disturbance.

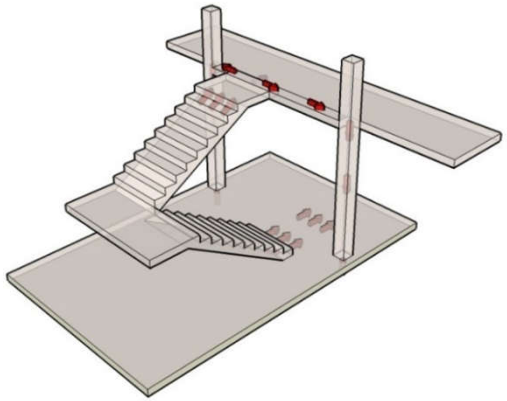
Wall

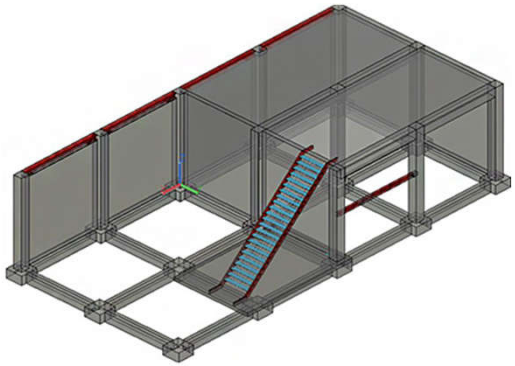
Wall must be placed over a beam. As wall does not carry any load opening can be created anywhere of the wall,100% opening in wall surface is possible.

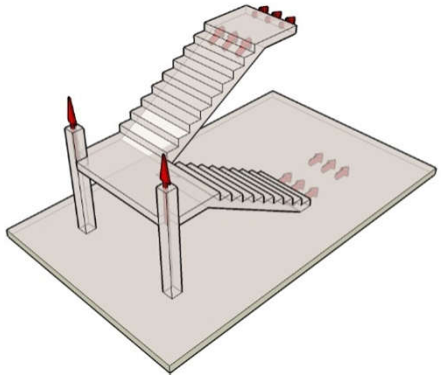


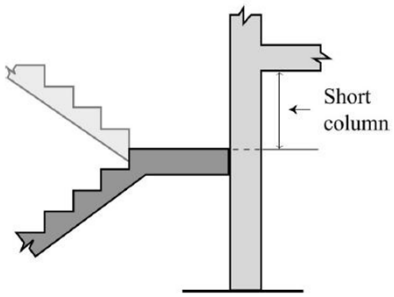
Stair

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

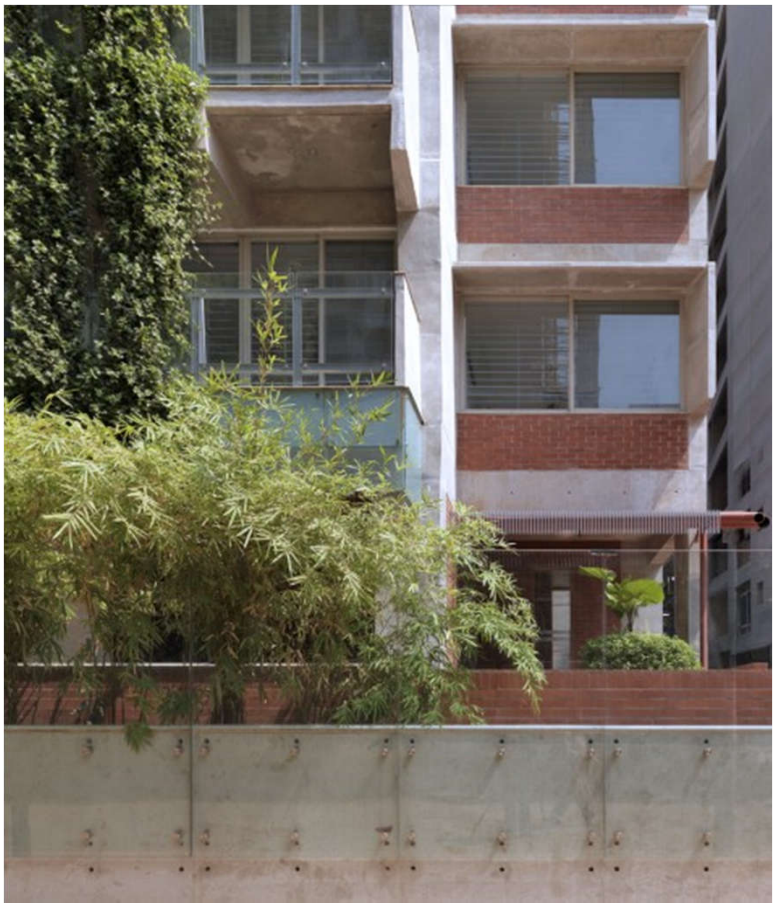
Context:

