PART- A

1. Define prefabrication.

The term prefab can apply to any construction method where the significant part of the construction takes place off site in a factory. That produces relatively large complex features that assembled at the site into the finished building.

2. What is meant by modular Coordination?

Modular coordination is a concept for coordinating dimension and space for which building and component are dimensionally it used and positioned in basic units (or) modules. The standard specify that the module basic $M = 100 \text{ mm}$. As the basic unit be used in a square of $M$.

3. What are the characteristics of Modular concept?

I) The basic module is small in terms of add size in order to provide design flexibility, yet large enough to promote simplification in the component variation in sizes.

II) Industry friendly features that not only for manufacturing but also the transportation and assembly requirements.

III) Internationally accepted to support international market.

4. Write out the advantages & disadvantages of prefabrication?

I) Self supporting readymade components are used, so the need for formwork, shuttering and scaffolding is greatly reduced.

II) On-site construction and condition is minimized.

III) Less waste may occur.

Disadvantages:

I) Careful handling of prefabricated components such as concrete panels (or) steel and glass Panels is reduced.

II) Similarly leaks can form at joints is prefabricated component.
5) Define the term Off-site fabrication.

Off-site fabrication is the process that incorporates prefabrication and preassemble the process involves the design and manufacture of units usually remote from the work site and the installation at the site to form the permanent work at the site.

6) Write short note on Production process.

The production of concrete blocks consists of four basic process. They are,

1) Mixing  2) Moulding  3) Curing  4) Cubing

7) List out the limitations of prefabrication.

I) Extra reinforcement is required to take care of handling and erection stresses.

II) Temporarily props may be required in some cases, before the un-site concrete joints achieve strength.

III) The cracks may develop at the joints between the precast on-site concrete due to shrinkage and temperature stresses. To overcome them extra steel is required across joint.

8) What are all the Prefab materials?

- Structural insulated panels (SIPs).
- Insulating concrete forms (ICFS).
- Prefab foundation system.
- Steel framing.
- Concrete framing.
- Large - modular system

9) Insulating concrete forms:

Insulating concrete forms (ICE) are a prefab construction material consisting of hollow EPS foam blocks that are stacked and glued together on-site, creating the form that is filled with reinforcing bars and concrete.

10) Write short note on Principles of MC Concept?

The principle objective of implanting MC is to improve productivity through the reduction of wastages in the production, installation process, to improve quality in the construction industry and to encourage an open system.
PART B

1. Explain Modular Coordination in detail

Modular coordination means the interdependent arrangement of a dimension based on a primary value accepted as a module. The strict observance of rules of modular coordination facilitated,

1. Assembly of single components into large components.
2. Fewest possible different types of component.
3. Minimum wastage of cutting needed.

Modular coordination is the basis for a standardization of a mass production of component. A set of rules would be adequate for meeting the requirements of conventional and prefabricated construction. These rules are adaptable for,

a. The planning grid in both directions of the horizontal plan shall be
   1. 3M for residential and institutional buildings,
   2. For industrial buildings,
      15M for spans up to 12m
      30M for spans between 12m and 18m
      60M for spans over 18m
   The centre lines of load bearing walls shall coincide with the grid lines
b. In case of external walls the grid lines shall coincide with the centre line of the wall or a line on the wall 5 cm from the internal face of the wall
C. The planning module in the vertical direction shall be 1M up to and including a ht of 2.8M.
d. Preferred increments for the still heights, doors, windows and other fenestration shall be 1M.
e. In case of internal columns the grid lines shall coincide with the centre lines of columns. In case of external columns, the grid lines shall coincide with the centre lines of the columns in the storey or a line in the column from the internal face of the column in the topmost storey.

A basic module can be represented as module and for larger project modules are represented as Mp.

For eg: For a project module in horizontal coodination, the component can be of 30cm and for vertical component size be of 10cm.

The storey height is fixed between finished floor levels as 2.8m and if the thickness of slab is <15cm storey height is fixed as 2.7m. The centre distance between the load bearing walls can be chose from a set of modules. The use of other dimensions is not allowed.

