تصميم معماري III

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جامعة المثنى

كلية الهندسة

قسم هندسة العمارة

المحاضرة رقم 14 – الاسبوع الرابع عشر

مبادىء في التصميم الانشائي لفضاءات المباني

مشروع تصميم فندق 5 نجوم في محافظة المثنى

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ELEMENTARY STRUCTURAL DESIGN

SPANS OF BUILDINGS

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INITIAL UNDERSTANDING

What structure is used for:

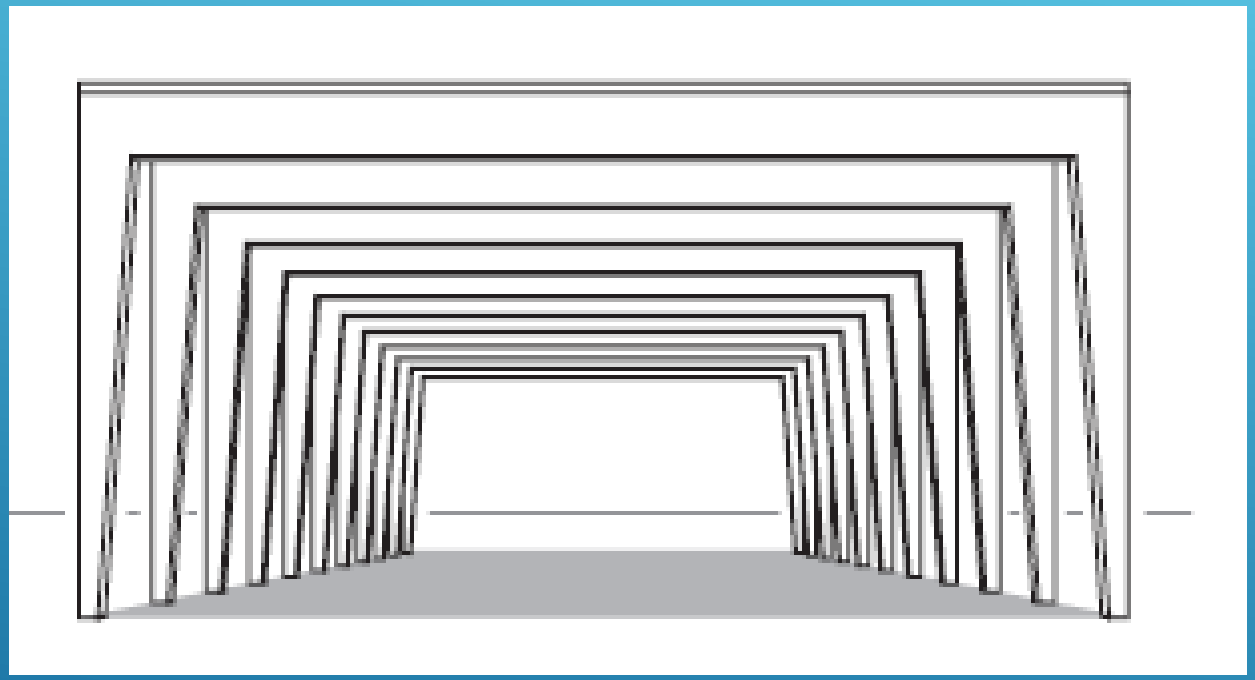
- way to organize
- give scale to the volume
- pattern the overall built volume
- Structural elements may play a visually and spatially dominant role in defining the identity of the building

Why Structural System is important?

- Building design decisions are determined by decisions on the structural system level
- Structural elements may play a visually and spatially dominant role in defining the identity of the building

SPACE AND STRUCTURE

SIMPLE RECTANGULAR SPACE

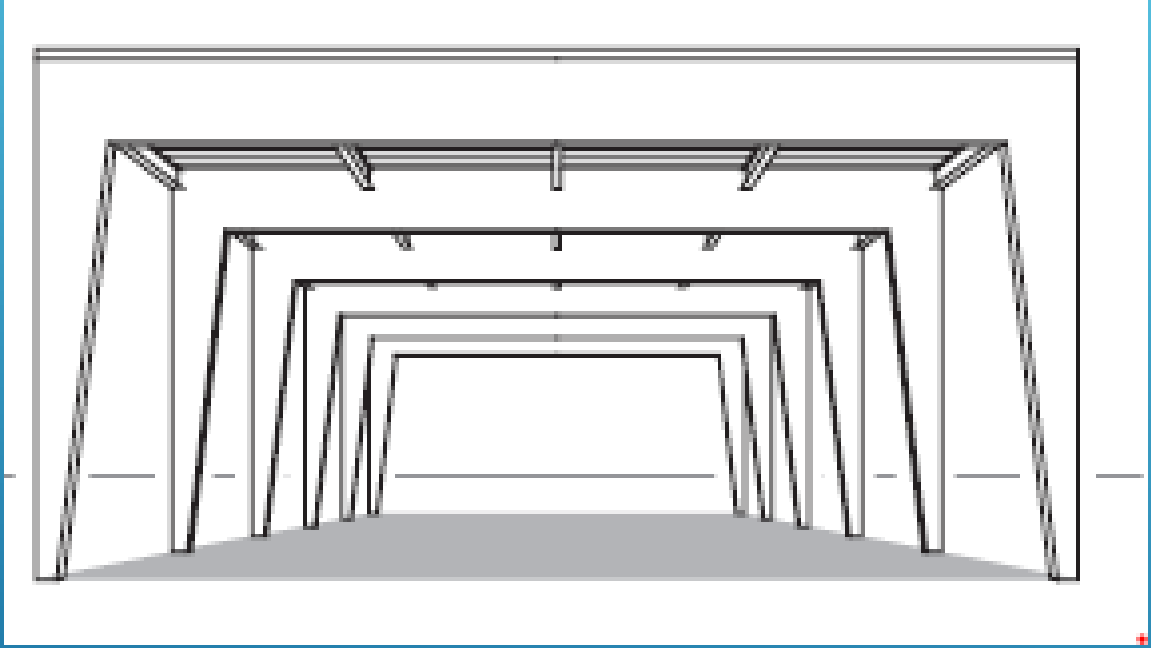


Spacing of primary elements:

- Rigid frames,
- Closely spaced,
- Create a sense of enclosure.

