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POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

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Department of Civil Engineering

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III Year – V Semester

CE3003- Prefabricated Structures

UNIT- I

INTRODUCTION :-

Need for Prefabrication - Principles - Materials - Modular co-ordination - Standardization - Systems - Production - Transportation - Erection.

Introduction :

Prefabricated structures are component members which are precast either in factories or in temporary plants established on the site

These Precast members are transported to the site where they are hoisted, set into their final positions and assembled to form a complete structure

Definition :

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing sete and transporting complete assemblies to the construction site where the structure is to be located.

Need for Prefabrication:

⇒ Prefabricated structures are used for sites, which are not suitable for normal construction methods.
Such as hilly region, and also when normal construction materials are not easily available.

⇒ Prefabricated structures facilities can also be created at near a site as is done to make concrete blocks used in plane of conventional structure.

⇒ Speed in construction.

⇒ Lack of space.

⇒ Proper utilization of space.

⇒ Mass production.

Principles of Prefabricated Structures:-

→ Design for prefabrication, Pre assembly and modular construction.

→ Simplify and standardize connection details

→ Simplify and separate building systems.

→ Minimize building components and materials

→ Select fittings, fasteners, adhesives and sealants that allow for quicker assembly and facilitate the removal of reusable materials.

→ Reduce building complexity

→ Design of reusable materials.

Uses of Prefabrication:

→ Prefabrication techniques are used in the construction of apartment blocks, and housing developments with repeated housing units.

→ Prefabricating steel sections reduces on site cutting and welding costs as well as the associated hazards.

→ This techniques is also used in office blocks, ware houses and factory buildings

→ Prefabricated steel and glass sections are widely used for the exterior of

large buildings offers bridge designers ④ and contractors significant advantages in terms of construction time, safety, environmental impact, constructability and cost.

→ Prefabrication can also help minimize the traffic congestion occuring during bridge building.

Prefabricated Materials:

Prefabricated building materials are used for buildings that are manufactured off site and shipped later to be assembled at the final location.

Some of the commonly used Prefabricated building materials are aluminum, steel, wood, fiberglass and concrete.

Synthetic materials are used for the walls and roofs. To provide enhanced security, a combination of both

metal and cloth materials are used.

→ Plastic flooring materials can be quickly assembled and are very durable

→ Prefabricated building materials used for small prefabricated buildings are steel, wood, fiberglass, plastic or aluminum materials.

These materials are cheaper than regular brick and concrete buildings.

Characteristics of Materials:

→ Easy availability
→ Light weight for easy handling
→ thermal insulation property
→ Durability in all weather conditions
→ Economy in cost.

Modular Co-ordination

→ Dimensional co-ordination employing the basic module or a multi module.

Purpose of modular co-ordination are

→ To reduce the variety of component size produced

→ To allow the building designer greater flexibility in the arrangement of components.

Bases of Modular Co-ordination

Dimensional co-ordination employing the basic module or a multi modale.

Purposes of module co-ordination are

→ To reduce the variety of component size produced.

→ To allow the building designer greater flexibility in the arrangement of components

The modular co-ordination is defined as the basic module to be adopted, the size of which is selected for general application for building and its components

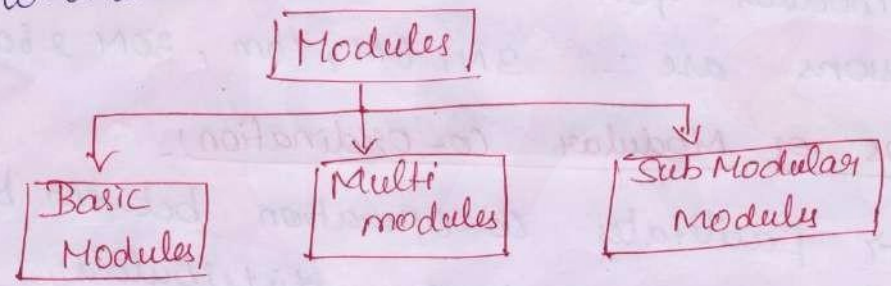
The value of the basic module chosen is 100mm for maximum flexibility and convenience.

The symbol used for basic module is M

1M = 100mm → It is international standard value.

Modules:

Modules is a standard unit of size of co-ordinate the dimensions of buildings



Basic Module:

It is the fundamental unit of size of modular co-ordination.

The basic module is represented by letter M while its international standardized value is

1M = 100mm

Multi Modules:

Multi modules are standardized

by selected whole multiples of the basic module.

Different multi-modules will suit particular applications. By using multi modules it is possible to achieve a substantial reduction in the number of modular sizes.

The international standard values of multi modules for horizontal co-ordinating dimensions are :- 3M, 6M, 12M, 30M & 60M.

Aims of Modular Co-ordination :-

→ Facilitates co-operation between building designer manufacturers distributors, contractors, and authorities.

→ Permits a flexible type of standardization which encourages the use of a number of standardized building components for the construction of buildings and building components.

→ Ensures dimensional co-ordination between installation as well as with the rest of the building.

Advantages of Standardization:

→ Easier design
→ Easier Manufacture
→ Easier erection and completion.

Factors influencing standardization

→ The no of types of elements will be limited and they should be used in large quantities.

→ To the extent possible the largest size to be used which results in less no of joints.

→ The size and the no of the prefabricate in limited by the weight in overall dimension that can be handled by the transportation.

Systems:

The term production of systems describes a series of operation directly concerned in the process of making or more aptly of molding precast units on

the face of it there are very many techniques.

Large prefabrication System:-

In large prefabrication system most of the members like wall panels, roofing/flooring systems, beams and columns are prefabricated.

One of the main factor which affects the factory prefabrication is transport. Suppose the factory is situated far away from the construction site and the vechicle needs to cross congested traffic areas with heavy weighing elements the Cast inside prefabrication is preferred.

Open system of prefabrication

In the total prefabrication systems, the space frames are casted as a single unit and erected at the site. This wall fitting and fixing or done on site.

Closed system :-

In this system, the whole things are casted with fixing and erected on their position.

Small Prefabrication :

Small, medium & Large prefabrication systems are mainly classified according to their degree of pre cast elements using in that construction.

For eg: brick is a small unit precasted and used in buildings. This is called as small prefabrication.

That the degree of precast element is very low.

Medium Prefabrication

Suppose the roofing systems and horizontal members are provided with precast elements. These constructions are known as medium prefabricated construction.

Here the degree of precast elements are moderate

Off site (Factory) Prefabrication

One of the main factors which affect the factory prefabrication is transport. The width of road walls, mode of Transport vechicles are the factors which factors the prefabrications which is to be done on site (or) factory

Open prefabrication system:-

There are two categories of open prefabricated systems depending on the extent of prefabrication used in the construction as given below.

⟹ Partial Prefabrication Open System
⟹ Full Prefabrication Open System.

Partial Prefabrication Open system:-

The system basically emphaizes the use of precast roofing and flooring components and other minor elements like lintels, sunshades, kitchen sills in conventional building construction.

The structural system could be in the form of insitu frame work or load bearing walls.

Full Prefabrication Open system:

In this system, almost all the structural components are prefabricated. The filler walls may be of bricks or of any other local materials.

Wall system:

Structural scheme with precast large panel can be classified as

→ cross wall system
→ Longitudinal wall system.

Cross wall system:-

In this system the cross walls are load bearing walls.

The facade walls are non-load bearing walls. This system is suitable for high rise buildings.

Longitudinal wall System:-

In this system, cross walls are non bearing walls, longitudinal wall are load bearing walls. This system is suitable for loco rise buildings.

Factory Prefabrication:

→ Done in a centrally located plant to manufacture of standardized components

→ Capital intensive work done throughout year preferably under a closed shed to and effects of seasional Variation.

→ High level of Mechanization
→ Curing
→ Moulds
→ concreting, Vibration.

Disadvantages:-

→ Extra Cost - transportation from Plant to site

→ Shape and site size and is limited due to lack of transport arrangement.

Site Fabrication:

→ Manufactured at site or near the site

→ Normally in Open space with local labours

→ Equipments, machines and moulds mobile in nature.

→ Reduction of Transport cost

Disadvantages:

→ Not Suitable for high degree of Mechanization.

→ Continuity of work is not available.

Process involved in Manufacture of Prefabricated Structure

The various processes involved in the manufacture of precast elements may be classified as

Main Process:

→ Providing and assembling the moulds, placing reinforcement cage in position for reinforced concrete work, and stressing the wires in the case of prestressed elements.

→ Fixing the wires and tubes, where necessary.

→ Pouring the concrete
→ Vibrating the concrete into the moulds
⇒ Demoulding the forms and stacking the precast products
→ Curing (Steam curing if necessary)

Auxiliary Process:

Process necessary for the successful complement of the processes covered by the main process.

→ Mixing and manufacture of fresh concrete (done in a mixing station or by a batching plants).

→ Prefabrication of reinforcement cage. (done in a steel yard or workshop)
→ Manufacture of inserts and other finishing items to be incorporated in the main precast products.
→ Finishing the precast products &
→ Testing of products.

Transportation:

⇒ It must be carried out with extreme care to avoid any jerk and distress in elements and handled / Transported as far as possible in the same orientation as it is to be placed in final position.

⇒ It should be properly planned and conformity with traffic rules and regulation as authorities.

⇒ The size of the element decide mode of/ size of transport vechicle.

⇒ Avoid excessive cantilever projection while transport.

⇒ Special cases in sharp bend curves/ uneven roads which leads undesirable stresses

⇒ Before loading, proper base packing materials, proper location, packing must be kept strictly one over the other.

Delievery:

⇒ Delivery of Precast elements should

planned according to the general erection sequence to minimize unnecessary site storage and handling.

⇒ precast elements should be loaded and delivered with proper supports, frames, cushioning and tie-downs to prevent damage during transports.

Handling:

⇒ Lifting and handling position shall be clearly defined particularly where these sections are critical.

⇒ It mainly involves the removal of the precast elements from the mould, transportation to the storage yard, and unloading operation and erection of these element at the job site.

⇒ We have to handle the elements according to their size and shape to avoid excessive stresses during handling.