In the design of a building, modular grid can be used consisting of parallel line spaced at a value of module M or Mp and a grid line chosen as a base for setting out a part of a building becomes a modular axis. In the fig (a), a typical grid is chosen for load bearing walls without duct. The interior walls are placed so that their centerlines coincide with the modular axis. In the fig (b), a grid is shown for load bearing walls with hollow ducts in between. The centre line of the grid is found by deducting the size of duct.

2. Systems of prefabrication:
System is referred to a particular method of construction of buildings using the prefabricated components which are inter related in functions and are produced to a set of instructions. With certain constraints, several plans are possible, using the same set of components, the degree of flexibility varies from system to system. However in all the systems there is a certain order and discipline. The system of prefabricated construction depends on the extend of the use of prefab components, their characteristics to be considered in devising a system:

i. Intensified usage of spaces
ii. Straight and simple walling scheme
iii. Limited sizes and numbers of components
iv. Limited opening in bearing walls
v. Regulated locations of partitions
vi. Standardized service and stair units
vii. Limited sizes of doors and windows with regulated positions
viii. Structural clarity and efficiency
ix. Suitability for adoption in low rise and high rise blocks
x. Ease of manufacturing storing and transporting
xi. Speed and ease of erection
xii. Simple jointing system
a) Based on Disuniting of member
b) Based on the construction

Based on Disuniting of member:

1. System consisting of linear member disunited at joints
2. System for prefabricates of entire rigid frame
3. System consisting of I,T,U of straight members disunited at points of minimum moment.
4. Two hinged and three hinged arches

![Diagram of members disunited at joints](image)

System consisting of linear member disunited at joints:

**Advantage:**

Disuniting at joints gives linear member. This means that a great advantage and facilitates from the view point manufacture and assembly.

**Disadvantage:**

1. Joints are at corners i.e. at points of maximum moment values, so forming the joint is difficult.
2. Joints must be over dimensioned to cope with insitu concreting. And one alternate solution to replace moment resistant joints by hinged connection.

System for prefabricates of entire rigid frame:
In this system, to reduce the no of joints and to precast larger numbers I one piece leads to the prefabrication of entire frame. Production of the frames does not cause any particular trouble but the hoisting is more difficult and requires careful preparation.

The stress distribution of staright members during hoisting is in general statistically determinate.

**Advantage:**

1. It is ideal for site prefabrication.
2. Small number of joints so rapid prefabrication work is possible.
3. Suitable for long walls consisting of great number of uniform frames.

**System consisting of I,T,U of straight members disunited at points of minimum moment:**

*Fig1.4 System consisting of Structures disunited at points where the moments are smallest Moments*
Another method of disuniting of structures is by division into different membranes at points where the moments are thin or smallest. This method is called as lambda method. Using this method hinge joints are made.

**Advantage:**

1. Functions are made at points of minimum moments or at points of contra flexure.
2. Disuniting the main girder in this manner makes the application of different skylights possible.

**Disadvantage:**

1. Hosting and temperature bracing of L joined asymmetric frame members is particularly complicated.
2. Temperature resting of frame member on each other necessitates the use of canilevers having half depth and proper forming of this cause difficulty.

**Two hinged and three hinged arches**

Arched structures are normally two hinged and three hinged arches. Arched structures are normally used for bridging span more than 20-25m. Their production and placing is more
difficult than straight members. Arch can be two hinged and three hinged but they can also be fixed at footings and can be constructed with or without tie.

These members are generally precast and assembled in statistically determinant three hinged variance and middle hinge is only eliminated after placing is finished. The reinforcing bars protruding both sides are welded together and the joint between the members is filled in with in situ concrete.

Arch structure can be precast in either vertical or horizontal positions. In the first case, shuttering made of timber or concrete is required having the same curvature as the arch itself. The prefabrication of larger arches in the horizontal position is found to be more economical. The construction of arch trusses can be properly carried out in the horizontal position only.