SPACE AND STRUCTURE

SIMPLE RECTANGULAR SPACE

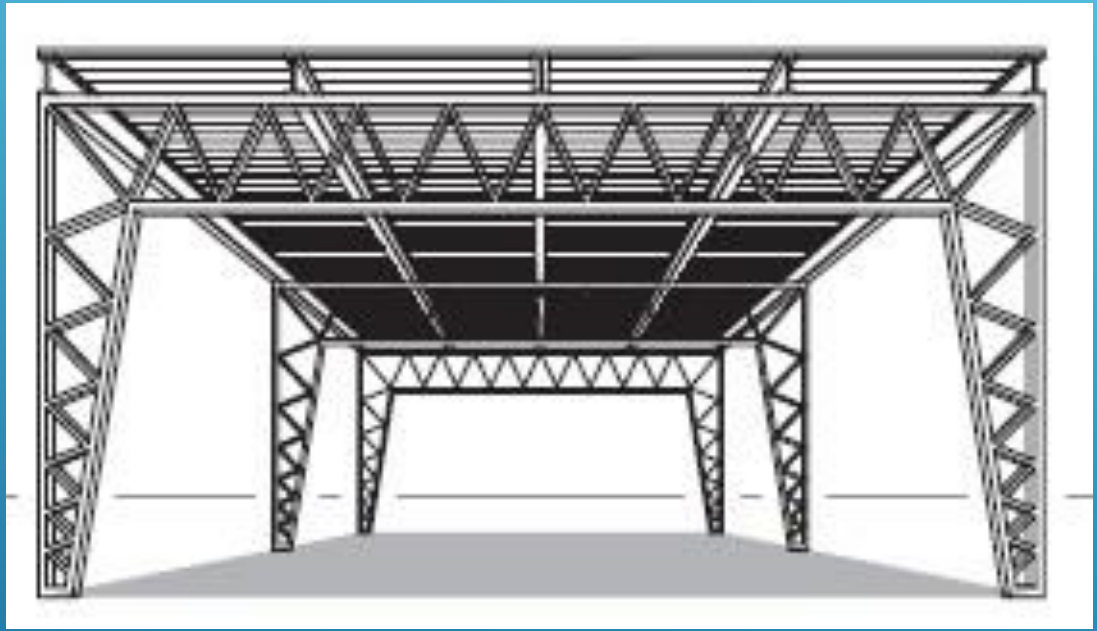


Spacing the primary frames

- Further apart
- Need for a secondary beam system
- The space feels more open

SPACE AND STRUCTURE

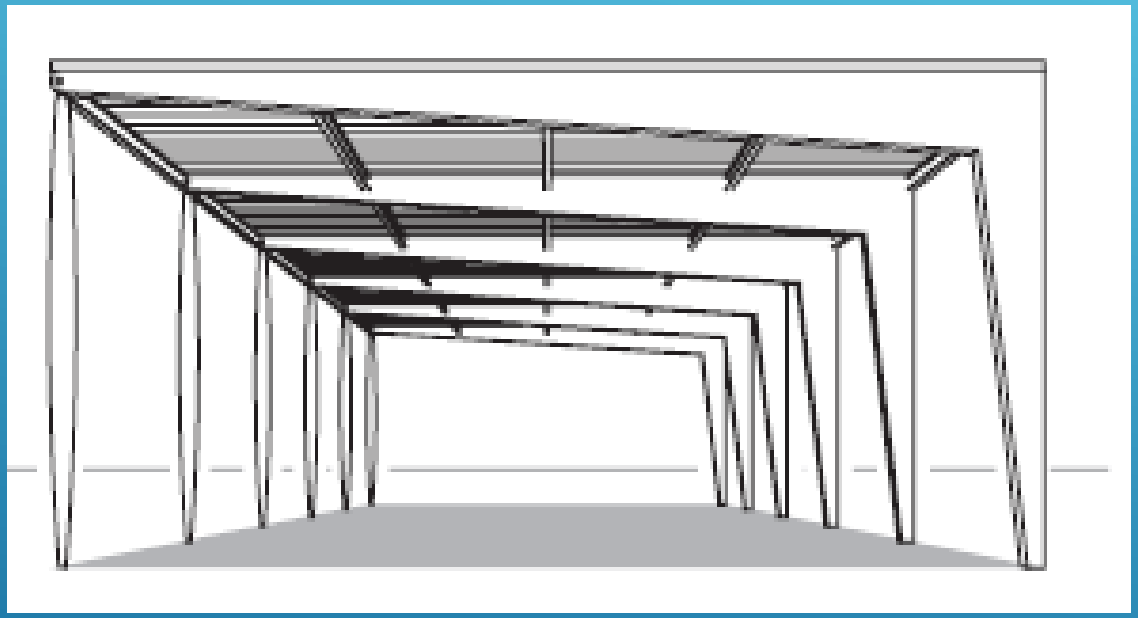
SIMPLE RECTANGULAR SPACE



- Increasing the spacing of primary trusses even further
- Begins to suggest a subdivision of the enclosed space.

SPACE AND STRUCTURE

SIMPLE RECTANGULAR SPACE



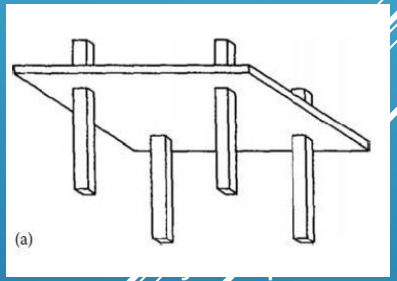
- Directional structure:
- Creating a pin-pin column on the left
- Rigid corner on the right
- Suggests transparency to the left side.

HORIZONTAL SPAN

Span length is a crucial factor in selecting a structural response
Some structural systems are appropriate for certain span ranges yet not for others.

LOW-SPAN SYSTEMS
INTERMEDIATE-SPAN SYSTEMS

- Designers are faced with an increasing range of structurally aviable options that are made from a wider range of materials.
- For spans on the order of 5 to 6 m, for example, all major types can be competitive.
- For example, in reinforced concrete, for a span of 6 m and for relatively light, uniformly distributed loads, the flat plate is often the preferable two-way concrete system.
- beam/slab systems are possible, but their higher span and load capacities are not needed for short spans.