⇒ Conveying equipment, such as belt conveyors, chain conveyors, screw conveyors bucket elevator, hoists etc.

⇒ Concrete mixers – Mixing machines

⇒ Concrete vibrators – Vibrating machines.

⇒ Erection equipment, such as cranes, derricks, hoists, chain pully blocks etc.

⇒ Transport machinery, such as tractor-cum-trailers, dumpers, lorries locomotive, motor boats and rarely even helicopters.

⇒ Bar straightening, bending and welding machines to make reinforcement cages.

In addition to the above, pumps and soil compacting machinery are required at the building site for the execution of civil engineering projects involving prefabricated components.

Types of Cranes:

For erection of prefabricated buildings the following cranes are used

Stationary Cranes:

- → Guyed derrick
- → Climbing crane
- → Tower crane with fixed base

Cranes on rails

- → Portal Cranes
- → Tower Cranes

Mobile Crane moving on ground

- → Truck mounted
- → Crawler mounted.

Stationary Cranes.

Guyed derrick:

These are used on framed buildings for erection of floor panels, columns and slab strips.

The derricks being lighter in weight can be shifted from floor to floor operating from an erected floor.

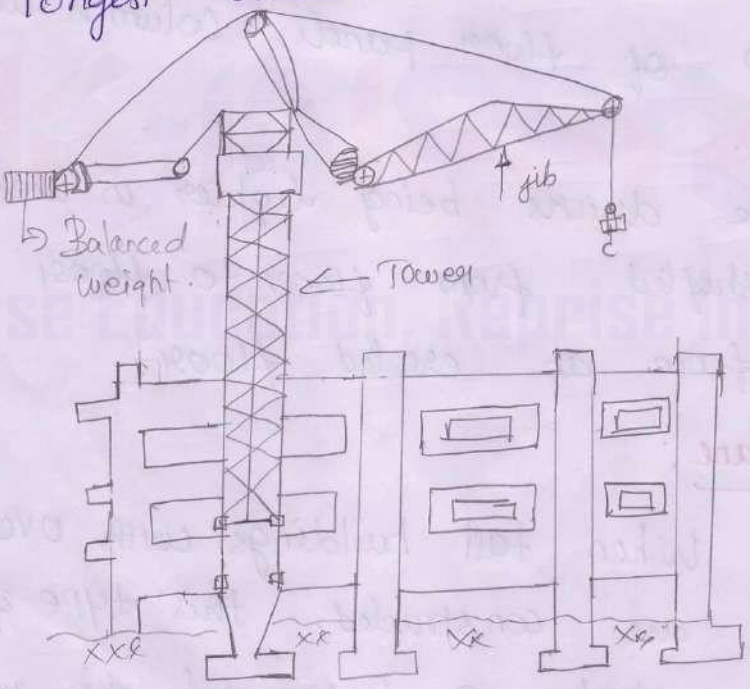
climbing Crane:

When tall buildings with over 20 storeys are constructed, this type of Cranes are used. A horizontal jib and

balancing counter weight is placed on the top of the shaft.

→ This shaft itself is stationary and crane operates 360° around the pivot on the shaft the crane can be lifted up to a new position as the building goes up on completion of the building Creation the crane is dismantled and taken out through the sides.

Such cranes will have to be Used when construction is carried out in longest areas.

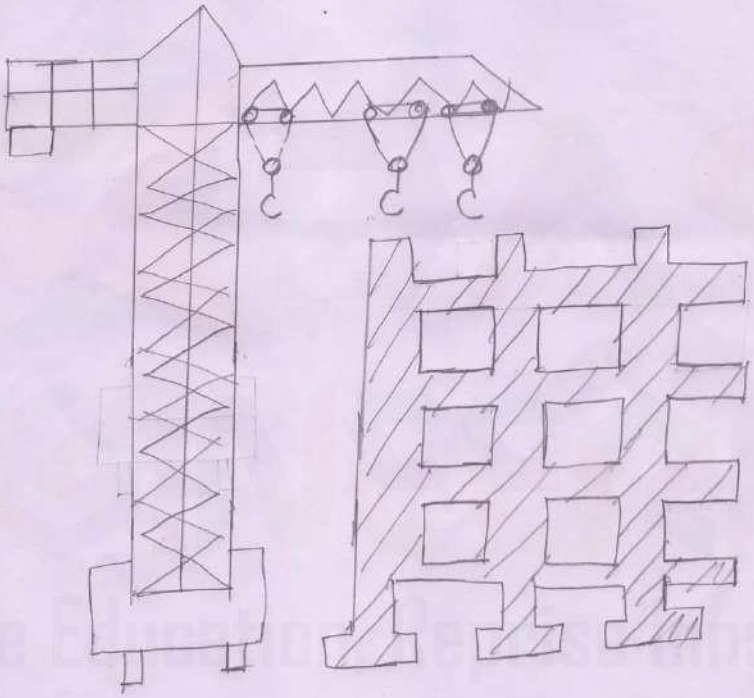


Climbing Crane.

Tower Cranes :-

The most versatile equipment used in prepabrication is a tower moving on rails.

The serious draw back with such a Crane is that they require heavy Crane tracks, lengthly & expensive assembly and dismantling.



Tower Crane.

Tower Cranes have a tower carriage on rails although long straight rails tracks are use, curves in tracks of radius of 5m, can also be built for slow movement aroun

The reach of the crane is by a horizontal fabrication often provided with a crab which moves on the horizontal fabrication.

Standardization:

For speedy construction we have to use repetitive use of building elements

Thus standardization of prefabrication elements become essential.

→ Standardization will facilitate quicker construction of similar elements, avoid duplication of effort.

→ To adopt prefabrication in actual practice, it is necessary that the main parameters of the whole building are standardized.

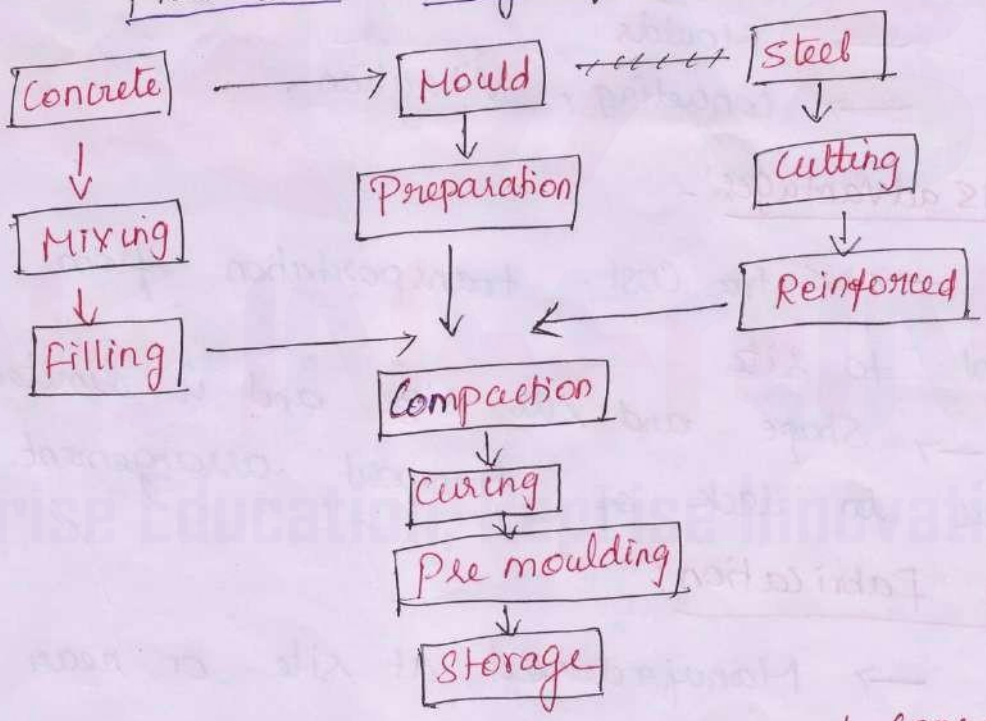
→ For each standard element, a limited no of types and sizes are established with a definite gradation in geometrical dimensions and reinforcement ratio.

→ columns constant dimension change in reinforced or if needed change in grade of concrete.

Production:

The term production of systems is describes a series of operation directly concerned in the process of making or more apply of moulding precast units on the face of it there are very many techniques since almost every type prefabsicates a specific series of operation in its production.

Flow chart : Stages of work in Precasting



Methods for Manufacture of precast Concrete Elements

1. Factory prefabrication
2. Site prefabrication.

Erection:

⇒ Sequence of erection - Checking of Precast elements availability

⇒ Precast elements positions.

⇒ Cleaning of elements and site for erection.

⇒ cleaning inserts before incorporation in the joints and grouting the joints

⇒ Crane capacity

⇒ crane boom length for handling

⇒ Crane rotation radius.

Equiments Required for Erection

There are various types of tools and machineries that are employed in the erection of precast elements.

The equipments used in the Precast Concrete industry can be classified into following categories

→ Machinery required for quarrying of coarse and fine aggregates.

UNIT-II
PREFABRICATED COMPONENTS

Behaviour of structural components - Large panel constructions - Construction of roof and floor slabs - Wall panels - columns - Shear walls.

Behaviour of structural components:

The following are the main components which are frequently used in our building Construction.

- ⇒ Roof / slab
- ⇒ slab
- ⇒ joist
- ⇒ Beams
- ⇒ Wall panels
- ⇒ columns.

Roofing / Flooring:-

The roofing / system consists of R.C planks and joists. The planks are casted to a standard size and they are connected with R.C.C. joist which are provided at a regular interval.

The loads from planks are transmitted to R.C.C joists and than to main beams.

The main beams are provided with channel sections 10 cm projections on the necessary sides with the spacing of joist The joist are seated in the channels and bolted together. the foundation unit is the only unit, which is going to cast in site.

Slabs:

The Roofing slab / flooring slab system consists of planks which is supported over R.C.C joist. The planks can be made in any one of the following form with or without prestressing.

- → Hollow core sections
- → Double tee sections
- → Channel sections
- → Light weight concrete roofing slab.
- → Solid Rectangular planks.