3. Transportation and Hosting of Prefabricates:

Truck cranes

Gantry cranes

Mast cranes

Derrick cranes

Twinned mast cranes

**Truck cranes:**

Truck cranes consist of chassis including mortar and pivoting upper part. These cranes are mobile and can travel on their own needs. Different features are:

1. Weight of the crane while travelling is 31.8 tonnes
2. Maximum height of hoisting hook is 36.6m
3. Crane can rotate through 360°.
**Disadvantage:**

Needs firm and compact soil.

**Gantry Cranes:**

These cranes are used mainly to serve the operation of manufacturing and storing areas in prefabrication plants.

Capacity 5T, Total weight 4.5T

Horizontal distance between 2 tracks is 7.8m

Maximum height is up to 11m

Mast height 10.9m and it can hoist up to 20 tonnes in operation.

**Mast Cranes:**

These are wide spread hoisting devices, simple and cheap. Operation requires great skill and practice. Useful in hoisting prefabricates in vertical direction. Suspension load can be slightly moved forward by slackening the rear staying cable. Hoisting load is done by a winch.

**Twinned mast cranes:**

It is used for hoisting member to great height. It consists of two steel column assembled from sections and connected at top by bridging structure.

Hoisting capacity using two cranes each of 35-70T

Operation of the crane required minimum 16 workers.

The crane can be transferred but takes 1-2 days and is suitable for high lifting but difficult to operate.

These are now a days replaced by 30T mast cranes hinged in 2 directions.

**Derrick cranes:**

Highly efficient lifting machines

It is stable or movable

Capacity 20-40T

Suitable for prefabrication halls

These cranes have booms which can move in horizontal directions.

**4. Erection of Buildings:**
Prefabriactured structurers are erected in convenient sections which when fixed correctly should be sufficiently rigid in all directions. Normal sequence of erection is

a. Structure units- external load bearing walls, columns, etc
b. Non structure units- internal walls, partition walls, etc
c. Floor panels, balconies, stair units
d. Specialized prefabricated units- chimney flumes, Ventilators, sanitary installation.

If the external walls are hand laid from small blocks or bricks, all necessary materials should be hoisted by crane and stacked near the ultimate position. The mansonry work is begun after the floor immediately above is laid.

The tolerances are comparatively strict and are normally coomplied with the use of a skilled rection gang. The distance between the walls are measured with the steel tape and the thickness of joint with rule having mm scale. The accuracy is verified by means of surveying instruments after all joints are connected or erected.

**Hosting of Columns:**

![Hoisting of columns](image)

The hoisting machine for small column is less than five tones. First of all pick up gear must be assembled on to the column and the column is then under pinned.

Thereafter the column is lowered temporarily on to a sheep shoe assembled at the foot and the roller track is pushed under the shoe. When column is hoisted the pick up points moves vertically and bottom resting on the roller tracks shifts towards the footing. When the column is lifted to the required height, the retaining cable is used to decrease and finally stop the swinging motion of the column.

**The hoisting and fixing up of the beams:**
1. Pick up and hoisting
   Beams in general are lifted at two points depending on the weight and dimensions as well as the load bearing capacity of hoisting machines. The hoisting grid can be executed with hydraulic jacks. The jacks are lowered and the beam is placed to the required position to the column.

Suspension:

For lifting up of trusses and large beams of length 25-30m, care is taken to lift the rocker in uniform rate with two hoisting machines otherwise the beams would be subjected to distortion during the lifting leading to cracks.

5. Methods of prefabrication:

Site prefabrication- for large prefabricates

Plant prefabrication- large scale production

Site prefabrication:

1. The RC members are produced at the site in the open air chiefly in the open air or in the temporary sheds
2. The difficulties in construction in general are felt in this mechanization can case.
3. Mechanization can not be of such high degree as site PF is done for smaller duration of time.
4. When the pre fabricates are of large size it is difficult to transport the pre fabricates to the site.
5. In comparison with plant prefabrication transportation of the members are not needed. As large members are not transported the design and weight of the prefabricates are not limited.
Plant prefabrication

1. The members produced are to be transported to the place of construction. This accounts for about 10-15% of the cost of production and assembling.
2. Certain restrictions are made in the dimension of prefabrication leading to restrictions in the design and development of prefabrication.
3. Prefabrication is appropriate for mass production for the manufacture of standardized members.
5. This method is most suited in the case of small prefabricates which are to be prefabricated in very large numbers.