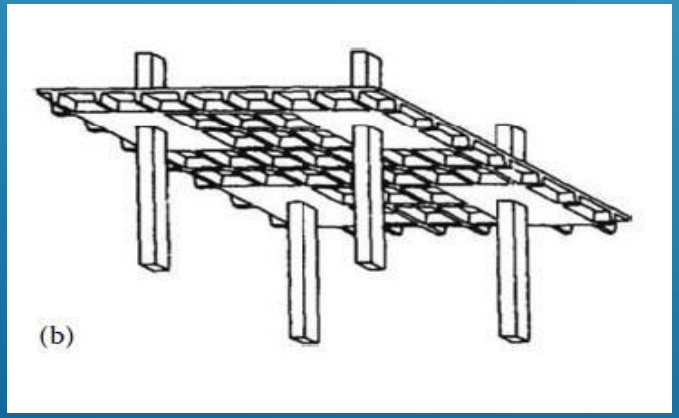
LOW-SPAN SYSTEMS
INTERMEDIATE-SPAN SYSTEMS

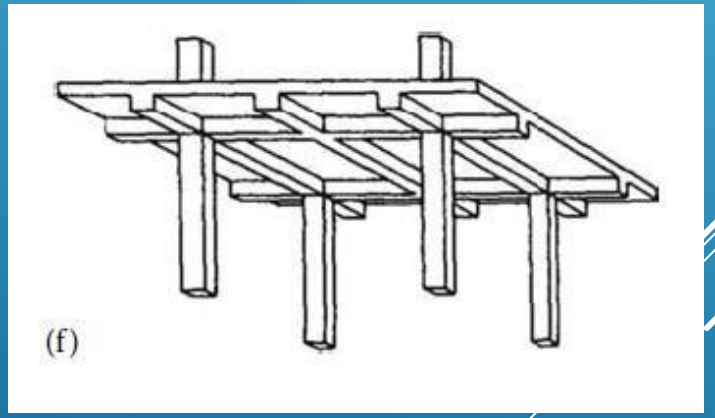
Other reinforced-concrete systems are possible, such as:

- waffle slabs system
- beam/slab systems

But,

- their higher span and load capacities are not needed for short spans.
- From a structural viewpoint, there is no incentive to go to the trouble and expense of creating the special formwork required to construct these more complex systems when a simple flat plate would work just as well for the conditions at hand.





LOW-SPAN SYSTEMS
INTERMEDIATE-SPAN SYSTEMS

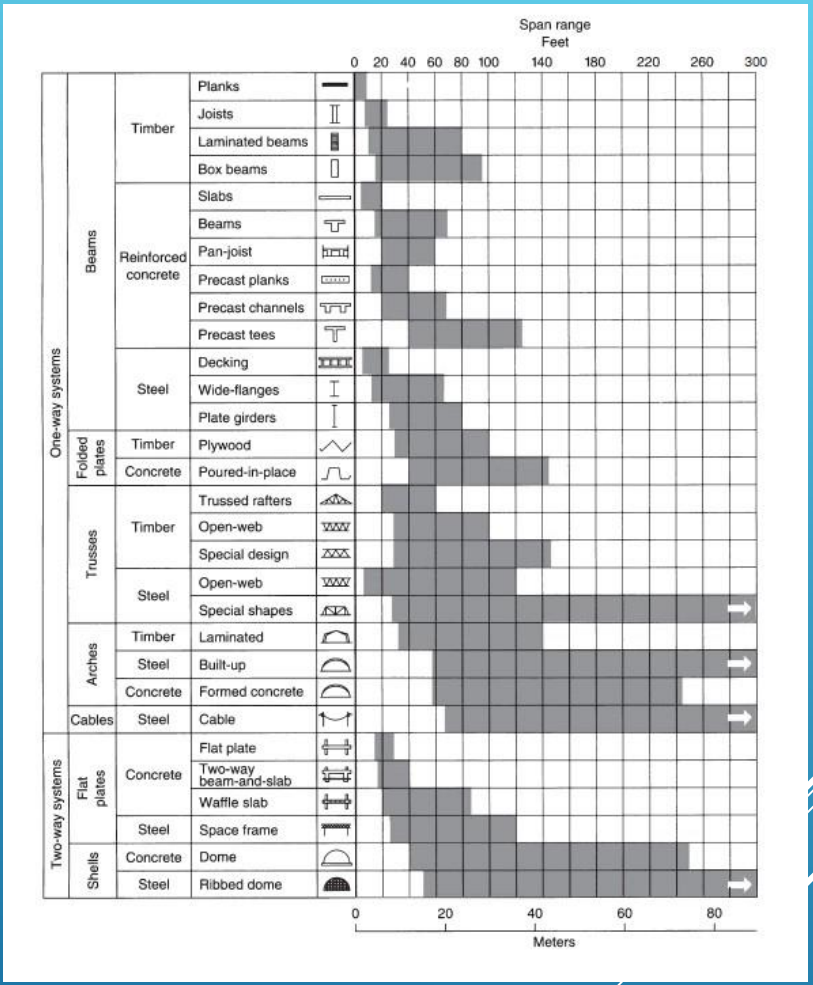
Hence,

- With increases in span or load, however, the flat plate begins losing its viability,
- Other systems become more appropriate.
- In low-span ranges, the deeper-shaped structures capable of long spans are still structurally possible, but the costs associated with the construction complexity of shaped structures do not offset possible material savings.

LONG-SPAN SYSTEMS

- As spans increase, fewer systems are available to resist the large external moments of long spans.
- As a result, it is often easier to choose a long spanning system compared to selecting short spanning elements where almost all systems can be made to work.
- A characteristic of appropriate long-span systems is that their structural depths are large in comparison with their spans
- Shaped systems such as arches, cables,or shaped trusses are efficient for long spans
- Cables,nets, or rigid shells have similar capabilities for long spans.
- Flat systems such as constant-depth trusses, space frames, and other structures also have been successfully used, but they do not normally match the efficiency of the shaped arch, cable, or truss elements.

Approximate span ranges of different horizontal spanning systems.