The usual width of these type of slabs are 0.5m & spanning to the requirement upto a maximum limit of 5m without prestressing. The thickness of planks are casted in two steps with different mould to access monolithic action.

Joist:

The joists are designed as a small beams loaded from planks. These joists transmit the loads to the main beam through the channels provided in the main beams.

In this joist, a triangular shaped stirrup are provided to get the proper bonding connection with the plank.

The joist are casted partially in the factory. In this projecting a connecting rod will be inserted and additional bars from planks also inserted.

Beams:

All the main and secondary beams

are the same size of 300mm x 30mm. Varies reinforcements are provided at various conditions according to the moments.

The beams are casted for the clear distance between the columns.

A square of 10cm x 10cm hole for a depth of 10cm are provided on either side to achieve the connection with other beam reinforcement or column reinforcement by proper welding.

At the junction of columns and beams it is necessary to put site Concreting. For this purpose the top ends of the beams are tapered properly so that it will give access to site concrete and for needle vibrators to get proper compaction.

Wall Panels:

The wall panels are casted with all fixings like door, Ventilator, Window frames. These wall panels are

non load bearing wall

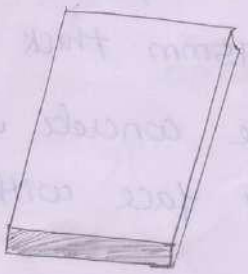
This wall is a sandwich type. That is cellular concrete blocks of 75mm thick is sandwiched by R.C.C. M25 grade concrete to a thickness of 37.5 mm on either face with minimum reinforcement.

The infillings may be any light weight, low cost material like brick bats, bricks, light weight concrete, aerated concrete etc.

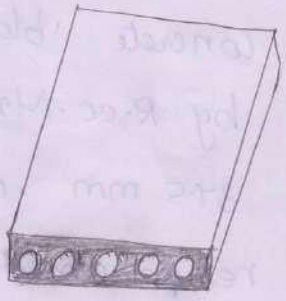
Columns:

Many types of columns available in prefabricated system. Grooves are provided on the required faces to keep the walls in position.

This grooves will acts as a part of columns, and since the area of column has been increased due to ~~this~~ fibs, will give addition moment carrying as well as load carrying capacity of columns.

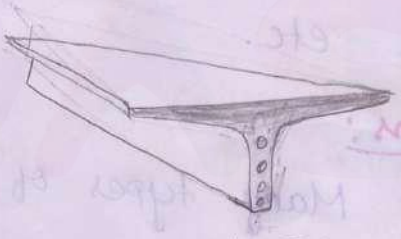


Solid Rectangular Planks



Hollow core slab

Double Tee section



Single Tee

Construction of roof and Floor, slabs, wall panels.

Precast components are 95% recyclable, low energy efficient, reduces waste during operations, reduces construction cost, levels of carbon dioxide generation is eco friendly.

Easy to install, reduces construction time, stronger than cast in situ structures can be prestressed or post stress to increa its performance.

Performance of the components:-

Appearance:

In Prefabricated construction, there is better quality control shape and size of Precast element.

The concrete panels with have a light gray concrete colour and have a smooth even finish due to high quality mechanized mass production units.

Structural capability:

Precast slabs and beams

can be designed to carry live & dead loads as per requirements with safety factor incorporated.

Additional reinforcement would be placed while filling up joints., In slabs provided with interlocking system to avoid inddependent displacement of slabs must be manufactured with M40 grad concrete in give durable and stronger slab than cast in situ slabs.

Thermal Properties:

As the precast units have thinner cross sections, components used in roofs or walls should be provided with adequate thermally insulating coverings for better thermal performance.

Sustainability (Environmental impacts).

There is disciplined use of scarce material like cement, steel and timber during the production and use installation of these precast panels.

Floors & Roofs

Structural floors/roofs account for substantial cost of a building in normal situation. Therefore any savings achieved in floor/roof considerably reduce the cost of building.

Use of standardized and optimized roofing components where shuttering is avoided prove to be economical, fast and better in quality.

Some of the prefabricated roofing/floor components found suitable in many low-cost housing projects are.

- ⇒ Precast RC planks
- ⇒ Prefabricated Brick Panels
- ⇒ Precast RB curved panels.
- ⇒ Precast RC channel Roofing
- ⇒ Precast Hollow Slabs
- ⇒ L Panel Roofing
- ⇒ Precast concrete Panels.
- ⇒ Trapezon Panel Roofing

Precast RC panel Roofing system:-

This system consists of precast RC planks supported over partially precast joist. RC planks are made with thickness partly varying between 3cm & 6cm.

When the plank is put in between the joists, the space above 3cm thickness is filled with insitu Concrete to get tee beam effect of the joists.

The planks are made in module width of 30cm with maximum length of 150cm

Precast

Precast joist is rectangular in shape, 15cm wide and the precast portion is 15cm deep.

Prefabricated brick Panel roofing system:-

The prefabricated brick panel roofing system consists of

→ prefab brick panel is made of first class bricks reinforced with 2 MS bars of 6mm dia and joints filled

either 1:3 cement sand mortar or M-15 Concrete.

The gap between the two panels is about 2cms and can be increased to 5cms depending upon the need. A panel of 90cm length requires 16 bricks and a panel of 120cm requires 19 bricks.

Precast curved brick arch panel roofing.

This roofing is same as RB panel roofing exept that the panels do not have any reinforcement.

Precast RC channel roofing:-

Precast Channel are trough shaped with the outer sides corrugated and grooved at the ends to provide Shear Key action and to transfer moments between adjacent units.

Width of unit = 300mm to 600mm

Over all depth = 130 to 200mm.

Precast hollow slabs roofing:-

Precast hollow slabs are panels in which voides are created by earthen kulas. with out decreasing the stiffness or strength.

These hollow slabs are lighter than solid slabs and thus save the cost of concrete / steel and the cost of walling and foundations too due to less weight.

The width of a panel is 300m and depth may vary from 100 to 150mm. as per the span the length of the panel being adjusted to suit the span.

Wall Panels:

Structural scheme with precast large panel wall can be classified as

- → Cross wall system
- → Longitudinal wall system
- → Two - way system.

Cross wall System:

In this scheme, the cross wall are load bearing walls whereas the facade wall are non-loading bearing, this system is suitable for high rise building.

Longitudinal wall System:

In this case, Cross walls are non-load bearing whereas longitudinal walls are load bearing walls. This system is suitable for low rise building

Two-way System:

The walls are placed in both directions and are considered to resist both the gravity and lateral load.

Pre cast Systems:

The concept of precast construct includes those buildings, where the majority of structural components are standardized and produced in plants in a location away from the building

and then transported to the site for assembly.

These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost.

The main features of this construction process are as follows

⇒ The division and specialization of the human work force.

⇒ The use of tools, machinery and other equipment, usually automated.

Large Panel Systems:

The designation large panel system refers to multistory structures composed of large wall and floor concrete panels connected in the vertical and horizontal directions so that the wall panels enclose appropriate spaces for

the rooms within a building. These panels form a box-like structure.

Frame Systems:

Precast frames can be constructed using either linear elements or spatial beam column sub assemblages. Precast beam column sub-assemblages have the advantage that the connecting faces between the sub-assemblages can be placed away from the critical frame regions.

Slab-column systems with shear walls

These systems rely on shear walls to sustain lateral load effects, whereas the slab-column structure resists mainly gravity loads.

- Lift slab system with walls
- Prestressed Slab Column system.

Large Panel Structures

All the main parts of a building, including exterior and interior walls, floor slabs, roofs and staircases

may be made up from large panel structures.

Large panel structures are used in two main design schemes,

Frame panel

Frameless panel

. In frame-panel buildings, all the base loads are borne by the building's frame, and the panels are usually used to fill the frame and as enclosure elements.

Large Panel Structure for Exterior Wall :-

Large panel structures for exterior walls consists of panels one or two stories in height and one or two rooms in width. The panels may be without openings or with openings.

In terms of design, the wall panels may be single (solid) layer and multi layer (sandwich).

Solid panels are manufactured from materials that have insulating properties and at the same time can perform supporting functions for example, light-weight concrete, cellular concrete and hollow ceramic stone.

Wall panels are produced in completely finished form, with ready to paint surfaces and with windows and doors.

The piping for heating and other systems and for wiring may also be installed in the panels.

After assembly, the joints between panels are filled with mortar or with light weigh or oridinary concrete and then sealed with elastic packing and special mastics.

Large Panel Structures for Interior walls.

The large panel structures of interior walls may be non-load bearing or load bearing.

In the ~~first~~ case of load-bearing structures, The wall panels, with combine enclosing and load-bearing functions, are made from heavy or light weight, silicate or cellular concrete, or ceramic work.

Large panel structure for floor slab:-

The large panel structures of floor slabs are usually made from reinforced concrete.

The area of the floor slabs in apartmen buildings usually equals the area of one room and may be as great as 30 sq.m

The large panel floor slabs of housing public, and administrative building are of both the solid and sandwich types.

Composite floor panels, consisting of a load bearing reinforced concrete panel combined with a floor or ceiling panel and sound proofing, insulating are often used in housing construction.

Shear Wall:

Definition:

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter of the effects of lateral load acting on a structure

⇒ In residential construction shear walls are straight external walls that typically forma box which provides all lalical support to the building.

Importance of Shear wall:

⇒ When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces, in building construction, a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors and roofs at the ground foundation in a direction parallel to their planes.

⇒ Lateral forces caused by wind, earthquake and uneven settlement load in addition to the weight of the structure and occupants create powerful twisting forces.

⇒ These forces can literally tear a building apart reinforcing a frame by attaching or placing a rigid wall inside it maintains the frame.

⇒ Shear walls are especially important in high rise buildings subjected lateral wind and seismic forces.

Purpose of constructing shear walls:

⇒ Shear walls are not only designed to resist gravity / vertical loads, but they are also designed for lateral loads of earthquakes / wind.

⇒ Walls have to resist the uplift forces caused by the pull of the wind.