Plant prefabrication is done under permanent plants or factories. It is done under the covered roof so the effect of weather does not affect the work. So the quality and strength of the members can be improved considerably. Plant prefabrication reduces the cost of prefabrication if the number of prefabricates needed is more.

Dimensions of prefabricates:

There are 3 commonly known dimensions for the prefabricates.

1. The design of the erection dimension governing the dimensional coordination of the prefabricates.
2. Theoretical dimension
3. The actual dimension of the element when delivered. The design dimension should be a multiple of a basic module size \( m \) or of a module \( \text{Imp} \).

Production of prefabricates:

Production techniques involved are

1. Stand method
2. Conveyor method or line method
3. Aggregate method

Stand Method:

In this method, the prefabrication mature where they are moulded while the production teams move to successive stands. The bed on which prefabricates are cast may be fixed or movable. Tilting forms are often used, and in this method steam curing is generally done.

Conveyor belt method:

The whole production is split up into series operations carried out at separate successive and permanent points served by specialized teams. The movement of the mould or prefabricate one point to another varies by means of conveyor belt trolleys.
The rigid steel forms are assembled at station 1 where they are mould oil to reduce the adhesion of concrete. The conveyor moves from 1 to 2 where prestressing wires are fixed & in the next station anchoring of the wires is carried out. The prepared mould is then carried to the station 1ie casting station. After casting, it is shifted to the vibrating table & finally stacked @ station 5 for setting.

After that, it is passed through tunnel autoclave for curing. After steam curing move too station 7 for demoulding & is finally stacked @ 8.

**Aggregate method:**

In the aggregate method, aggregate describes large complex permanently installed machines & mechanical appliances which carry out most of the separate operations involved in the casting of the concrete composition. The stand is operated by a permanent team & the only move the prefabricate makes is to the maturing point.

Aggregate method is used in the production of multi duct hollow floor pannel in Poland. At production point the reinforcement is fixed in the form & remote controlled aggregate (machine) inserts the duct formers, cast & vibrates the concrete, floats @ the top of the floor. The prepared prefabricate then move to the autoclave chamber in which hardening of concrete is accelerate. In many factories combined technology are employed when complex prefabricate are required.

Advantages:

1. The stand technique is the most flexible one. It is used in varying degrees of mechanization, in all kinds of prefabricate factories.

2. It is simple & less capital is required. It can be used for field prefabricate also.

3. Aggregate method is used for large scale production in which case number of machineries is required.
UNIT II. PREFABRICATED COMPONENTS.

PART A

1. LONG WALL SYSTEM:

   The main beam (or) load bearing wall are placed to the long axis of building. It is applied to the building with large prefabricated and similar to traditional brickwork. The longitudinal wall crosses the floor load must possess not only thermal.

2. How are roofing members in prefabricates classified?

   ➢ Small roofing members.
   ➢ Large roofing members.
   ➢ Reinforced planks (or) ties.
   ➢ Light weight concrete roofing members.
   ➢ Small reinforced concrete roofing members.
   ➢ Purlins.

3. How are the prefabricated component classified?

   a) Based on the area (or) size of prefabricates.
   b) Based on weight of prefabricates.
   c) Based on the function.
   d) Based on the shape.
   e) Based on the material.

4. What are the space bordering?

   These members are used to give spaces like walls both load carrying and partition walls. This may (or) may not contain doors and windows the provision for the same is as per the requirement. Another example for the space bordering member are floor slabs.

5. What is the meant by surface forming members?

   In the case of surface forming members, the load carrying and surface bordering are united and a uniform load carrying surface is found loaded by complex forces and economic shapes.