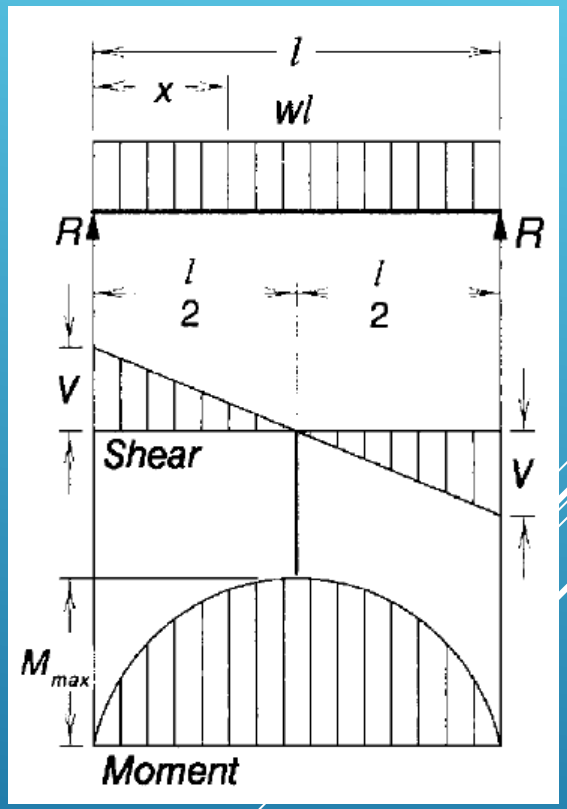


UNDERLYING PRINCIPLES GOVERNING SPAN LENGTHS

- Design moments for uniformly distributed loads are proportional to the square of the length of the span.

$$M_{max} \text{ (at center)} \ldots\ldots = \frac{wl^2}{8}$$

- Doubling a span length, for example, increases design moments by a factor of 4
- Member sizes, of course, depend closely on the magnitude of the design moment present
- Even though deflections can be the governing structural design criteria for longer spans

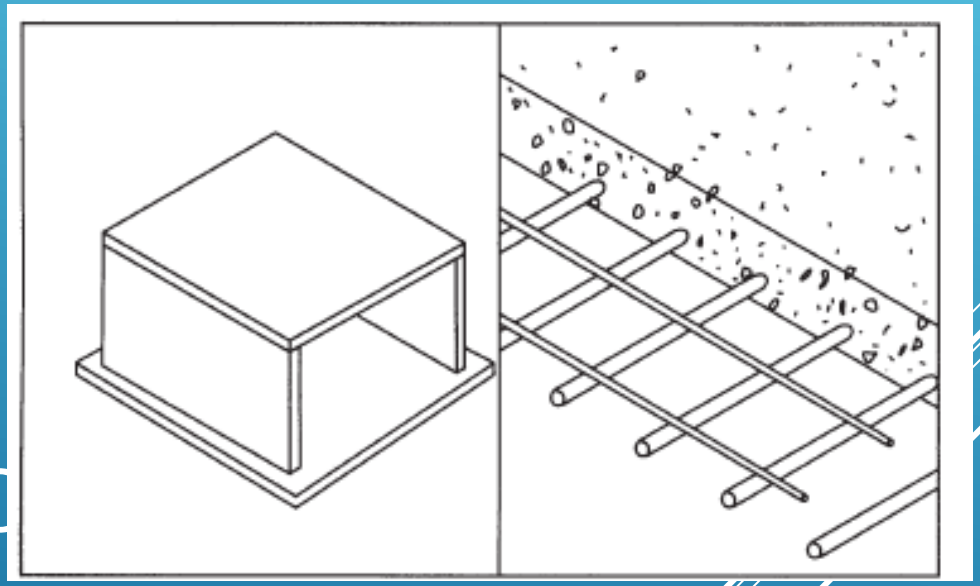


REINFORCED CONCRETE STRUCTURES

REINFORCED CONCRETE STRUCTURES

SOLID SLAB SYSTEM

- Simplest of reinforced-concrete spanning system
- easy formwork is an attractive feature of this system
- constant-depth systems are particularly suitable for short spans



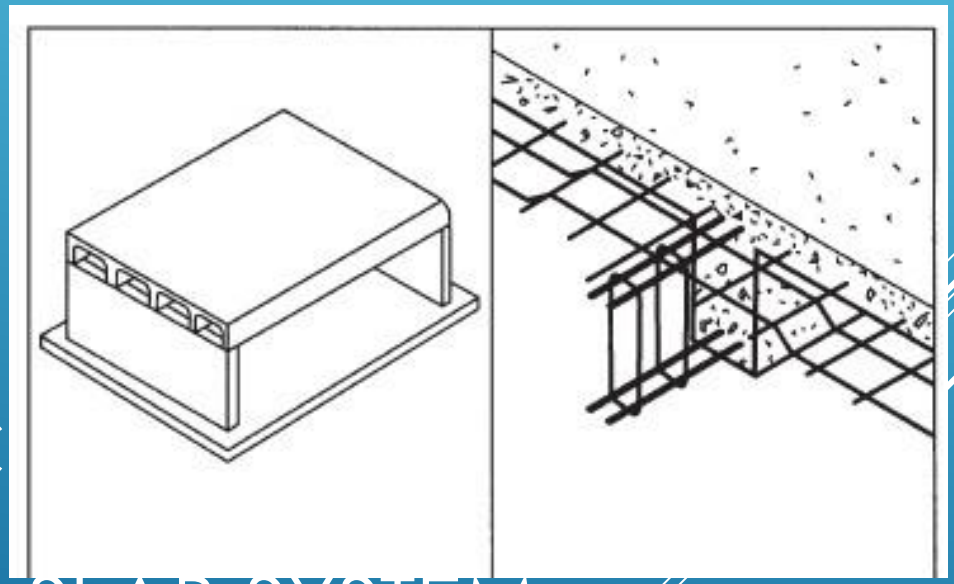
REINFORCED CONC
STRUCTURES SOLID SLAB SYSTEM

REINFORCED CONCRETE STRUCTURES

RIBBED SLAB SYSTEM

BEAM AND SLAB SYSTEM

- With longer spans, the dead weight of the solid slab becomes excessive and ribbed slabs are preferable
- One-way beam systems with transverse one-way slabs can be used to span relatively long distances (particularly if the beams are posttensioned) and carry heavy loads.
- Such systems are relatively deep.
- Beam spacing is usually determined by what is most reasonable for the transverse slab.