UNIT - III

DESIGN PRINCIPLES

Disuniting of structures - Design of cross section based on efficiency of material used - Problems in design because of joint flexibility - Allowance for joint deformation

Disuniting of structures :-

The solution of problems connected with the transportation and placing of structures demands, as a rule their disuniting into smaller members.

One bay frames, not exceeding 40 tons in weight, may represent an exception, because the problem of their hoisting and placing can be solved with the aid of modern available housing machine and equipment.

In general, there is a trend towards the use of larger members.

That is justified by more than one reason

In addition, the hoisting of one larger member is as a rule less expensive than that of two smaller members having the same combined weight.

The dissolving into larger members means lower costs of hoisting and placing, as well as savings in jointing costs.

This is due to the smaller number of joints, eg. if 30 frames with a weight of 40 tons each are to be assembled, then the costs.

Advances in construction technology also lead to the use of larger members. For example in the Soviet Union the spacing between the main girders

one-storeyed industrial structures increased from 6 to 12-18m while in general, the spans increased up to 24-36m in certain cases given to 60-100m.

Systems of disuniting

→ Systems consisting of linear members. disunite at joints.

→ System for the prefabrication of entire rigid frames.

→ systems consisting of L, T and U shaped or straight members disunited at points of minimum moments.

Design of cross section of load-carrying structures

The cross-sections of precast reinforced concrete structures can be T-I-U and V shaped. They may be solid and their profile can be hollow or divided.

Beams of Rectangular T, I, U, V shaped and Hollow cross sections

No doubt, the most simple cross section of precast structure is the rectangular.

Now a days this is only used for lighter members to be produced in smaller numbers.

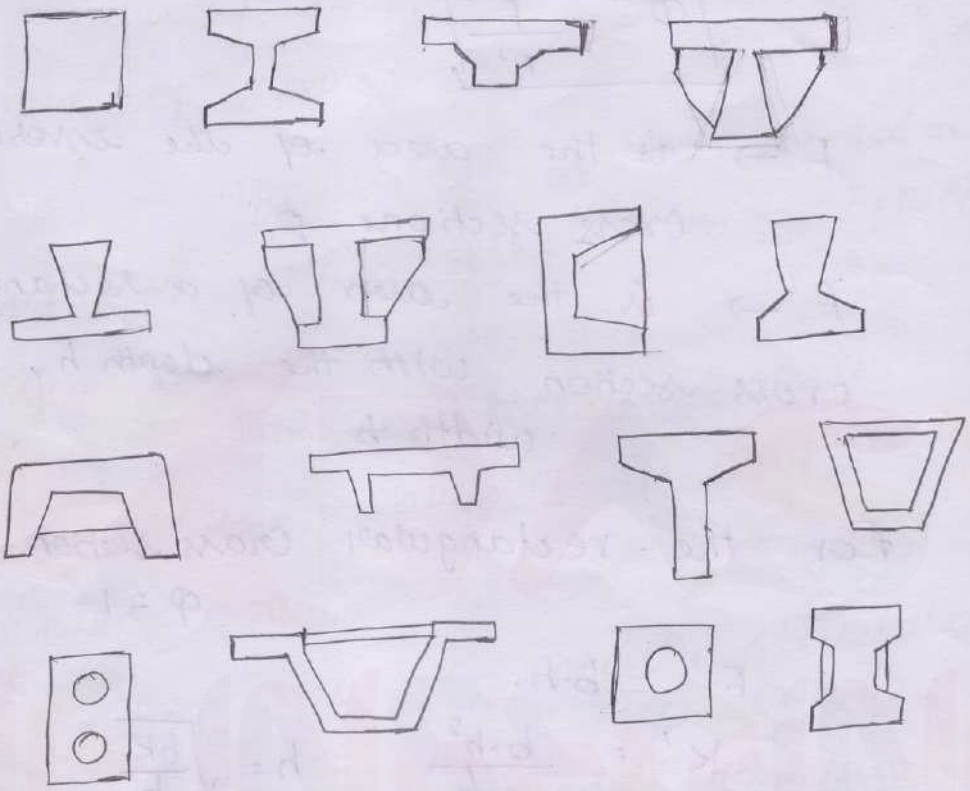
I - T - U and V shaped as well as hollow cross sections are frequently used in prefabrication.

Compared with equivalent rectangular cross sections their use means 30-50 percent saving in concrete and 5-10 percent in steel.

These cross sections are, from the view point of internal space effect also, more appropriate than the rectangular one.

Cross sections to used for precast ⑤ structures

a) beams b) columns.



One of the great advantages of precast reinforced concrete structures over monolithic ones lies in the possibility of forming cross-sections which, from the view point of the theory of strength of materials.

The economy of cross sections is usually measured by the form factor φ the value of which is

$$\varphi = \frac{F}{F'}$$

$F \rightarrow$ is the area of the investigal cross sections

$F' \rightarrow$ is the area of a rectangula cross section with the depth h, width b

For the rectangular cross section

$$\varphi = 1$$

$$F' = b \cdot h.$$

$$k' = \frac{b \cdot h^2}{6} \qquad h = \sqrt{\frac{6k}{b}}$$

$$\varphi = \frac{f}{\sqrt{6kb.}}$$

$k \rightarrow$ modulus of resistance

for I, T, U & V shaped etc. cross sections $\varphi < 1$, The smaller φ is more economical is the cross section.

For reinforced concrete structures, ④ their cross-section being heterogeneous the relation is not so simple and the value ϕ supplies only an approximate measure of saving.

The value of the form factor valid for section steel with an I-profile is $\phi = 0.31 - 0.33$.

For prestressed concrete structures the value of ϕ may decrease to $0.45 - 0.50$

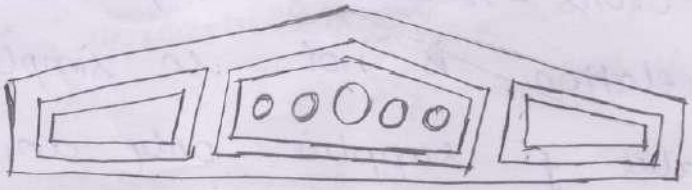
For pre cast concrete structures - $0.50 - 0.60$

Fret, Trusses and Vierendeel structures

There is generally no difference constructionally between fretted and solid beams.

The reason for different openings in the body of a fretted beam is merely to obtain savings in

materials and to lessen the dead load

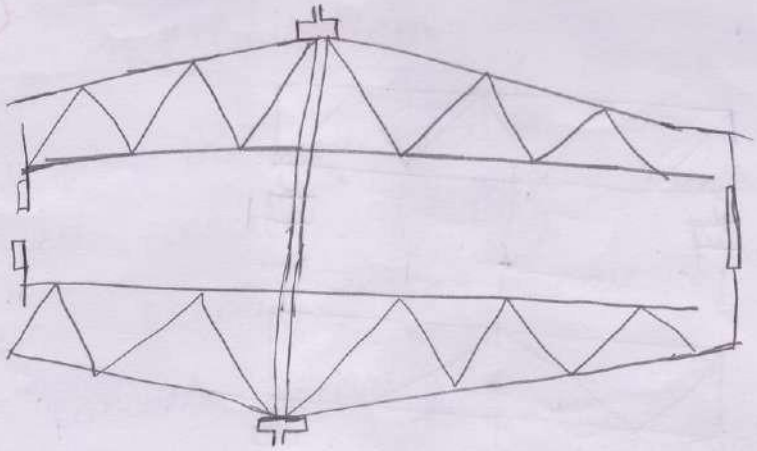


Fretted reinforced concrete girder.

The use of reinforced concrete structures having a divided cross section, as have Vierendeel columns and trusses, is becoming increasingly common.

Trusses and Vierendeel structures in addition to making the smallest demand in material, open up new possibilities for the aesthetic forming of the interior of buildings.

The manufacture of these structures in a horizontal position requires less material for their shuttering, their reinforcement and concreting is also fairly simple.



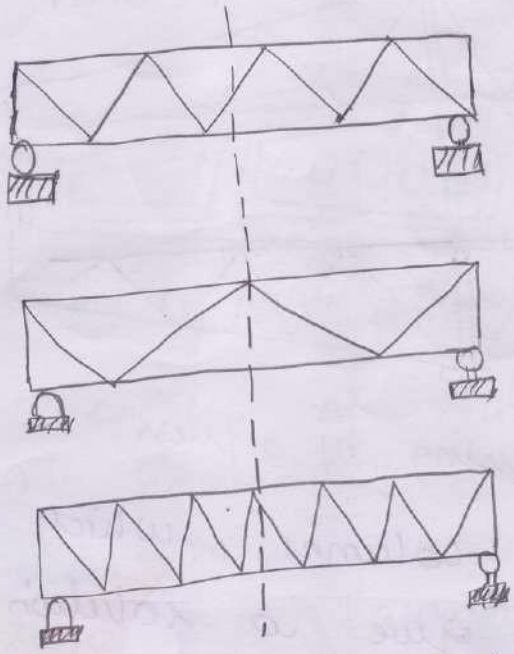
Stressing of a truss.

Vierendeel columns, which are also fretted give a solution which does not disturb the space effect.

An additional advantage of these types of columns is that tubes, pipes and other lines can easily be attached to and led through, the shafts.

Prestressing of the tensioned basal of a truss precast in the horizontal position can be accomplished more easily if the following method

is used.



Investigations by stresses for different kinds of trusses.

The spread of reinforced concrete trusses, trussed arches and virendeel columns has been impeded by their difficult monolitic execution, complicated reinforcement as well as by the difficult calculation of secondary stresses.

Various specifications:

(11)

Reinforced concrete The Hungarian code for Standard permits the case of the same concrete quality a 10-15% higher limit stress for precast structural produced by plant prefabrication than for monolithic ones.

Referring to the thickness of concrete of shell plates an unfavorable deviation from the designed thickness must be taken into consideration. The value of the latter as 1.0cm for in situ concrete and 0.5 cm for precast shells.

For reinforced concrete structure manufactured in permanent plants a deviation reduced by 50 percent may be taken into consideration.

In the calculation of the linear stress, must be assumed. The value of this deviation is 1.0 cm for monolithic structures.

For the cross sections of cantilevers situated at the support double the deviation ie, 2.0 cm must be considered.