   Example: Shell structures folded plates structures etc.
6. Differentiate between **synclastic** and **anticlastic**.

In the case of synclastic, the curve of the shell is in the same side (e.g., hemispherical shell) whereas in the case of anticlastic, the curvature of the shell is in opposite direction (e.g., hyperbolic shell).

7. Write a short on dome structure.

A dome is a space structure covering a more (or) less square (or) irregular area. The best known example is the dome of revolution, and it is one of the earliest of the shell structure.

Excellent examples are still in existence that were built in Roman times.

8. Define shear wall.

These are simple type and these shear walls under forces and horizontal shear along its length are subjected to bending and shear.

To resist these forces, the uniform distribution of steel along its length is used in simple shear walls.


1) Plain rectangular shear wall

2) Bar bell type.

3) Framed shear wall.

4) Coupled shear wall.

5) Care type.

10. What is ring system?

# Load bearing walls and beams are placed in both ways longitudinally and transversely. In the building with ring system of support floors are normally supported on all four edges and span is two direction.

# In skeleton construction these floors are placed directly on columns.
PART B

1. Explain about Roofing members in detail.

Roofing members are classified as,

i. Reinforced planks.

ii. Light weight concrete members.

iii. Small reinforced roofing members.

iv. Purlins

v. Large reinforced roofing members.

Reinforced planks:

Reinforced planks made of hollow tiles. The reinforced planks with longitudinal circular holes. Thickness of these tiles is 60mm, 80mm & 100mm & the width is 200mm & length is vary from 360mm to 400mm. On the upper side one longitudinal groove is provided.

Reinforcement is placed into these grooves which are subsequently filled with cement mortar. In this way, roofs of length 2 to 3m & thickness of 60 to 100mm & width 200mm can be constructed.

The end tiles resting on the support are provided with 3.11mm dia stirrups protruding from the tile. There are kept together over mortar of 40mm thickness & in further concreting of joint, the joint is completed.

Light weight concrete roofing members:

Light weight concrete roofing members play a role in addition to space bordering & load bearing in heat insulation. The thickness varies from 7.5 to 25cm for reinforcement of Light weight concrete roofing members. Weiding nets is used. Steel reinforcement is given additional coating to prevent any corrosion. Care is taken to give good bonding of reinforcement with concrete.

The unit weight of these members is 750kg/m3 & width of 50cm. Its varies from 1.75mm to 6m. Precast members can be made either in usual way using light weight materials, sand as aggregate & combination of high strength concrete. The top & bottom layer of about 2 to 3cm thickness is provided with high strength concrete. Its consists of prestressed 2.5mm dia embedded in these layers. The middle portion is made with light weight concrete.

Small reinforced concrete roofing members:

The Small reinforced concrete roofing members is essentially precast simply supported ribbed concrete slab width varying from 450 to 120cm & length varying from 2 to 4m.

Purlins:

Purlins are precast concrete beams supported by the main girders serving the purpose of bearing for the roof covering. The cross section of purlins is generally rectangular but it can also have trapezoidal, T, L and I shape.
Precast purlins can be simply supported or cantilever beams & for the bearing of loads beyond these weight simply supported purlins can be transformed into continuous beams. It is very simple & easy to place. For cantilever purlins placing of hinges should be determined in a manner to develop positive & negative moments equal to each other. This can be arrived by placing the hinges @ 0.1451 from the support where I is the spacing between the supports.

Large reinforced concrete roofing members:

Large reinforced concrete rest on the main girders. These are generally used for large hall structures & these are most advanced type of precast structures. Members are manufactured corresponding to spacing of the frame length of about 6 to 10m & width of 1.3 to 1.8m. As they are most supported on main girder purlins are not required.

Four kinds of members exist:

1. Normal members.
2. Intermediate members.
3. Members with cornice.
4. Members with gutter & eves border.

2. Write a detailed note on shear walls.

The types are classified as

1. Rectangular type or Bar bell type.
2. Coupled shear wall.
3. Framed shear type.
4. Core type shear wall.

When walls are to carry only compressive force, they can be designed as plain concrete. When walls are subjected to tensile forces (due to wind force) due to eccentric loading & earthquake load the walls are RC walls, shear walls are previously provided to resist the wind forces only. Hence became popular & to provide shear walls to resist EQ forces.