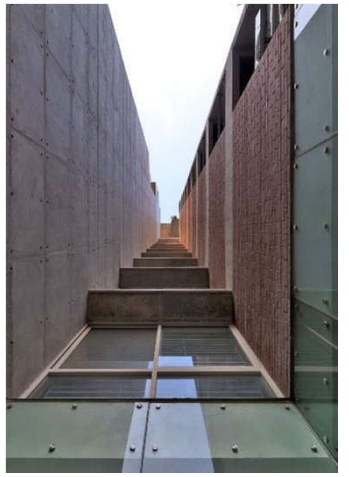
Suitable for composite climate

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.

Weakness

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

Opportunity:

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

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 .

FLAT SLAB

Post slab structural system:

Members: Column , Slab

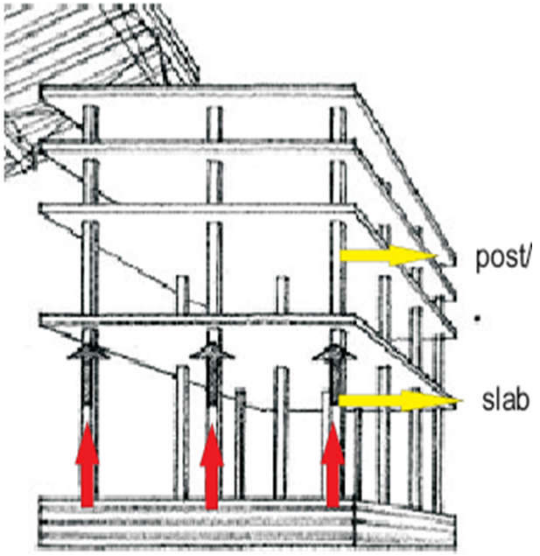
Slab_ Horizontal structural member

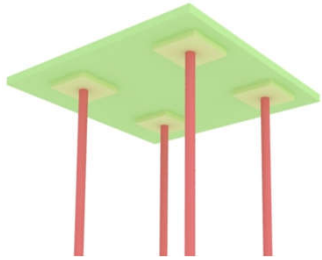
Post_ Vertical structural member

Classification of post slab:

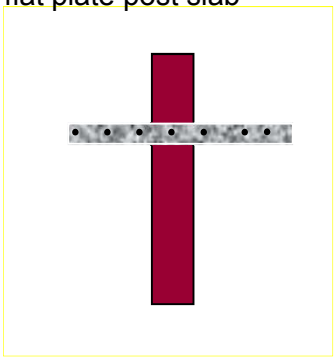
A. flat plate

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

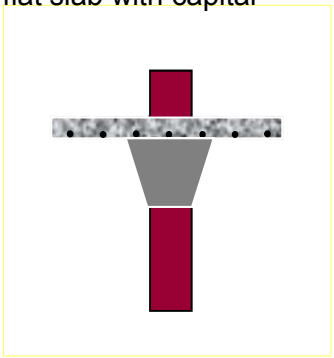




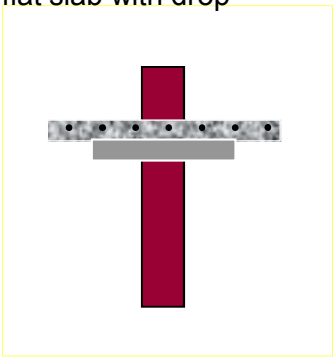
flat plate post slab



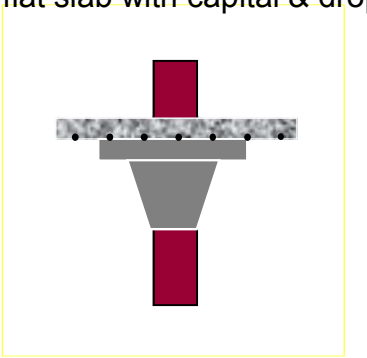
flat slab with capital



flat slab with drop



flat slab with capital & drop



FLAT SLAB

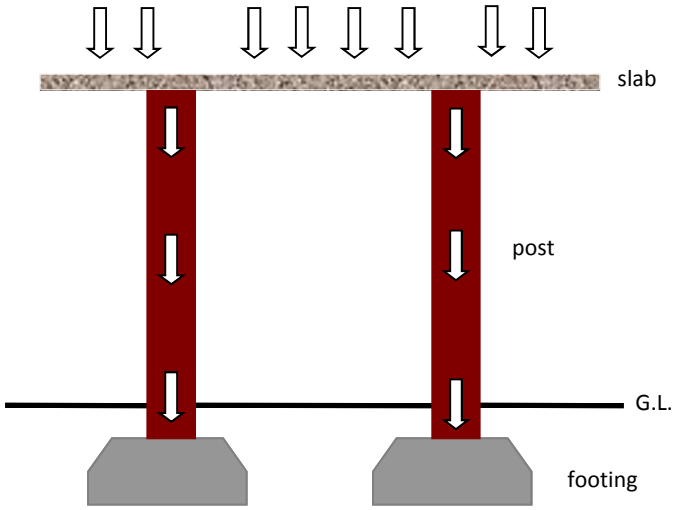
Materials:

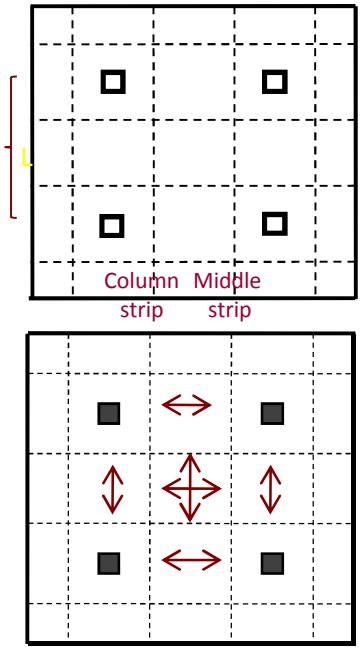
R . C . C , iron

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:

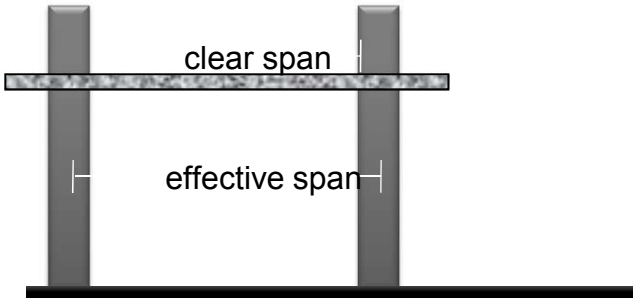
effective span

horizontal distance between center points of two vertical support.

clear span

horizontal distance between internal faces of two vertical support.

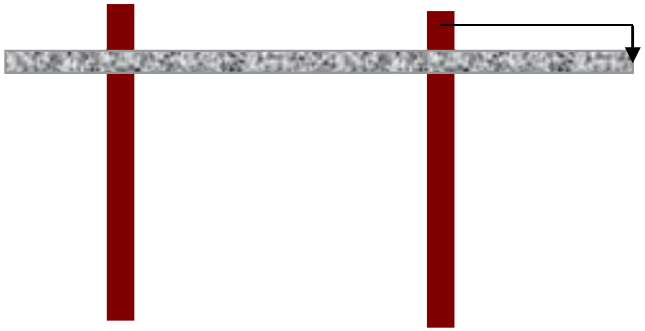
Ecomonical17’-22’



Cantilever:

Floor slab in all across must be cantilevered and it will be 1/3 of the span of the post

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

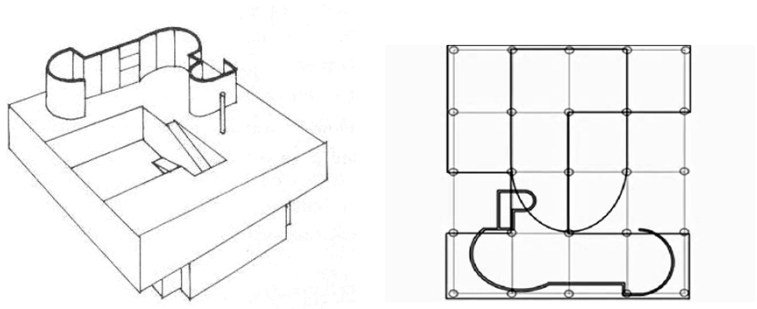


Position of wall:

Wall can be built freely as desired in different floors.