Dimensioning of joints:

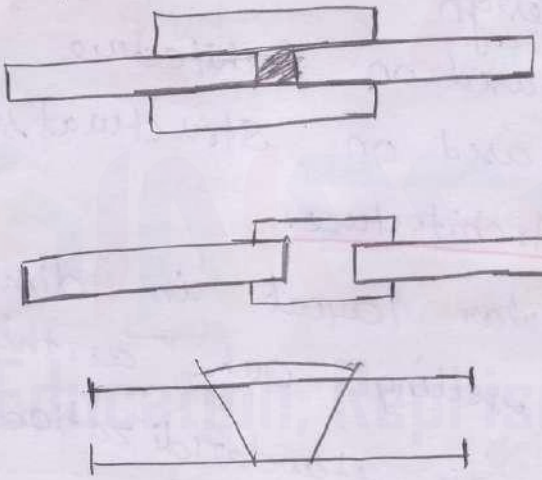
The lengthening of steel bars and the in-situ concrete for joints cannot always be of the same quality as in precast structures.

Therefore, some codes of Reinforced concrete (among others the Hungarian code of 1949), specify the lessening of permissible and limit stresses in cross-sections, where precast members are to be joined by in situ work.

The lengthening of tensioned steel bars should be avoided, but if such a lengthening should be inevitable, then at places where the lengthening itself is to be carried out.

The most suitable welded lengthening is an arc-welded joint consisting of four welds and two laps.

a)



Lengthening of steel bars by welding using tape.

The cube strength of cement mortar used for the casting of gaps

should be atleast 120 kp/cm². For ensu adequate sound insulation between joints to be found in a floor must be filled with cement mortar.

If through the joint compressive forces should be transmitted, the width of the joint at its top must be atleast 3 cm.

Problems in designs because of joints

General design
→ Based on Architecture
→ Based on structural system.

Based on Architecture.

→ Modular layout in dimensions and gridline setting out as this will enable easy standardization in Precast design.

→ Suitable size of panels position of joints and edge details.

→ Standardization of sections minimizing panel types and major design variation as far as practicable.

Based on structural system:

→ Overall structure framing design and stability at various stages of construction

→ Selection of structural elements to be precast.

→ Types of connection design to ensure structual adequacy and practically in site execution.

⇒ Connection design to allow for Panel tolerenance, adequate space with in joints to avoid rebar clashing/ congestion

Major considerations in design of Precast concrete systems:

→ Load assessments and load paths

→ Establishment suitable structural form or system.

→ Precast component selection and panelization with standardization.

Joints and connections:

In precast connection design apart from strength requirement other considerations such as ease of manufacturing, erection and tolerance for works efficiency.

In theory all joint connections can be designed with structural adequacy for its performance needs with precast elements manufactured as per design.

All joint design shall also cater for water tightness, durability, fire and aesthetic considerations.

Types of precast joint:

(11)

→ compressive joint
→ Tensile joint
→ shear joint.
→ Flexural and torsion joint.

compressive joint.

Using direct bearing or intermedi
medium such as mortar.

Tensile joint

Use of steel splice connectors, welding of cast in steel plates, lapping grouting or starter / site laid rebars et

Flexural and torsional joint

Moment joint connection can be achieved with sleeve coupling using splice, bolting, welding, composite joint casting with rebars etc.

Design of expansion joints:-

Notations

θ → skew angle

$\alpha \rightarrow$ Co-efficient of thermal expansion

0.0000060 /°F for Concrete

0.0000065 /°F for steel.

$\beta \rightarrow$ Shrinkage co-efficient for reinforced concrete 0.0003

$M \rightarrow$ factor accounting for the restraining effect imposed by superstructu

0.8 for cast in place.

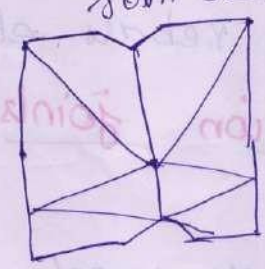
0.5 for prestressed girders.

0.0 FOR steel girders bridges.

$L \rightarrow$ Length of structure contributing to expansion or contraction of the joint.

M_s = Movement due to shrinkage after.

M_p = movement parallel to joint.



Uncompressed width.

Allowance and joining of prefabricated (19) Members

Precast reinforced structures are of many types, because almost all reinforced concreted structures used in both architectural and civil engineering constructio can be pre fabricated.

→ Load carrying structural member
→ Space bordering members
→ Surface forming structural members.

Load carrying structures can be classified in various ways. From the view point of prefabrication load carryi structures can be divided into main groups according to their dis uniting into members.

Load carrying structures:

The most convenient method of classifying structures from the

View point of prefabrication is, as has already been stated, to distinguish them by the manner in which they are divided into members.

On the other hand, there is a great difference in respect to prefabrication in the case of frame structures having identical dimensions.

Unit –IV
JOINT IN STRUCTURAL MEMBERS

Expansion Joints

An expansion joint is an assembly designed to safely absorb the heat-induced expansion and contraction of various construction materials. To absorb vibration, or to allow movement due to ground settlement or earthquakes. They are commonly found between sections of sidewalks, bridges, railway tracks, pipeing systems, and other structures.

Expansion joint design:

A design specification shall be prepared for each expansion joint application. Prior to writing the expansion joint design specification it is imperative that the system designer completely review the structural system layout, and other items which may affect the performance of the expansion joint. Particular attention shall be given to the following items.

The system should be reviewed to determine the location and type of expansion joint nwhich is most suitable for the application. Both the EJMA Standards and most reliable expansion joint manufacturers'' catalogs provide numerous examples to assist the user in this effort. The availability of supporting structures for anchoring and guiding of the system, and the direction and magnitude of thermal movements to be absorbed must be considered when selecting the type and location of the expansion joint. Conventional rubber expansion joint Expansion joints are designed to provide stress relief in piping systems that are loaded by thermal movements and mechanical vibration. To deal with the various forces on the joint they require fibre reinforcement which guarantees both flexibility and strength. Conventional expansion joints are reinforced using prefabricated fibre plies. The use of these fabric plies makes it impossible to control the orientation of the fibres on complex shapes such as the bellow of an expansion joint. In both cases the inability to use the fibres in an optimal way leads to the following disadvantages:

High Material Cost:

- More fibres needed than necessary
- More rubber needed than necessary
- Additional parts such as metal reinforcement rings necessary with multiple bellows

Lower Performance

- High rubber wall thickness and fibre pack make product less flexible
- Undesired radial and axial expansion under pressure.

1) Introduction 2) Necessity 3) Advantages 4) Pre requisites 5) Types of prefabrications

Pre-fabrication means that the structure is disunited in its disunited in its members and
these are precast in factor built and equipped particularly this purpose or in temporary
plants establish on the site. Then the precast reinforced core members are shipped to the
place where they used. Here they are hoisted set into their fix places and assembled in the
form of a complete structure. The stages involved are
1) The structure is divided into no of units.
2) The different units are precast in permanent plants.
Permanent prefabrications - plant prefabrication.
Temporary plants (sheds) - Site prefabrication
3) Transported to the site
4) Hoisted and put into their places
Prefabrications eliminates the use of scaffle.
Necessity:
Million houses in rural areas.
20 million houses in urban areas speedier construction.
Conventional methods - time consuming
- The components are not a man power is not effectively.

Factors:
1) Cellular concrete plant at Madras
2) Hindustan Housing Factory at New
3) SIPOREX, India Limited at Poona
4) Key Jay Spirole private limited.
In New Delhi they are manufacturing -sleepers & poles.

Object or AIM:
1) To accelerate the building construction.
2) To increase the building activity.
3) To effectively utilize the man power.
Pre-Requisite:
1) Large demand of flats in a limited area
2) Availability of adequate funds & buildings materials
3) Prospective planning of building activities and long time orders.
4) Standardization allowing mass production
5) Adequate mechanization of production process.

Advantages of pre-fabrication over the monolithic methods of construction:-

1. Partial or total saving of material used for scaffolds.
2. Multiple use of structuring
3. Possibility of far more accurate and better work transits.
4. Cross sections more advantages from the new point of stream
5. Working time can be shortened.
6. Fewer expansion joints are required.
7. Interruptions in concreting can be omitted.
8. The work can be carried out with a high degree of mechanization.
9. Requirements in man power decrease.
10. Helps to avoid the seasonal character of the buildings industry.
11. Re use of the members. In pre fabrication scaffolding materials are needed as a temporary support.

The single set of moulds can be used from 10 to times in case of small members. Only the lateral boards are made of timber and the other parts being usually of R.C. In case of plant prefabrication the moulds are made of steel. If they are made of timber. They are covered with steel steels. The same structuring can be used for casting both small and large members.

Since the members are produced in easily accessible places on the ground better. Workmanship can be obtained the moulding assembly of the reinforcement and the concreting can be performed more precisely due to better workmanship and higher strength can be obtained. Since the permissible and limit stresses can be higher, cross sections can be decreased resulting in the decreases in dead load. The reduced deed load means less concrete and a decrease surface of structuring resulting in the reduction of prime and the use of cross sections which are structurally advantages namely an I profile or tresses does not cause particular difficulties in prefabrication. The application of such a cross section or a tress instead of a girder would be much more difficult in the case of monolithic structure. Even unreasonable because of the complicated shultering, reinforcement and concreting. In the monolithic construction the separate builds spaces can be performed only in sequence namely the foundation. There the concrete, reinforcements, then the concreting of the structure. In the ease of prefabrication these constructional process namely the generally started, beginning of the foundation work. The estimation that about 80% of the time is required for prefabrication and 20% for site works. The greater part of shrinkage of precast concrete members occurs before their placings because of numerous joints the effect of temperature changes is also far less important and hence the spacing of expansion joints can be increased. In monolithic structures it is the duty of the foreman to select palces where

concreting can be interrupted. A matter not usually fore seen by the designers who does not deal with the problem on the other hand for pre-fabricated structures junctions must be carried out according to plans of later place specified and considered by the engineer. In the fabrication since the work is carry out on mass scale we cane go in for mechanization instead of manual labour and thereby the quality is considerably improved. In the case of prefabrication the application of industrial methods makes possible the employee me of hands adequately trained within a few weeks. The work is carried out throughout the year it is always easier to give labourers for works to be done in a permanent

Plant prefabrication is absolutely independent the vagaries of the weather. In the case of site prefab the production of smaller members namely roofing members, wall panels, windows, purlins etc can be made in a covered place. In the case of large members the same is not possible but they can produced at an earlier date during favourable weather conditions. In the case of monolithic construction it is difficult to carryout the work during rainy seasons. The dismantling of building constructed of precast members and the use of certain of these at other places is possible in the case of pre-fabrication such a thing is highly impossible with monolithic structures.