SHEAR WALLS:

These are simple type & these shear walls under forces & horizontal shear along its length are subjected to bending & shear. To resist the forces the uniform distribution of steel along its length is used in simple shear walls. In case of bar bell type 2 boundary elements are provided on either side. Minimum steel is provided over the 0.7 to 0.8L & the remaining steel is placed steel is placed @ 0.12 to 0.15L. These walls are designed in such a way that they never fail in shear but only by yielding of steel in bending. Shear failures are sudden & brittle. One disadvantage of this type of wall is that during EQ the shear walls attract all the earthquake forces & dissipates the forces in to the wall. The loss of energy by cracking of the wall is difficult to repair. This can be eliminating by providing coupled shear wall.

Coupled shear wall:
If two straight walls are joined together by relatively short span beams they are called as Coupled shear wall. The stiffness of resultant wall increases in addition to the structure can dissipate most of the energy by yielding the coupling beams with no damage to the main walls. It is easy to repair the coupling beams than repairing the walls.

The action of the coupling beams of the shear walls. The beams are displaced vertically they tend to bend in a double curvature. The consistent shear can reduce the axial force in the upwind wall by a large amount & reduce pressure can lower the shear capacity of the wall. To take up for this force diagonal lateral steel is more effective.

The design should be taken care of to see that the system develop plastic hinges only in the coupling beams before shear failure & coupling beams should be designed to have good energy dissipation capacity.

Framed shear wall:

Framed shear walls can be provided with or without brick infills.

3. Write a brief note on shell structures.

These are load bearing structures having curved surface. The advantage of shells is that it provides large column free area for the monolithic construction. The cost of shuttering & scaffolding is very high but if manufactured in a precast factory in large scale. The production cost can be considerably reduced.

The shell structure can have ribs in the centre & provided with curved membranelike roof. The shells built of precast members used in the construction of industrial buildings are many. The thickness of shell varies from 2 to 10cm. Some precast shells, s are produced with dimensions which are very difficult to transport. To avoid such difficulty large size shells are precast near to the resting or construction place.

The transportable or small size shell members can be precast in factories & these are transported to the site. Examples: Barrel shells, Saddle or hyperboloid shells, cupola or paraboloid shells.
Types:

a. Single barrel:

The structure above is a single barrel with edge beams. The shell has been allowed to project beyond the edge of the stiffener in order to show the shape of the shell. Stiffeners are required at columns. They do not necessarily have to be complete diaphragms but may be arches with a horizontal tie. The thickness is based on design of a slab element, the thickness of the barrel shell is usually based on the minimum thickness required for covering the steel for fireproofing, plus the space required for three layers of bars, plus some space for tolerance. If these bars are all half inch rounds, a practical minimum would be 3 ¼ inches. Near the supports the thickness may be greater for containing the larger longitudinal bars.

If more than one barrel is placed side by side, the structure is a multiple barrel structure & if more than one span, it is called as multiple span structure.

Multiple barrel structure:

This structure shows a multiple barrel with vertical edge beams at the outside edges. The stiffeners have been placed over a roof. The advantage of having the stiffeners on top is that there are no interruptions to the space inside the shell so both the inside appearance & the utility are better. The movable formwork may be used which will slide with little decentering lengthwise of the shell.

The multiple span structure should have an occasional expansion joint to reduce shrinkage & thermal stresses. This can be accomplished by cantilevering half the span from each
adjacent stiffener. A small upturned rib placed on each side of the joint & accordion type sheet metal flashing is arranged to prevent roof leakage.

The maximum spans for this type shell are again limited by the geometry of the cross section. Assuming the maximum width of barrel to be 50 feet & maximum end slope to be 45°, the rise would be about 14 feet, the maximum span would be in the order of 150 feet.