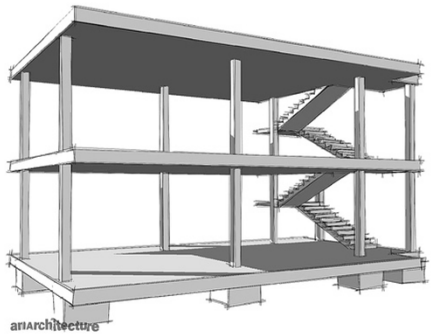
it is recommended to built walls on the column strips.

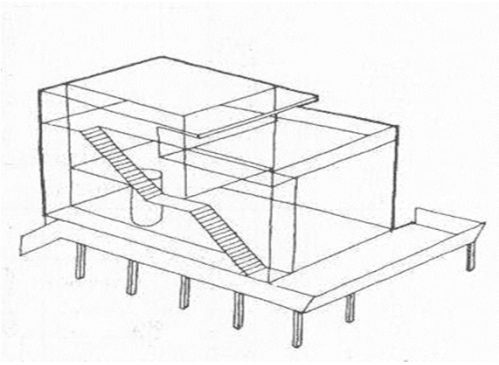
It is better to avoid the middle strips from first floor.



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

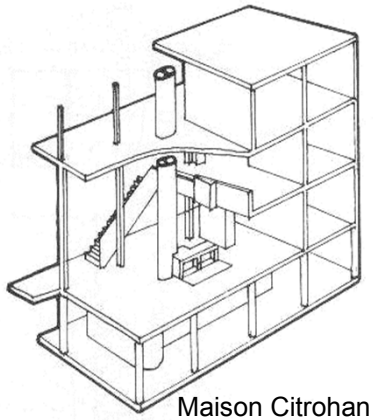
Villa Stein-De-Monzie
Le Corbusier

Punch in slab:

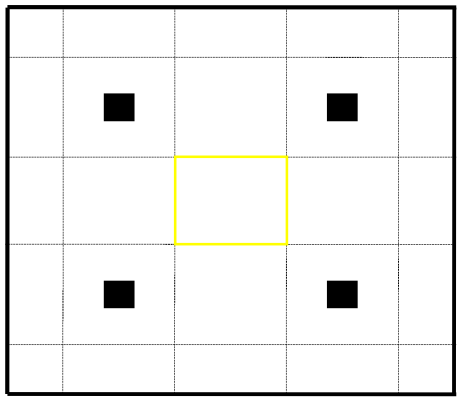
in the area common to the slab middle strips.

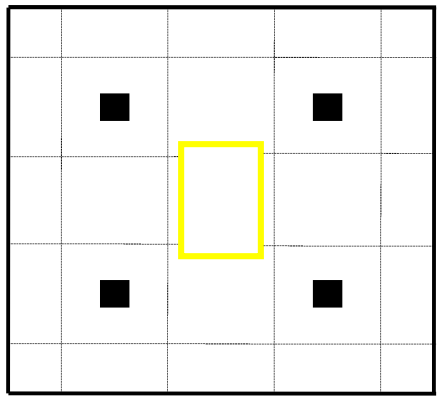
in the area common to two column strips, not more than one-eighth the width of the strip in either span should be interrupted by openings..

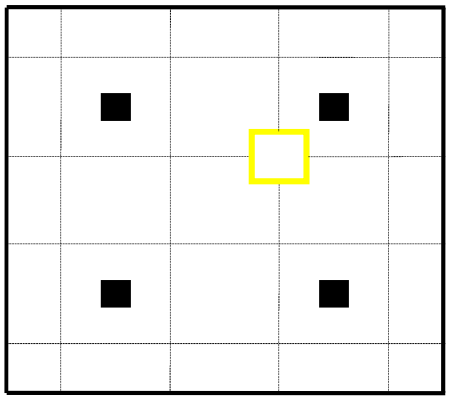
in the area common to one column strip and one middle strip, not more than one –fourth of the re-enforcement in either strip should be interrupted by the opening.