Production techniques in pre-fabrication
In Concreting : 1. Moulding the concrete to the require shape.
2. Hardening of concrete.
In prefabrication : 1. Refined methods of moulding
2. Accelerate the rate of hardening objectives in the manufacture of

pre-fab compoenets are
1. Least amount of labour.
2. Specailist possible production.
3. Imporved quality

Types of Structue
1. Fame less - large paneled
structures - External and Internal
wall panels - Floor and roof panels (of room single)
2. Framed buildings : Columns, beams & floor elements.
Stages of work in pre-casting
Concrete Mould Steel
Mixing Preparation Cutting
Filling Reinforcing

On -SITE : Open yard casting or covered but purely temporary or semi-permanent type of set-up with partly mechanized facilities.

Factors Influencing method of manufacture

The single and the total no of elements to be produced
1. The single of the element may decide the reinforcement of space for production as well as the capacity of the handling equipment is decided by the heorist element.
2. Desired rate of output: This will have direct bearing on the nf of moulds required degree of mechanization and need for accelerated method of curving.
3. Shape, type and construction features of these elements
Features such as special shares, projected reinforcement, required finish on the surface on single layer or multi layer largely influence the design of the mould and technical castings.
Horizontal casting techniques are favoured for curved elements, multi larged elements and element which require some particular finish vertical casting is favoured for single layer solid panel which require no special finish on their surfaces.
4. Facilities available in the production set u : An accelerated curing facility will result in quick turn over of mould which can be advantageously used.

Machineries like over
head gantry crane, will aid speedly production in handling.
5. Economic aspects : The cost of production should be minimum.
Both moulding and demoulding in horizontal position -External panel wall ; floor panes withprotruded reinforcements, beams, columns, etc.
-Extra reinforcements to take ease of bending stresses.

Tilting Moulds :
Demoulding is carried out in almost vertical position. No extra reinforcement is necessary.
One end is hinged and the other end is lifted with the aid of a fack or lifting equipment. Slip forming & Extrusion:
This method is achieved with a moving machine mould which forms the cross sectional shape of the element and the element hardening at the point where it is moulded. Precast pre stressed floor elements both solid & hollw are manufactured using this
techniques. Concrete laying - slips (Concrete buckets of various capacities)
Spreading - either manually or with a mechanical spreads.
Vibrating - with the help of shutter vibrates.
Screening - long & heavy wooden floats surface finishing - Travelling.

Mould for a pair of wall panels:

Vertical Moulding:-

Best suited for panels that require a smooth surface on both sides.

Advantages :

1. A large no of units can be produced in a small space.
2. Concreting the units proceeds fast.
3. No need to spread the concrete
4. Surface finishing not necessary due to smooth mould faces.
5. Heat of hydration developed is conserned and accelerates curing.

Single Moulds:

These are employed for casting volumetric elements such as sanitary units, ventilates shafts and refuse chuter. Battery moulds are employee for internal panel walls and floor panels. The swing down moulds are used for simultaneous manufacture of two wall panels.

Flow Line Production :

This is a travelling horizontal mould system in which the moulds are moved and the element from one position to the rest a series of stations, such as demoulding, mould cleaning and oiling, placing of reinforcements concreting vibration, surface finishing and curiving a stream chamber forms the part of the continuous travelling a chain and the chain can be in the horizontal plane or in the vertical plane.

Schematic diagram of flow line production:-

Moulds:-

1. They should have volumetric stability to ensure dimensional accuracy.
2. They can be reused a large no of times with minimum maintenance cost.
3. They should be easy to handle and close tightly so that no liquid can lead out.
4. They should not have adhesion to concrete and easy to clean.
5. They can be sued for various cross sections shapes of the components.

Wooden moulds:

1. Concrete sticks more easily. to prevent this, a coating of mould oil or wood lequer is
given.
2. It can be used 30 to 40 times. The dimensions should be checked frequently.
3. They are used fro smaller production programmes.

Steel Moulds :

1. Because of the smooth surface demoulding is fairless easy.
2. Indiscreminate harmmering by workmen should be avoided.

Concrete moulds:
1. These are used in vertical battery moulding.
2. The workability is low
3. These moulds enable hish degree of dimensional accuracy, but are un-suitable for

making modifications.
4. These moulds are stationary not often transported.
5. The surface of the mould must be absolutely smooth of otherwise excessive adherion may cause difficulties in demoulding.

Plastic Moulds:
1. Moulds made of glass fibre reinforce plastics are commonly used.
2. They have the advantage of freedom of shaping and low weight.
3. Demoulding is
4. They are easily transportable.
5. The same mould can be used 70 to 80 times without repair.

Manufacture Of Precast Elements:
1. Wall panels :-
Type of moulding depends upon the constructional features and the surface finish. In the case of internal panel wall-vertical battery wall. In the case of external panel wallhorizontal moulding is usually done.
2. Roof or Floor Elements:
Depends on the type of building we construct whether residential or public building with large span. In the case of residential building the entire roof or floor is cast as a single unit. In the case of public building where long spans are encountered. The elements are east in the form of hollow core floor slabs. Trough units and ribbed slabs which are normally of PSC.
3. Beams and Column :
Usually horizontal moulding is done. In the case of staircases vertical or horizontal moulding is done. In the case of sanitary units vertical moulding (as a single unit) is done.
1. Placing of concrete by strips slips
2. Spreading of concrete is done manually or mechanically.
3. Compaction by vibrators or by vacuum process or pressing.
In the case of vibration it is effected by means of internal vibrations and external vibrations. Internal vibrations in the form of immersion vibrators is used in places where we have conjusted reinforcements. External vibrators ae generally used with steel moulds. Vacuum process is suitable for components with large surface area or relatively thin

elements. In the case of compaction by pressing. The freshly poured concrete is subjected to a pressure of about 70 ksc. It sequences out excessive water forming a cohesive slab which can be immediately remoulded.
Accelerated curing techniques are adopted for quicker turnover. It may be in the form of steam curing or heat treatment. Hot water or hot air. The duration of stream curing cycle is influenced by the factors like type of cement, water cement ratio, size of the members, the desired strength. With proper steam curing it is possible to achieve 60% of the moist curned 28 days strength of the concrete in 24 hours. In open casting yard for steam using specially made hoods are used which are insulated and sealed to prevent excessive loss of heat and moisture. In the case of flow line product. The chamber is sufficiently long to ensure that the products remain wihin the chamber for the desired time.

Demoulding and storage:
The units are first demoulded from the sides and then from the bases and the earthwork required to separate the unit from the base is more than the weight of the unit to account the adhesion of the unit to the base. Wall element are stored vertically. Floor and roof elements are stacked horizontally with & wooden strips in between two elements. Surface Finishing Techniques:

a) Surface formed in the mould.
b) Mechanical treatement of surface.
a) Textured surfaces are obtained by lining the mould with suitably patterned rubber
linings, plastic steel or timber. Smooth surfaces are obtained by resin coated or plastic zined mould surfaces.
b) This can be applied by freshly cast concrete or by the hardened concrete. In the case of freshly cast concrete. It is done by hand travelling or by rolling with a smooth steel tube on the compact concrete or by tamping with the edge of long wooden floor. In the case of hardened concrete. It is done by point tooking or by grinding the surface when soft aggregate are used.

Production Tolerance:-
By production tolerance use mean the limiting value of admissible deviations in the
actual dimensions. The deviations may be caused.
1.
2. Loose fitting of joints.
3. Joints and mould sides under pressure of concrete.
The limiting values are
1. Length ± 10mm
2. Width ± 3mm
3. Thickness ± 3mm

4. Flatness - 1/300 of the length.
Planning of precast concrete works:-
Requirement of space and facilities.
Space for production :
It is based on height and no moulds horizontal moulds -larger areas - vertical battery moulds -least amount of floor space. Height of the casting shed is based on space required. To lift and move one precast corpponent over another. The head room can be sufficiently decreased by having moulds in pits. Extra space must be provides for making the reinforcements stages cleaning and up the demoulded units. Space for storage yard: This depends on the daily output and the demand. The space must be sufficient to store minimum of 3 weeks production. The storage yard may be preferably aligned with the casting shed to facilitate movement of overhead cranes. Space for facilities: This depends on the type & single of ancillary facilities required namely storage of raw materials such as cement, coarse aggregate & fire aggregate, reinforcement steel. Conc batching plaint, fitters and joiness shop, Boiler and compress house. Laborator & Office. Modular co-ordination, standardization and Tolerance Basic Dimensions : This is the dimension between the axis defined by the dimensional grid. The dimensional grid is the two dimensional co-ordinate system of reference line defining the layout of the building. Nominal or Theoretical

Dimensions :
It is the planned dimension of the prefabricate arrived from its basic dimension and its joints.

Actual Dimensions :
It is the dimension of the prefabricated when produced and its differs from the nominal dimension by the production discrepancies which are unavoidable.
The tolerance is the sum of acceptable positive and negative discrepancies of actual dimensions from the theoretical one. The limits of tolerance are based on the manufacturing and erection requirements.
Modular Co-ordination : If the inter dependent arrangements based on the Pre Fabrication and System
Building Definition
Pre-fabrication means that the structure is disunited in its members and these are precast either in factories built and equipped particularly for this purpose or in temporary plants established n the site. Then the precise reinforced concrete members are shifted to the place where they are to be used, here they are hoisted, set into their final places, and assembled to form a complete structure.

Stages involved in pre-fabrication
1. The structure divided into number of units.