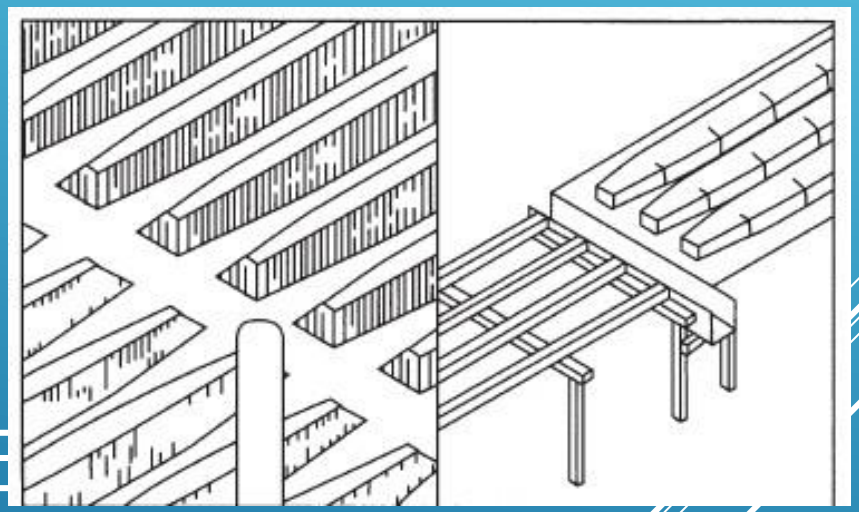
REINFORCED CONC
STRUCTURES RIBBED SLAB SYSTEM

REINFORCED CONCRETE STRUCTURES

RIBBED SLAB SYSTEM

ONE WAY PAN JOIST SYSTEM

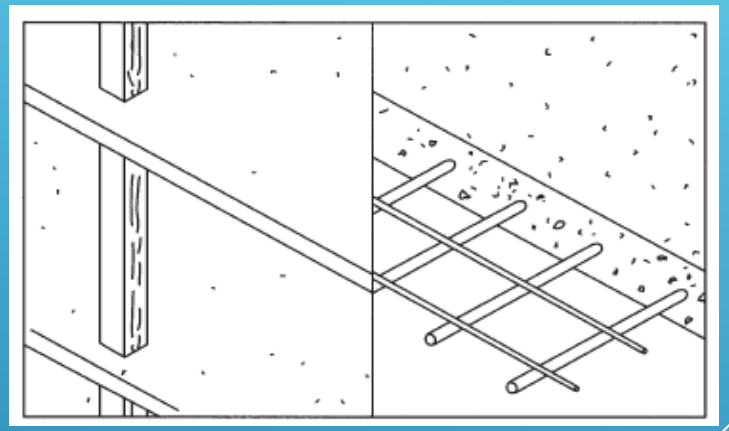
- Consists of ribbed slabs constructed by pouring concrete around special forms made of steel or fiberglass
- Transverse beams of any depth can easily be cast in place at the ends of pans so the system can adapt to a variety of column grids.
- The ribbed slab is more suitable for longer spans than a solid slab.
- With posttensioning, very long spans can be obtained.
- The pan joist system is too complex and uneconomical for short spans.

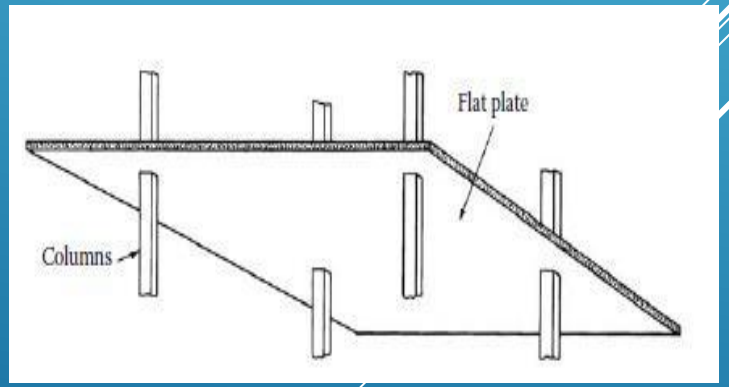


REINFORCED CONCRE
STRUCTURES RIBBED SLAB SYSTEM

REINFORCED CONCRETE STRUCTURES FLAT PLATE SYSTEM

- The flat plate is a two-way, constant-depth,reinforced- concrete slab system
- Appropriate for use with light floor and roof loads and relatively short spans.
- finds wide application in housing construction.
- Spans are, however, limited in comparison with ribbed or beamed systems.
- Lower floor-to-ceiling heights are more feasible with flat-plate construction than with many other systems.
- Relatively large amounts of reinforced steel are required as a result of the thinness of the plates used.
- The governing design factor for flat plates is often the punch-through shear in the plate at the columns.
- Special steel reinforcement is often used at these points. At plate edges
- columns also are moved in from the free edge to ensure that the interface area between the slab and column remains as large as possible.



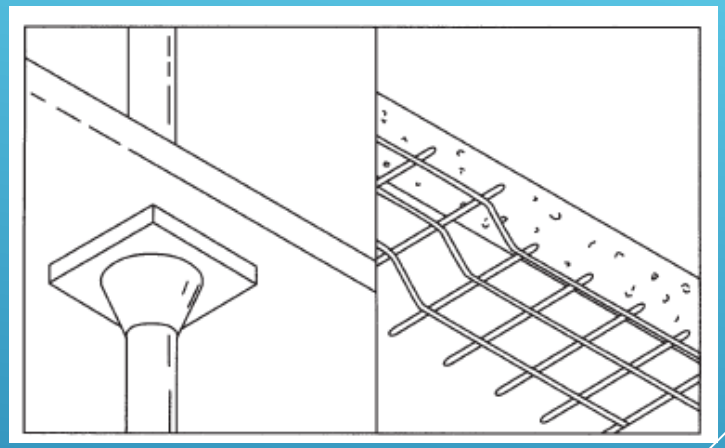


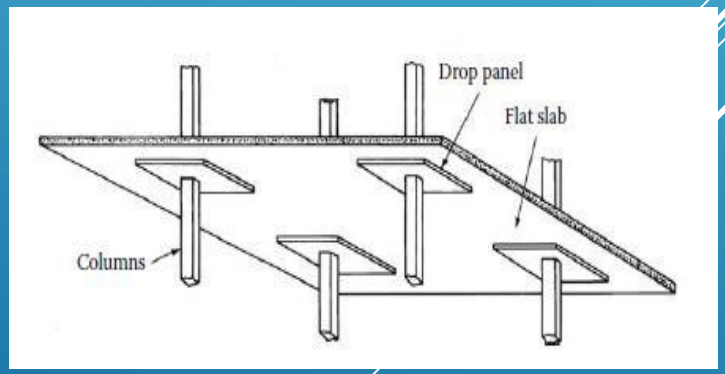
REINFORCED CONCRETE STRUCTURES FLAT PLATE SYSTEM

REINFORCED CONCRETE STRUCTURES
FLAT SLAB SYSTEM

- The flat slab is a two-way, reinforced-concrete system similar to the flat plate, except that the interface area between the plate and columns is increased by adding drop panels or column capitals.