North light shells:

This type of shell structure is used to provide large areas of north light windows for factories requiring excellent natural lighting. The windows may be slanting or may be vertical. The member at the bottom forms a drainage trough with the curved shell & materially assists in stiffening the structure. The effective depth of the shell is not the vertical distance between the two ends but is more represented by the depth if the shell is laid flat with the ends of the circle on the same horizontal line. The spans for the north light shell must be rather small in comparison to the vertical depth of
construction. The edges of adjacent shalls should be tied together by concrete struts serving as mullions between the window glazing.

Long barrel shell:

Long barrel shell obtained when the semicircle or a segment of same is translated along the longitudinal axis.

![Diagram of Long Barrel Shell]

Generally used for shed for industrially purpose & buildings for large column free areas. Generally the prefabricated barrels off sizes 3.5 to 5m & 10m long with edge beams having thickness of 60mm. The thickness of the shell should not be more than 40mm. The dimension of these members were finally limited by the load carrying capacity of the available hoisting machines using the girder system built of precast prestressed trusses with parallel chords, areas having a span of even more than 15m can be covered with barrel shell.

Folded plate:

![Diagram of Folded Plate]

A folded plate structure with 3 segments for each barrel. The forces from the reactions of the sloping plates on these rigid frames will be quite large and at an outside column they will not be balanced by thrusts from the adjacent plates. The size of the frames may be reduce by using a steel tie between the tops of the columns. The dimensions of the plate are dependent on both the with of the barrel & on the span. The depth of the shell should be about 0.10 times the span & the maximum slope of a plate should not be greater than 40°. For example, assume that the span is 60 feet & the baywidth is 24 feet. The depth of the shell should be about 6 feet & the horizontal width of each plate with a 3 segment plate should be about 8 feet. The slope of the plate is 6/8, which is about 37° & is satisfactory. The thickness of plate could be about 3 ½ inches. The principle components in a folded
plate consist of 1.inclined plate 2.edge plate which must be used to wide plate.3.Stiffeners to carry the loads to the supports & to hold the plate.4.Column to support the structure in the air.

4.Discuss about domes in detail.

Domes are constructed with many planes so they resemble the facets of a diamond. The structural problem in designing these shells is to provide enough angle between the planes so that an actual rib is formed which will be stiff enough to support the plane surface. Usually it is best to start with a spherical translation surface.

Folded plate dome:

This makes use of tapered folded plate slanting to the centre in the form of a tent. It can be built so that each of the triangular elements is self supporting during construction except for possibly a single shore at the crown. To obtain natural light the top may be cut off & a ring inserted with a sky light. The arch thrusts are taken through this ring & the difficult forming of the narrow plate at the crown is avoided. If the structure is large there would be very high bending stresses due to the curvature & the ring would be very large.

Multi facet dome:

There may be discontinuous in the layout of intersections which make or destroy the visual effect & make the structure more difficult to design. This dome can be of much greater span than the previous example because the span of the individual slab element is less. A dome hexagonal in plain can be made continuous with adjacent units if it is necessary to cover a large area.

Half sphere- vertical walls:

A half sphere for a dome of revolution does not require a thrust ring at the base so it can be placed on vertical walls & made continuous with a wall. This design is used for tanks because the roof becomes a part of the tank. The vertical portion of the sphere is not difficult to construct if pneumatically applied shotcrete or a similar process is used. The structure with arched openings an a plastic dome on the crown has a rather oriental feeling. The most serious problems in the architecture of dome is acoustics. In a domed ceiling the sound may reverberate as many as 20 times unless there is acoustical treatment.

Domes-Square in plan:

This structure is a spherical dome with portions sliced off to form a square or rectangle. Most areas to be covered are rectangular so a circular dome is not always a good solution to the planning requirements. This dome is supported by four rigid frame & would only be suitable for small span because the frame would get quire in large. For long spans it is necessary to place a tie between the knees of the frame. These ties can be made a part of the windows. Stresses in the shell are direct compression stresses except across the corner where there are direct tensile due to the outward spread of the forces. The arches or rigid frames pick up the shell forces by shear parallel to the arches which are zero at the top & maximum at the bottom. There is no component of force in the shell perpendicular to the arches.