Maison Citrohan
Le Corbusier







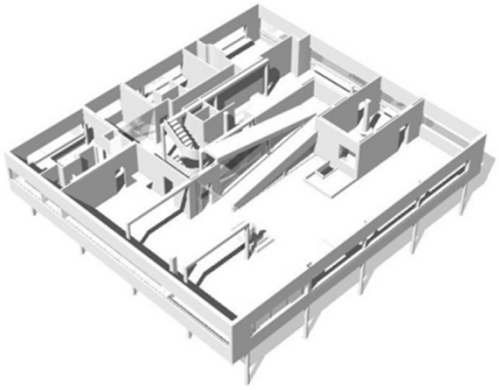
Position of wall:

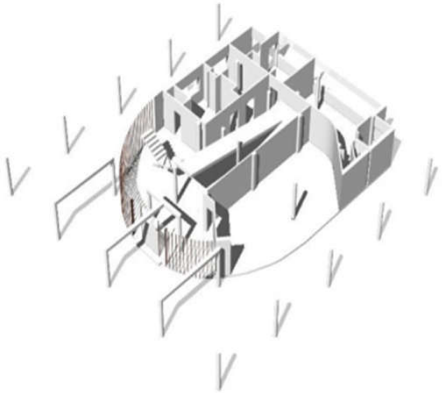
Wall can be built freely as desired in different floors.

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 Loyd Wright

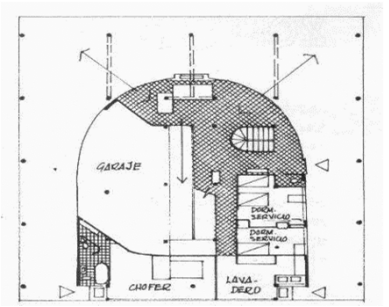




MRF Headquarter
Charles Correa

Expression:

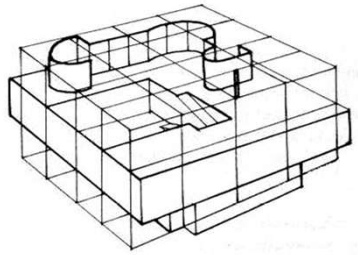
The plan of the building of post and slab system is regular shaped and respect strong square grid pattern.



The slab is always cantilevered from the post.

Solid void relationship is strongly achieved

Vertical reference is maintained



Expression:

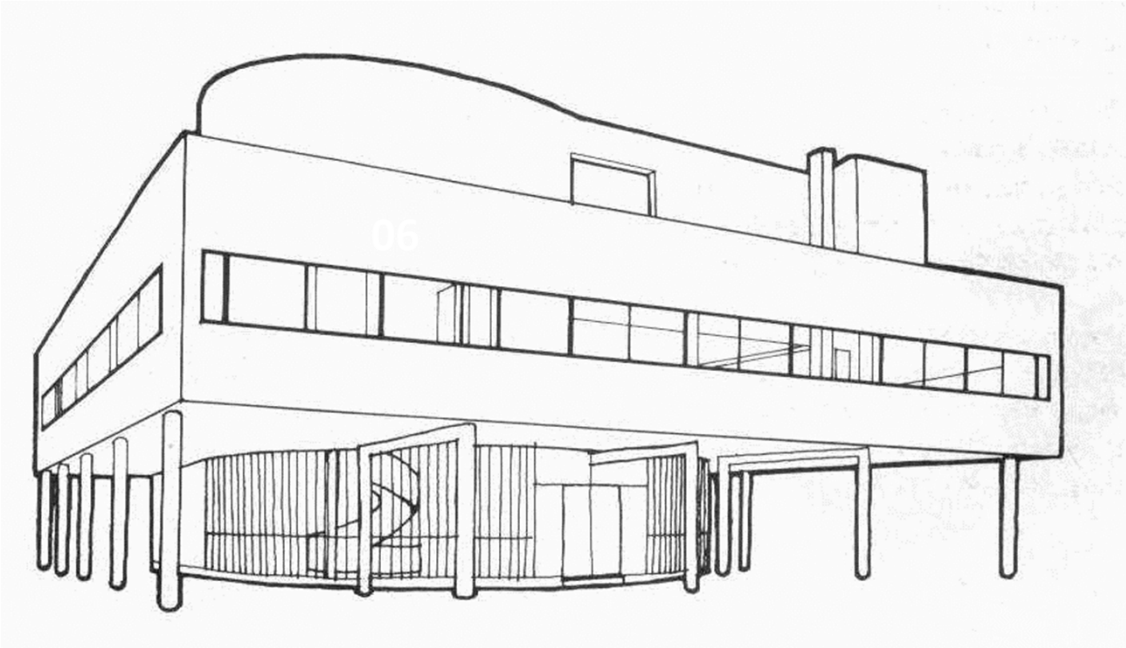
Massing constructed in post and slab system has an effect of floating

Continuous opening can be provided

Advantage:

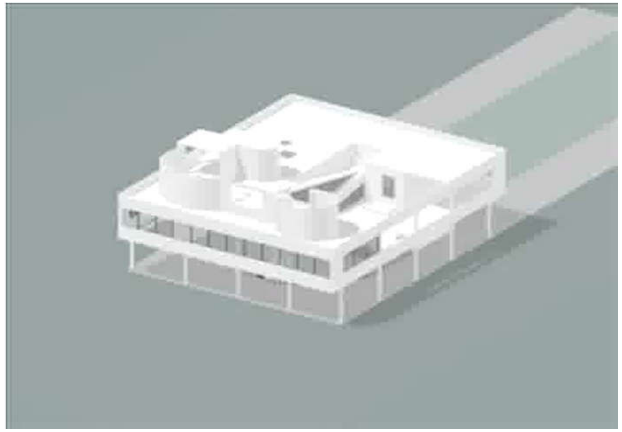
Ribbon window or large opening is a greater opportunity
Cantilever 33%_50% possible
Slabs can be cut as freely as needed
Position of enclosing wall can be changed in different floor plan
Different types of shading device can be used
Partition wall can be use as required

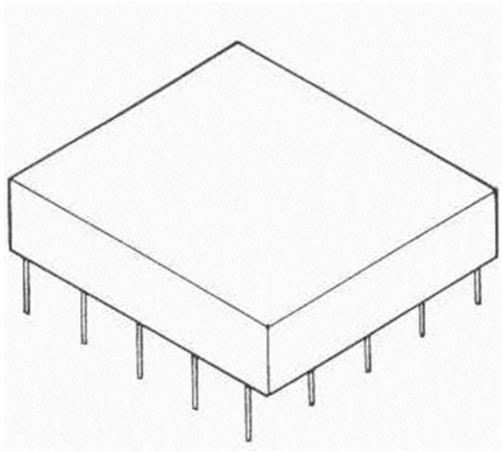
CASE STUDY:



Villa savoya
Le corbusier

Load transfer system:





slab/floor

↓

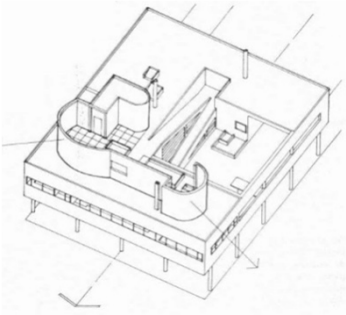
Column

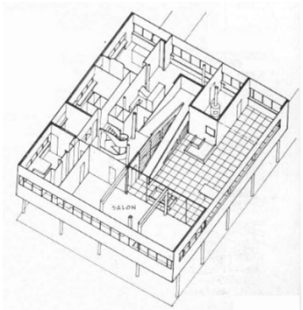
↓

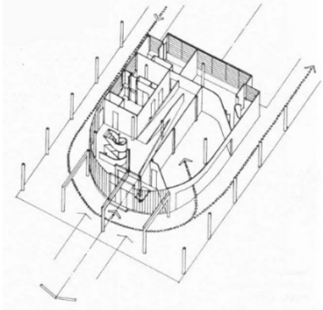
Footing

↓

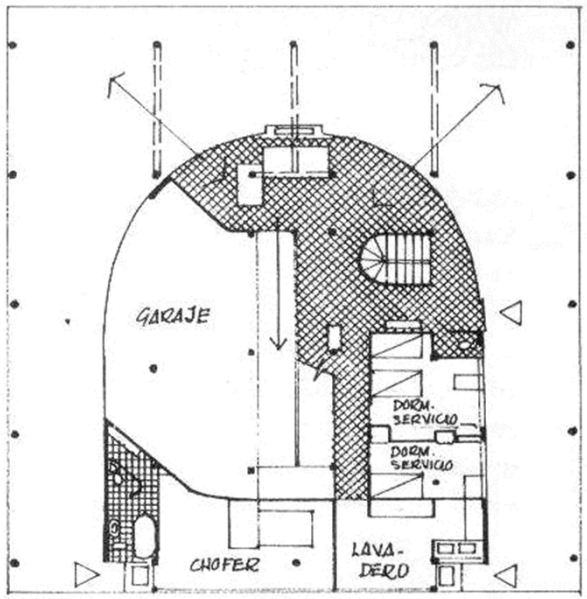
sub soil



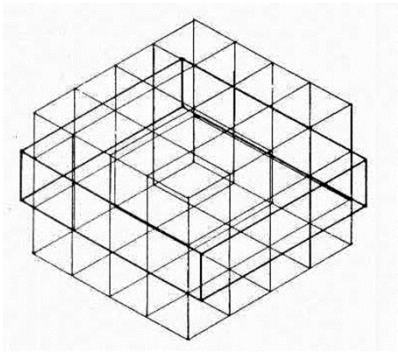


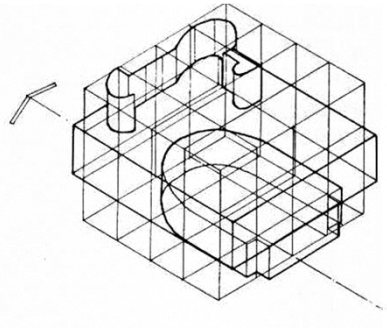


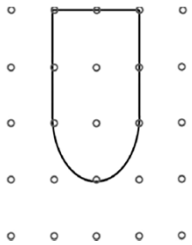
Orientation:

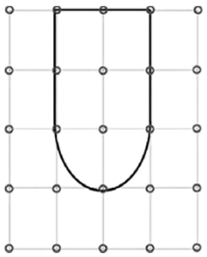


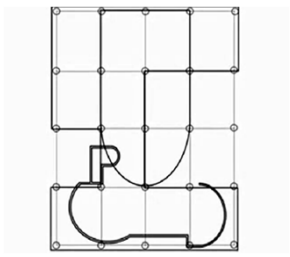
Square grid pattern





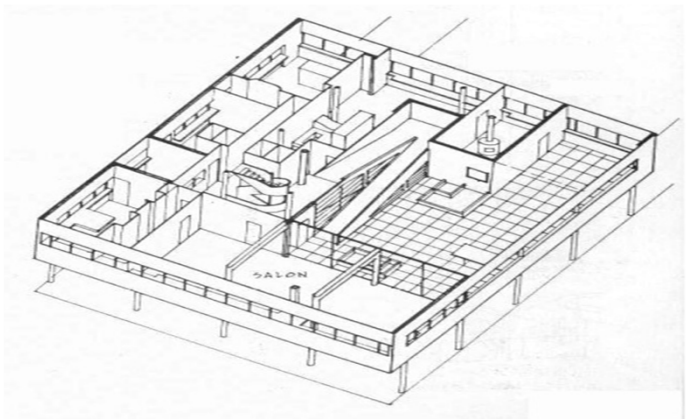


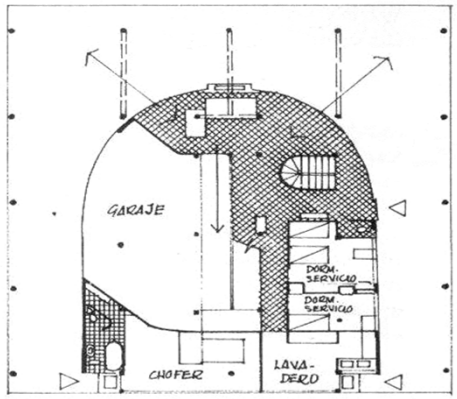




Opening:

Continuous opening, ribbon window

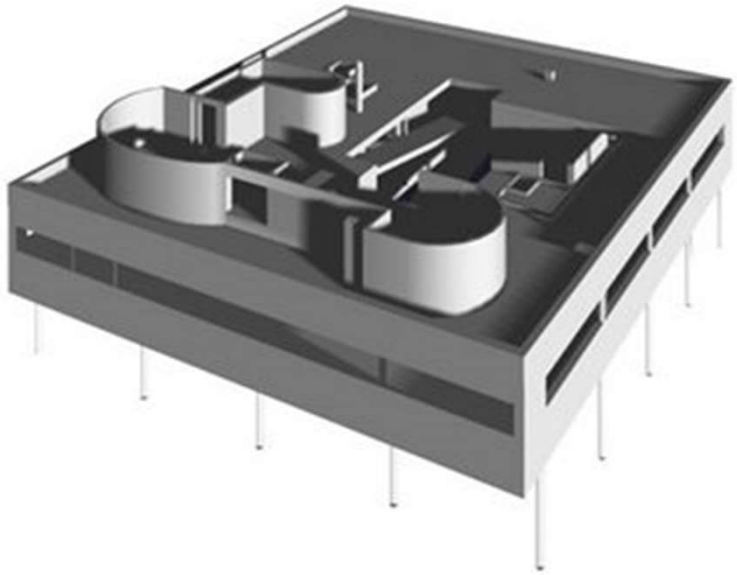


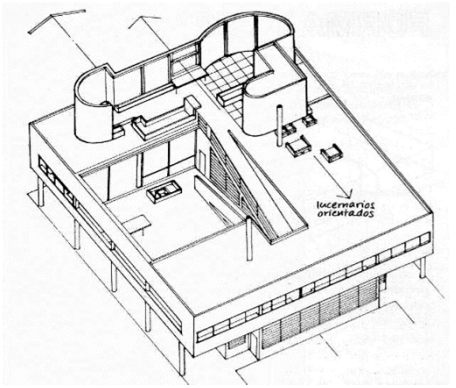


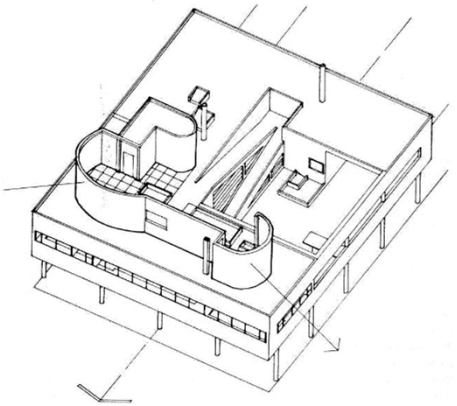
Cantilever:

Punch in slab:

Large Punch, without disturbance of beam

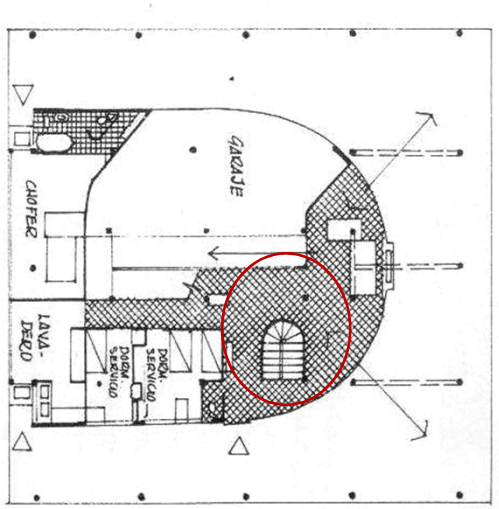






Stair in the middle strip

".....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

FLAT SLAB (SWOT)

Post slab structural system

Strength

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

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.

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.

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

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.

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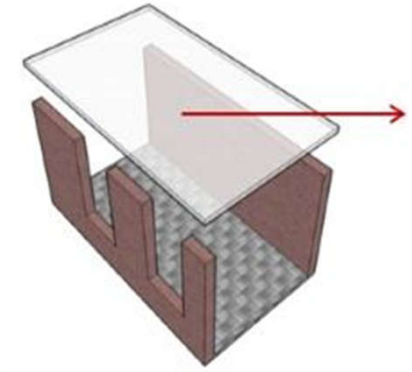
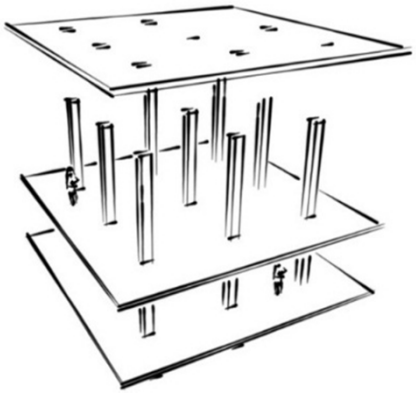
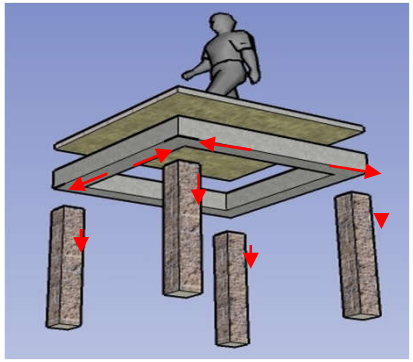


Slab

3. Post slab structural system.



2. Post-lintel structural system



COMMON FEATURE

Topic	Wall slab	Post lintel	Post slab
Structural system	Load -slab-wall foundation-ground	Load-slab-beampost-ground	Load-slab-postground
Opening	Absence of continuous opening -Nearly 1/3of 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 any where Of the wall	wall can be made anywhere

Reference

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STHAPOTTO O NIRMAN

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