- The drop panels or column capitals reduce the likelihood of punch-through shear failure in the slab.
- The system is particularly appropriate for relatively heavy loading conditions (such as those found in warehouses)
- The system is suitable for larger spans than are possible with flat plates.
- The system is particularly appropriate for relatively heavy loading conditions (such as those found in warehouses) and is suitable for larger spans that are possible with flat plates.
- The capitals and drop panels also help make the slab-and-column assembly more resistant to lateral loads than the flat-plate system.

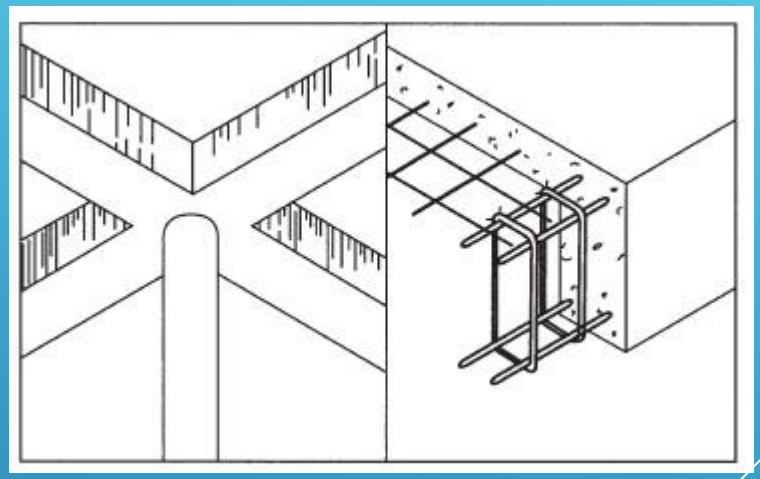


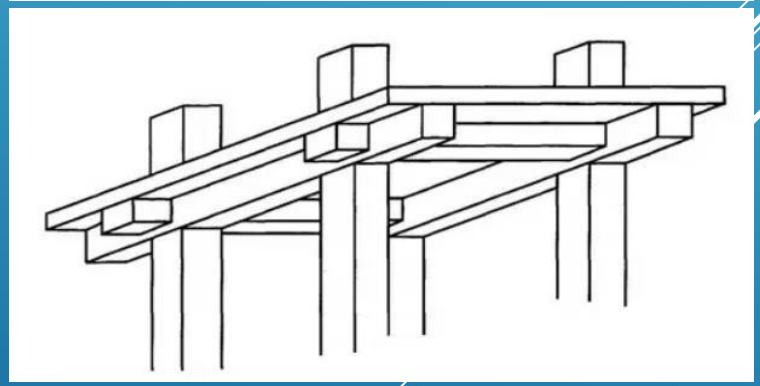


REINFORCED CONCRETE STRUCTURES_FLAT SLAB SYSTEM

REINFORCED CONCRETE STRUCTURES TWO-WAY BEAM-AND-SLAB SYSTEM

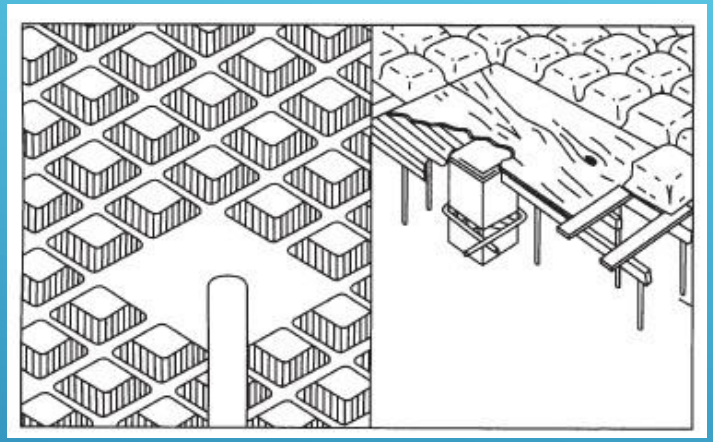
- Reinforced-concrete plate with beams, monolithically cast in place along the periphery of the plate.
- The system is good for medium spans and high loading conditions.
- Large, concentrated loads also can be supported if carried directly by the beams.
-
- The system has broad application and is generally limited by the depth available in the ceiling space for the beam stem.
- This system considered a "heavy-duty" system is often used for framing non typical floors such as ground floor and plaza levels, which are typically subjected to heavier superimposed loads due to landscape and other architectural features.

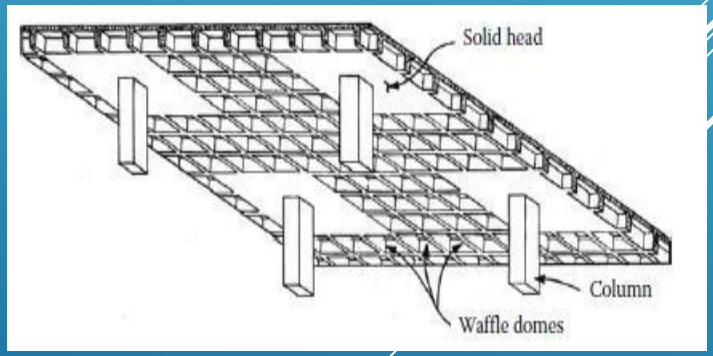




REINFORCED CONCRETE STRUCTURES THE WAFFLE SLAB SYSTEM

- Two-way, constant-depth reinforced concrete system having ribs in two directions.
- The ribs are formed by the use of special domed pans made of steel or fiberglass.
- The voids formed by the pans reduce the dead-load weight of the structure.
- more useful than flat plates in longer span situations.
- These slabs can also be posttensioned to increase their spans.
- A thickness of concrete is usually left around column tops (by not using pans in these locations).
- This solid area serves the same function as drop panels or capitals
- in a flat slab.
- The possibility of shear failure is reduced and the moment resisting
- capacity of the system is increased.
- The span of the waffle system and its lateral-load-carrying capacity can be increased by casting in place beams spanning between columns. This is done by eliminating the pans along these lines (or spacing them farther apart), adding appropriate reinforcing, and casting a full depth of concrete.