2. The different units are precast in permanent factories (plant fabrication) or temporary
plants (site prefabrication).
3. Transported to the site.
4. Hoisted set into their final places and assembled to 1. Partial or total saving of material used for scaffoldings.
2. Mulitple use of shuttering
3. Possibility of far more accurate and better work manship.
4. Working time can be shortened.
5. Fewer expansion joints are required.
6. Interruptions is connection can be omitted.
7. The work can be carried out with a high degree of mechanization.
8. Requriements in man power decrease.
9. Re use of the members.

Design of expansion joint:

1. Basic Dimensions

This is the dimension between the axes defined by the dimensional grid. The dimensional grid is the two dimensional co-ordinate system of reference line defining the layout of the buildings

2. Nominal or theoretical dimensions

It is the planned dimension of the prefabricate arrived from it's basic dimension and it's joints.

3. Actual dimensions

It is the dimension of the prefabricate when produced

If the interdependent arrangement of the basic dimensions of the building based on the primary unit accepted components so that they apply to
any building that is laid out on the 10cm (4") modular basis without cutting or altering at the site.

5. Planning module (Mp)

It is a multiple of the basic module for specified applications. The planning module Mp = 3 cm is the common horizontal dimension or Mp= 1M is used for the vertical dimension, when Mp=60 cm for the length dimensions.

6. Modular grid

This is a particular case of the dimensional grid consisting of two dimensional coordinate system of reference lines (modular lines) at a distance equal to the basic module or the mult module (Mp). This multi module may be the same or different for each of the two dimensions of the reference system. The area between the modular lines is called the modular

1. Easier desing

Elimiation of unnecessary choices.

2.Easier manufacture

Limited number of variants.
3.Easier erection and completion Repeated use of sepcialised equipment.

4.6.Factors infuenceing standardization:-

1. The most rational type of member for each element is selected from the point of production from the assembly serviceability and economy.
2. The number of types of elements will be limited and they should be used in large quantities.
3. To the extent possible the largest size to be used which results in less no of joints.
4. The size and no of the prefabricates is limited by the weight in overall dimension that can be handled by the handling and erection equipment and by the limitation of transportation. Hence it is preferable to have all the and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. The term is used to distinguish this process from the more conventional construction practices of transporting the basic materials to the construction site where all assembly is carried out. The term prefabrication also applies to the manufacturing of things other than structure at a fixed site. It is frequently unused when fabrication of a section of a machine or any movable structure is shifted from the maid manufacturing site to another location, and the section is supplied assembled and ready to fit. It is not generally used to refer to electrical or electronic components of a machine, or mechanical parts such as pumps, gearboxes and compressors which are usually supplied as separate items, but to sections of the body of the machine which in the past were fabricated with the whole machine. Prefabricated parts of the body of the machine may be called ‘sub-assemblies” to distinguish them from the other components.

Contents

The process and theory of prefabrication
An example from house-building illustrates the process of prefabrication. The conventional method of buildings a house is to transport bricks, timber, cement, sand, steel and construction aggregate, etc, to the site, and to construct the house

on site from these materials. In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roof and prefabricated (assembled) in a factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and boiled together. Prefabrication is used in the manufacture of ships, aircraft and all kinds of vehicles and machines where sections previously assembled at the final point of manufacture are assembled elsewhere instead, before being delivered for final assembly. The theory behind the method is that time and cost is saved if similar construction tasks can be grouped and assembly line techniques can be employed in prefabrication at a location where skilled labour is available, while congestion at the assembly site, which wastes time, can be reduced. The method finds application particularly where the structure is composed of repeating units or forms, or where multiple copies of the same basic structure are being constructed. Prefabrication avoids the need to transport so many skilled workers to

the construction site, and other restricting conditions such as a lack of power, lack of water, exposure to harsh weather or a hazardous envioronment are avoided. Against these advantages must be weighed the cost of transporting prefabricated sections and lifting them

into position as they will usually be larger, more fragile and more difficult to handle than the materials and components of which they are made.

“Loren” Iron House, at Old Gipostown inMoe, Australia Prefabrication has been used snce ancient times. For examples, it is claimed that the world’s oldest known engineered roadway, the Sweet Track constructed in England around 3800 BC, employed prefabricated timber sections brought to the site rather than assembled on-site. Sinhalese kings of ancient Sri Lanka have used prefabricated buildings technology to erect giant structures, which dates back as far as 2000 years, where some section were prepared separately and then fitted together, specially in the Kingdom of Anuradhapura and Kingdom of Polonnaruwa. In 19th century Australia a large number of prefabricated houses were imported from the united Kingdom. The method was widely used in the construction of prefabricated housing in the 20th century, such as in the United Kingdom to replace houses bombed during World war II. Assembling sections in factories saved time on-site and reduced cost. However the quality was low, and when such prefabricated housing was left in use for longer than its designed life, it acquired a certain stigma.

UNIT - V

DESIGN FOR ABNORMAL LOADS

Progressive Collapse - Code Provisions - Equivalent design loads for considering abnormal effects such as earthquakes, cyclones, etc - Importance of avoidance of Progressive collapse.

Introduction

Throughout history, there have been many significant structural failures. While many of these failures have resulted in negative consequences (i.e, death, injury, Property loss, etc) these events present an opportunity to evaluate the validity of Engineering design approaches and procedures.

In an attempt to improve structural design and prevent structural disasters, Engineers continue to refine design guidlines.

World wide, there are several building that directly address the type of Progressive Collapse, while some regulations. While Some regulations do a better job of Conveying Progressive Collapse requirements than others. Currently there is no explict Engineering design method available Pertaining to this Potential Structural Problems.

Progressive Collapse

Typically, Progressive (disproportionate) Collapse is the result of an abnormal loading event. Four general classes of abnormal loads are:

1) Accident Impact
2) Faulty Construction
3) Foundation failure
4) Vollent Change in Air Pressure

Accidental Impact

Several Cases of Progressive Collapse have been caused by accidental impact. An Example of this form of abnormal loading is an automatic striking a key member (s) in a structure i.e, building, bridges etc.

Faulty Construction

There have been several instances throughout history where poor Construction practices have led to Progressive collapse. A notable eg of this was the skyline plaza apartments in building in Fair fax County Virginia. This failure was attributed to Premature removal of supporting forms. This led to localized failure.

Foundation failure:

Failure of a small portion of a structure foundation can result in a loss of primary support. This failure could be the result of problems with erosion, geology, cattering due to explosion etc. If the remainder of the structure is unable to redistribute this change in load caused by the loss in support, extensive damage to the structure, could be much greater.

Violent change in Air pressure:

An extreme change in Air pressure can stem from any source such as explosion caused by gas, high explosives etc. An example of a progressive collapse in air pressure was the 1995 terrorist bombing of the A.P murrah Fedral building

Code Provisions

Codes And Standards

Since the Progressive Collapse of the Ronan Point apartment tower in 1968, many Codes and Standards have attempted to address, the revise of this type of Collapse. Complex Survey of these effort is beyond the Scope of this Paper, but a Small Sampling of current Paper, but a Small Sampling of current and recent Provisions related to Progressive Collapse.

ASCET - 02:

The american Society of Civil Engineering minimum Design loads for building and other Structures (ASCE - 2002). has a Section on general Structural integrity" that reads thus:

Building and other structure shall be designed to sustain local damage with the structural system as a whole remaining stable and not being damaged to an extent disappropriate to the original local damage. Degree of redundancy is not specified and the requirements are entirely threat independent.

ACI 318 - 02

The american Concrete Institute Building Code requirement for Structural Concrete ACI 2002 include extensive "Requirements for structureal integrety" in the chapter on reinforcing steel details. Though the Commentary states that it "is the intent of these section to improve redundancy". There is no explict mention of redundanky or alternate load paths in the code.

GSA PBS Facilities Standards 2003

The 2003 Edition of the GSA's facilities Standards for the Public Building Service returned the Progressive Collapse heading from the 2000 Edition, but replaced all of the words reproduced above with this short statement "Security Design".

GSA PBS Progressive Collapse Guidelines 2003

The GSA Progressive Collapse Analysis and design Guidelines for new Federal office.

Buildings and major modernization Projects (GSA - 2003 b) begins with process for determining whether a building is Exempt from Progressive Collapse Considerations. Exempt is based on the type and size of the structure, and is unrelated to the level of threat.

Equivalent design loads for effects such as Earthquake cyclones.

In this section, we will review loads, typically considered in building design. These are:

1) Earthquake Loads
2) Wind loads

Earthquake Loads:

Earthquake are catastrophic events that occur mostly at the boundaries of portions of the earth's crust called tectonic plates, when movement occure in these regions, along faults waves are generated at the Earth surface that can produce very destructive effects. After shocks are smaller quakes that occur after all large eq. They are usually most intense in size and number within the first week

They can cause very significant re-shaking of damaged structures, which makes earthquake induced disasters more hazardous.

A number of moderate quake.

They can cause very significant re-shaking of damaged structures, which makes earthquake - induced disasters more hazardous.

Design Concept:

Earthquakes, we must contend with appreciable that failures will occur in the near future. otherwise, all the wealth of the world prove insufficient to fill our needs. the most modest structures would be fortunes. we must also face uncertainties on a large scale while designing Engineering systems whose ; performance properties are still debated to resist future earthquake.

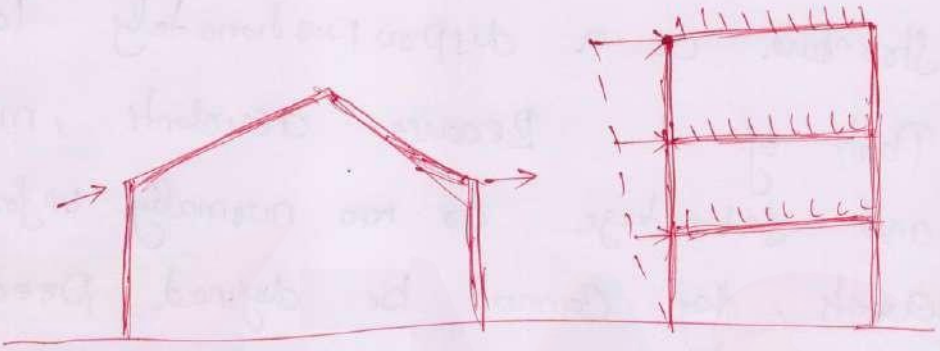
above whose characteristics we know even less.