Multiple Domes:
The domes is rectangular & is continuous with the adjacent domes. The edges of dome are supported by tied arches or brousing trusses. If windows are needed in these arches, the mullions may be made to serve as vertical hangers for the bottom chords of the arch. In constructing the shell, each one of the dome elements is an independent structural unit so the forms may be moved without shoring all or part of the dome already cast. The shell thickness of this type of dome does not need to be greater than a circular dome except at the triangular corners. Membrane action ceases to exists & the corner should be designed as a slab.

**Translation domes:**

This structure looks very much like the square dome. A translation shell is generated by a vertical curve sliding along another vertical curve. The curves can be circles, ellipses or parabolas. Therefore the vertical sections are all identical as opposed to a circular dome in which all vertical sections vary in height. This is a big advantage in construction of the formwork. This method can provide a rectangular dome with the same height of arch on all sides, thus making a rectangular dome feasible.

Most of the load is carried by the side arches with some coming directly to the corners. A tie at the springing of the arches but usually this will be covered by the walls. Such shells are suitable for quite long spans with some interior lighting furnished by skylights in the shell.

5. Explain about Warped surface in detail.

Warped surfaces have a great advantage for shell structure because they may be formed from straight form boards even though they are surfaces of double curvature. There are two types which are most useful: the conoid which as its name suggests is a portion of a cone & the hyperbolic paraboloid, a name for a particular mathematical surface. This type of shell structure can be built to what appears to be the ultimate in lightness of construction, minimum reinforcing & ease of moving forms.

Stresses in the hyperbolic paraboloid shell are almost entirely membrane (direct tension & compression) & all forces are delivered as shear parallel to the stiffening ribs. The shell thickness in structures is one & one half inches except for slight extra thickness at the intersection of the surface. This dimension is based on a cover of one centimeter on each side of two layers of bars & not an any structural requirement for strength.

6. Write a detailed note on Wall system.

**Walls:**

Generally classified based on the function as load bearing & non load bearing walls. Eg. partition wall. They transfer self weight only & they are provided to create barriers that can be visual, thermal or acoustic.

**Stiffening walls:**

Provides 3 dimensional stiffness. The load bearing walls which are referred to as supported walls do not possess foundation of their own but are either carried by beams or slabs or directly attached to load bearing walls. The supported walls can form on integral part of structure or remain as non structural depending on stiffness.
Depending on the orientation of the main beams or load bearing walls relative to long axis of the building. Prefabricated wall system are classified as,

Long wall system

Cross wall system

Ring or two way system

Long wall system:

The main beams are load bearing walls are placed parallel to the long axis of building. It is applied to the building with large prefabricates and is similar to traditional brick work technique. The longitudinal external walls which carry the floor loads must posses not only thermal properties but also sufficient load carrying capacity.

The long wall system construction is typical with large blocked structure and special pier blocks between the windows which carry loads from lintel and the walls above. The horizontal still blocks are not loaded. In some designs space between the piers is filled by prefabricated unit consisting of RC window frame complete with window.

The internal wall blocks are normally of full storey height subject to limitations imposed by lifting equipments available. Both internal and external walls are made of some material.

Cross wall system:

Load bearing walls and beams are placed at right angles to the longitudinal axis of the building. In this system the floor units are provided with two way structural units which distributes the to the cross walls and this system is more prominent. The internal walls are made of ordinary concrete for load bearing walls and the external walls and the external walls are made of light weight concrete to reduce the weight of the structure.

Generally the room size is nearly square in this system.

Ring system:

Load bearing walls and beams are placed in both ways longitudinally and transversely. In the building with the ring system of support floor are normally supported on all four edges and span in two directions. In skeleton construction these floors are placed directly on columns.

In this system, the floor slabs are designed to span in both direction and are loaded on to the supporting walls. For large load panels cross beams are hidden within the thickness of the panel.