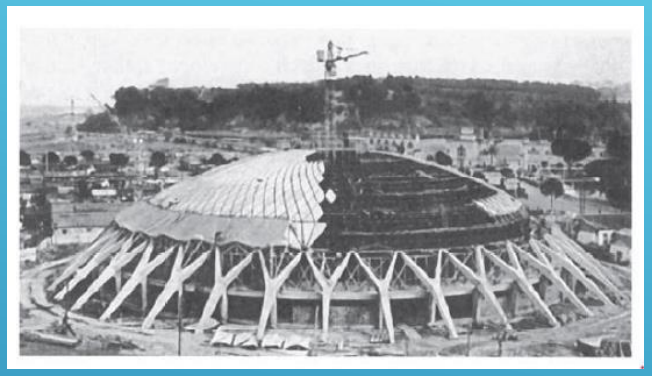


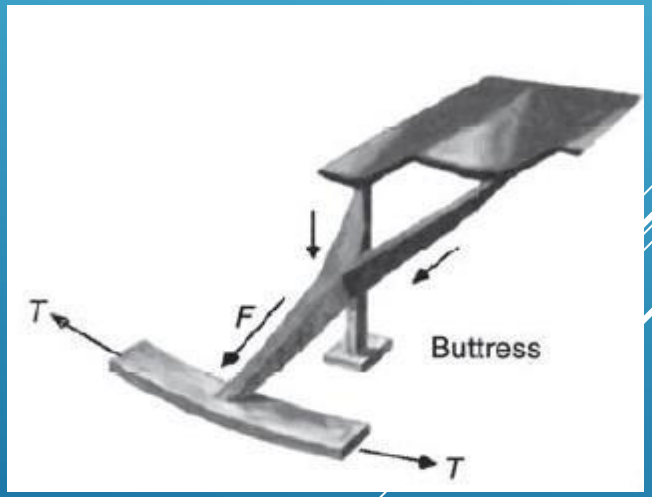


REINFORCED CONCRETE STRUCTURES THE WAFFLE SLAB SYSTEM

REINFORCED CONCRETE STRUCTURES CURVED SHAPES

- Any singly or doubly curved shape (e.g., a cylinder or dome) can be made from reinforced concrete.
- Reinforcing typically consists of a mesh of light steel rods throughout the shell, with special additional steel used in localized areas of high internal force.
- Posttensioning is commonly used for special elements (e.g., tension rings in domes).





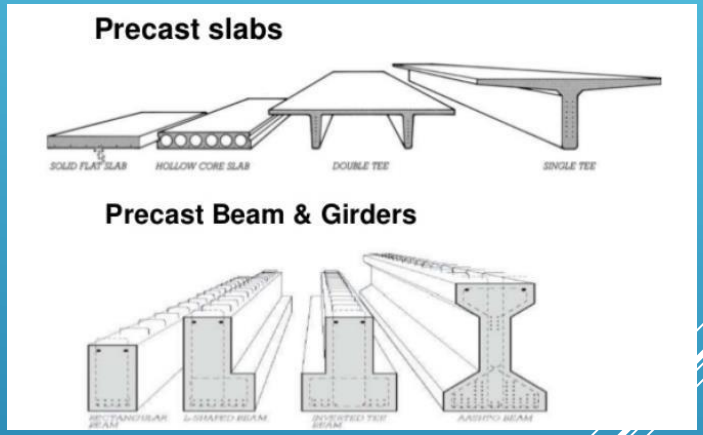
REINFORCED CONCRETE STRUCTURES CURVED SHAPES

Palazzetto del Sporto, Piazza Apollodoro, in Rome, Italy, by Pier Luigi Nervi.

- The dome was made of precast ferroconcrete elements supported by Y-shaped buttresses.
- A huge tension ring is buried in the ground.

REINFORCED CONCRETE STRUCTURES PRECAST CONCRETE ELEMENTS

- Precast concrete elements are fabricated off-site and transported to the job.
- They are one-way spanning elements that are most often pretensioned.
- A range of cross-sectional shapes is fabricated that are suitable for a wide variety of load and span conditions.
- Precast concrete elements are appropriate for uniformly distributed occupancy and roof loads and not for concentrated loads or unusually heavy distributed loads.
- These members are most often simply supported.
- Moment connections are made possible by using special steel connections but are difficult.
- Large cantilevers also are difficult and must be kept to a minimum.
- Precast elements are most successful when used in a repetitive way.

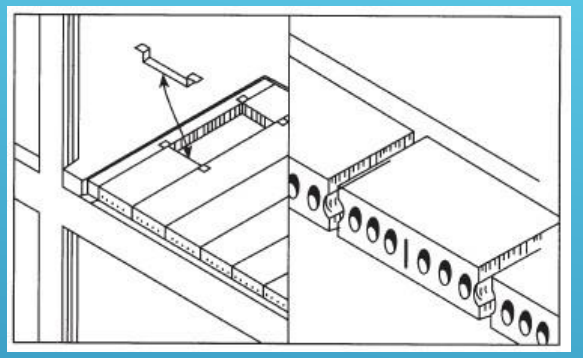


REINFORCED CONCRETE STRUCTURES PRECAST CONCRETE ELEMENTS

REINFORCED CONCRETE STRUCTURES

PRECAST PLANKS

- Both short-span and long-span planks are available.
- A poured-in-place, concrete-wearing surface is placed on top of the planks, which are often used with precast reinforced-concrete beams or with steel open-web joists.
- Long-span planks are available that span between 5 and 11 m depending on the exact width and depth of the element.
- These long-span planks are usually prestressed and cored to reduce dead weights.
- A poured-in-place, concrete-wearing surface is placed on top of the planks. This concrete also forms a shear key between adjacent elements so the resultant
- structure behaves like a one-way plate.
- Precast planks are most appropriate for light occupancy or roof loads.
- They are simply supported and often used with load-bearing walls as the vertical support system. (The walls must be either masonry or concrete)
- Precast planks also are frequently used with steel or reinforced-concrete beams.