Although over the years, experience and research have diminished our uncertainty and concerns regarding the characteristics and occurance regarding, though that there will be such a change in the nature of knowledge to relieve us of the necessity of dealing openly with random variables.

Wind Loads:

Wind is a term used to describe horizontal motion of air. Motion in a vertical direction is called current. Winds are produced by differences in atmospheric pressure that are primarily attributable one caused by unequal distribution of heat from the sun, and the difference in thermal properties of land and ocean surfaces, when temperature of adjacent regions

become unequal, the warmer, lighter air rises and flows over the colder, heavier air. winds initiated in this way are modified by rotation of earth.



Earthquake loading.

Abnormal loading.

Through accident misuse or sabotage, properly designed structure may be subjected to conditions that could lead to either general or local collapse. It is usually impractical for a structure to be designed to resist general collapse caused by gross misuse of a large part of the system or severe abnormal loads.

Progressive Collapse. Progressive collapse is defined as a spread of an initial local failure from element to element, eventually resulting in the collapse of an entire structure or a disproportionately large part of it. Because accidents, misuse and sabotage are normally unforseeable events, they cannot be defined precisely. Likewise, general structural integrity is a quality that cannot be state in case local collapse.

Collapse Patterns

It is discussed in the following Patterns

(1) Earthquake collapse patterns

(2) Design alternative for reducing Progressive collapse

(3) Guidelines for achieving structural integrity.

Earthquake Collapse Patterns

We typically accept higher risks of damage under seismic design forces than under other comparable extreme roads, such as maximum live load or wind forces. The corresponding seismic design forces are generally too high to resisted within the elastic range of material response, and it is common to design for strengths, which are a fraction of that corresponding to elastic response, and to expect the structures to survive large earthquakes by in elastic deformation and energy dissipation corresponding to material distress, Earthquake shaking cause damage to structure but it is the gravity that causes collapse. Redundancy and ductile behaviour can prevent or reduce extent of collapse.

Design Alternatives for Reducing Progressive Collapse

There are number of ways to obtain resistance to Progressive Collapse and the important among them are the following :-

1. During the design process, consider resistance to Progressive Collapse through the provision of minimum levels of strength, continuity & ductility.
2. Provide alternate load paths so that the damage is obtained and major collapse is averted.
3. Provide sufficient strength to resist failure from accidents or misuse.
4. Provide specific local resistance in regions of high risk to have sufficient strength to resist abnormal load in order

for the structure as a whole to develop alternate paths.

Guidelines for Achieving Structural Integrity

1. Generally connections between structural components should be ductile and have a capacity for relatively large deformation and energy absorption under the effect of abnormal conditions.
2. Good plan layout. An important factor in achieving integrity is the proper plan layout of walls & columns
3. Provide an integrated system of ties among the principal elements of structural systems. These ties may be designed specifically as components of secondary load - carrying

4. Returns on walls. Returns on interior and exterior walls will make them more stable.

Cyclone effects

Improving wind / cyclone :: Resistance of Building - Guidelines :

The Coastal areas of India receive a number of cyclonic wind storms practically every year. Causing devastation over large due to.

(i) High Speed winds, which destroy traditional homes and uproot trees and electric line supports

(ii) Floods, caused by heavy rains

(iii) Storm surge waters, first flowing toward the land then receding back towards the sea, drowning people & Destroying homes, agriculture trees etc. whatever comes in the path of the following flowing waters

Scope:

These guidelines deal with the Construction of wind / cyclone resistance to buildings of both Engineered and non-Engineered types. The Proposed measures are generally applicable to wind resistant Construction, but have Particularly been framed keeping in view the regions having wind velocity greater than or equal to 39m/sec.

Wind Pressure on Building And Storm Surge Heights:

(a) Basic wind Speed zones:

The marco-level wind Speed zone of India have been formulated and published in IS: 875 Indian Standard Code of Practice for wind loads.

55 m/s (198 km/h) - Very high damage Risk - zone A

50 m/s (180 km/h) - Very high damage Risk Zone - B

47 m/s (162.2 km/h) - High Damage Risk Zone

44 m/s (158.4 km/h) - Moderate damage - A

39 m/s (140.4 km/h) - moderate damage - B

33 m/s (118. km/s) - Low damage.

The basic wind speed height are applicable to 10m height above mean ~~sea~~ ground level in an open terrain with a return Period of 50 years.

Design wind speed and Pressure:

The basic wind speed is reduced or enhanced for design of buildings and Structures and due to factors like

(1) The risk level of the structure measured in terms of adopted return Period and life of Structures (5125, 50 or 100 years)

(ii) Terrain roughness determined by the surrounding building or trees, height, size of the structure.

(iii) Local topography like hills, valleys, cliffs or ridges etc. Thus general basic wind speed being the same in a given zone, structures in different site Conneations would have appreiable modification and must be considered determining design wind velocity.

The design wind pressure at height z above ground level on a surface normal to the wind streams is given by

$$P_z = 0.0006 V_z^2$$

where V_z = design wind velocity m/s

These factors play on important role in determining the vulnerability of given building types in given wind speed zones. By changing the cladding areas, different pressure co-efficient will be these.

c Coastal Areas

The Coastal areas are subjected to severe wind storms and cyclonic storms. It is known that is certain events, the wind gusts could appreiably exceed, the specific basic wind speed (55 %). But for design structure the above macro level zoning stated is considered as sufficient.

d) Storm Surge

Besides the very high velocity winds, the coastal areas suffer from the on staught of sea water over the coast due to storm surge generate cyclones. A storm surge is the sudeden abnormal rise in sea level caused by the cyclone. The surge is generated due to interaction of air, sea, land. Sea water flows across the coast aswell as inland.

Design Consideration Roofs:

Depending upon the construction material used and the geometrical aspects the roof can be broadly classified into two main types.

(a) Flat roofs of various types
(b) Pitched roof with various covering materials

Flat Roofs

Flat roofs may consist of

(i) R.C. Slabs
(ii) Wooden or R.C Joists, inverted T-irons placed usely spaced and carrying brick tiles, Stone slabs or seeds with clay
(iii) Prefabricated R.C elements of various designs placed side by side
(iv) Where of R.C slabs are rigid in their own planes, the other types will require their integration through diagonal bounding

or topping R.C screed.

b) Structural deck concrete of grade not leaner than M15 shall be provided over precast components to act monolithic with them

Pitched Roofs:

(a) The main load bearing structural members are timber or steel trusses, purlins and bracings. The cladding may be of GI or AC sheeting, tiles, timber planks or prefabricated R.C or ferrocement elements. It will be preferable to use sheeting with adequate fixtures than tiles or cyclone areas.

(b) Analysis and designed of Pitch roof is carried out as per provisions of relevant Codes of practice. IS - 800 - 1984 for steel trusses and IS - 883 - 1970 for timber trusses

Framed building

As an alternative to vertical load bearing walls, reinforced concrete, steel or timber framing can be used.

In RC constructions, the frame comprises of rigidly connected beams and columns or posts.

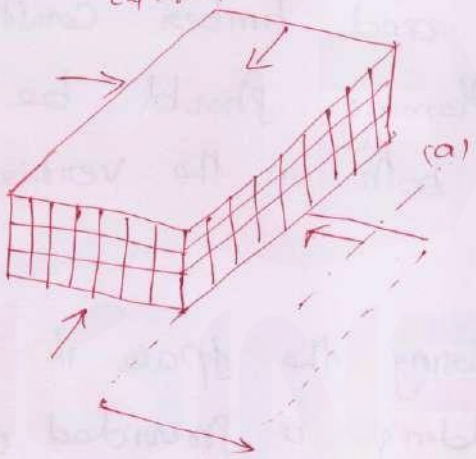
In steel and timber construction complete structural framing should be adequately braced both in the vertical and the horizontal planes.

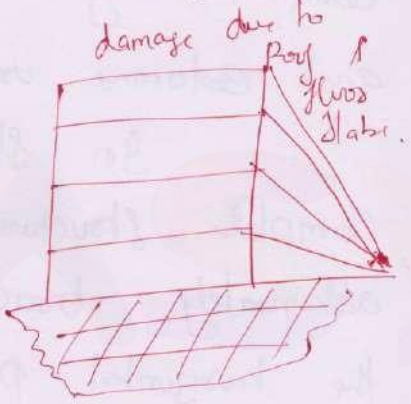
Cladding - For enclosing the space it is necessary that cladding is provided firmly secured to columns or posts, on all the externals faces and where partitioning is required.

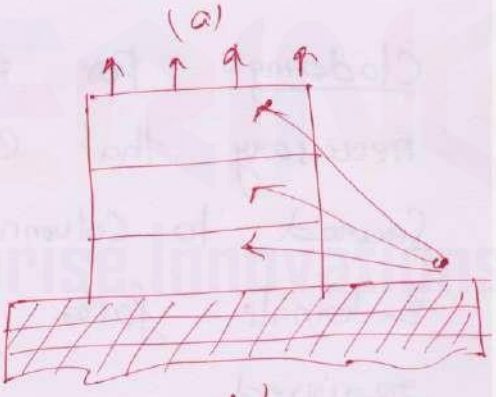
Bracing - Adequate diagonal bracing with strong end connections shall be provided in steel timber framing in both the

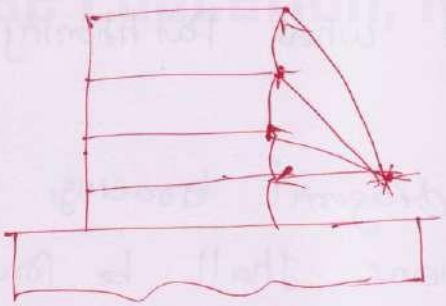
horizontal and vertical planes to improve their lateral load resistance.

Anchoring - The flame columns and shear wall where used shall be properly anchored into the foundation against uplift forces, as found necessary.









(b)

Damage due to building sway due to ground shown.

Earthquake collapse Pattern

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III Year – V Semester

CE3003- Prefabricated Structures