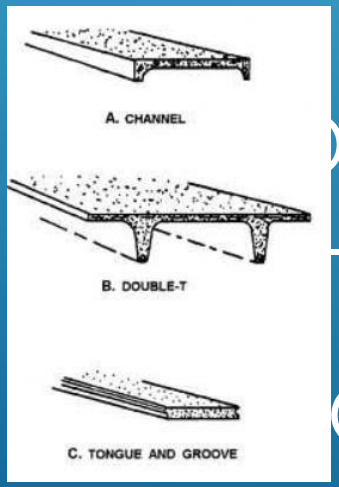


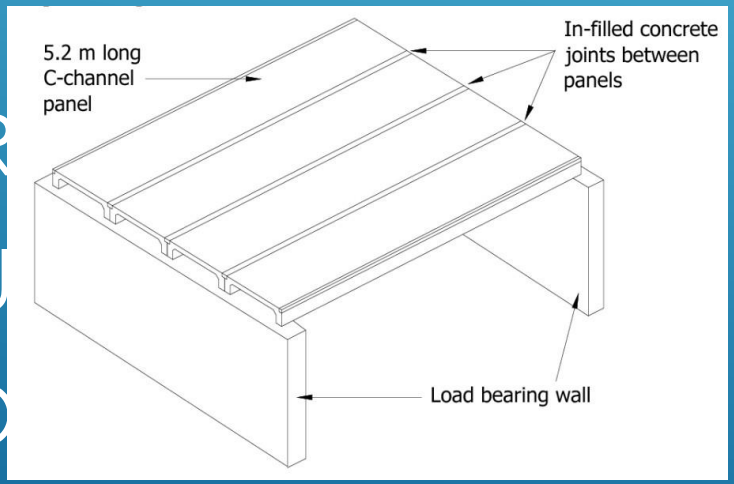
REINFORCED CONCRETE STRUCTURES PRECAST PLANKS

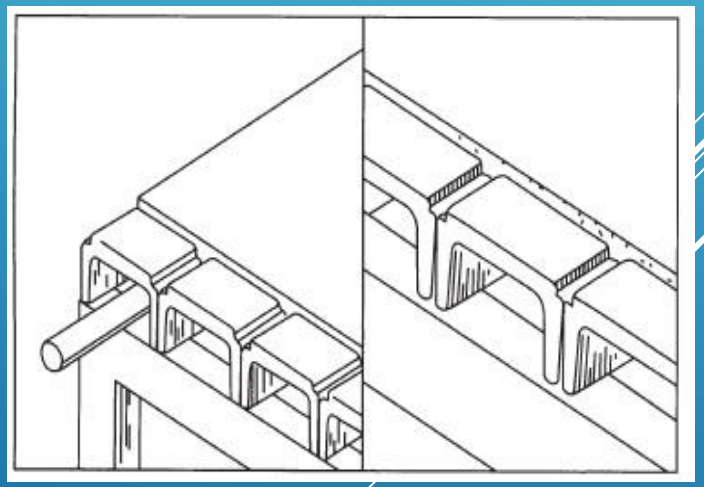
REINFORCED CONCRETE STRUCTURES

CHANNELS AND DOUBLE TEES

- These ribbed,one-way, precast, prestressed elements are suitable for longer spans than planks for occupancy and roof loads.
- A poured-in-place, concrete-wearing surface is placed on top of adjacent members.



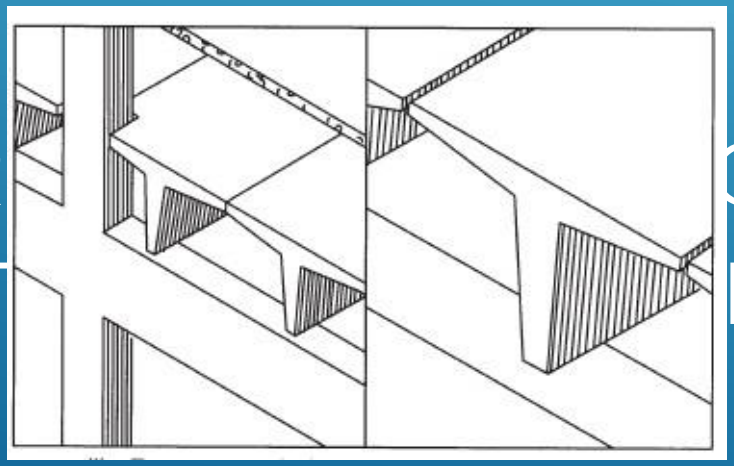




REINFORCED CONCRETE STRUCTURES

SINGLE TEES

- These typically large, precast, prestressed elements are most suitable for relatively long spans.
- They are rarely used with short spans because of the difficulties erecting them.
- Invariably simply supported, single tees are suitable for heavy occupancy and roof loads.
- They are, for example, often used in parking garages and other buildings having large spans and heavier-than-usual loads.



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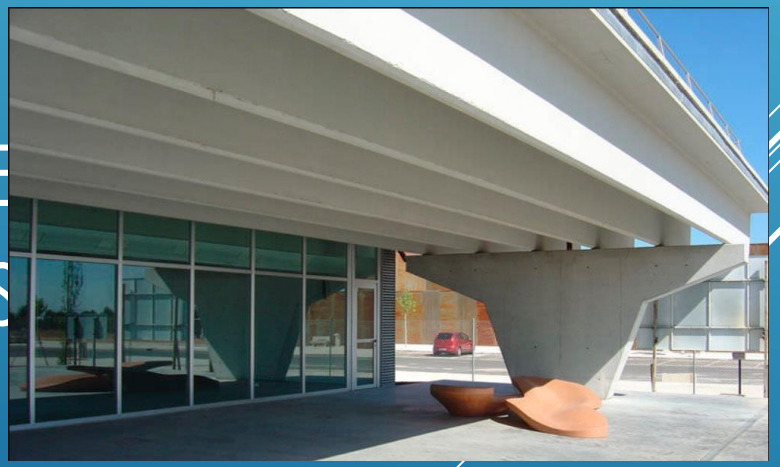

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