NSCET E-LEARNING PRESENTATION

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CE 6016 – PREFABRICATED STRUCTURES

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UNIT II  PREFABRICATED COMPONENTS
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Syllabus

- Behaviour of structural components
- Large panel constructions
- Construction of roof and floor slabs
- Wall panels
- Columns
- Shear walls
The following are the main components which are frequently used in building are

- Roof/Slab
- Slab
- Joist
- Beams (main & secondary)
- Wall panels
- Columns
The roofing/flooring 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 joist and then to main beams.
- The main beams are provided with channel sections 10 cm projections on the necessary sides with the spacing of joist.
- The joists are seated in the channels and bolted together.
The loads from slab to the main beam will come as point loads and a typical frame with different loadings are analysed. The foundation unit is the only unit which is going to cast in site.
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.

According to the span & loads:
- Hollow core sections
- Double tee section
- Channel sections
- Light weight concrete roofing slab
- Solid rectangular planks
The usual widths of these types of slabs are 0.5 m & spanning to the requirement up to a maximum limit of 5 m without prestressing.

The thicknesses of planks are casted in two steps with different mould to access monolithic action with adjacent slab by putting necessary reinforcement & concreting site.
The joists are designed as a small beams loaded from planks.

These joists transmit the loads to the main beams through the channels provided in the main beams.

In this joist, triangular shaped stirrups are provided to get the proper bonding or connection with the planks.

The joists are casted partially in the factory.

The apex portion of the triangular stirrup will be projecting from the casted top surface.

In this projecting a connecting rod will be inserted and additional base from planks also inserted.

This will give monolithic action as well as the plank will act as a continuous slab over the joists.
OPEN WEB STEEL JOISTS are fabricated from steel bars arranged in triangular patterns, fastened between two steel angles at top and at bottom. Steel joists are actually small trusses.
BEAMS (MAIN & SECONDARY)

- All the main and secondary beams are the same size of 300mm x 300 mm varies reinforcements are provided at varies conditions according to the moments.
- The beams are casted for the clear distance between the columns.
- A square of 10 cm x 10 cm hole or a depth of 10 cm are provided on either side to achieve the connection with other beam reinforcement or column reinforcements by proper welding.
- After welding the concrete has to be done at the junction with proper care.
At the junction of beams and columns, it is necessary to put site concreting.

For this purpose the top ends of the beam are tapered properly so that it will give access to site concrete and for needle vibrators to get properly compaction.
The wall panels are casted with all fixing like door, ventilation, window frames.

These wall panels are non load bearing wall. Therefore neglect solid rectangular cross section wall panel with R.C.C. from the view of thermal effects and safety.

The minimum of 150 mm is provided as wall thickness.

This wall is a sandwich type.

That is cellular concrete blocks of 75 mm thick is sandwiched by R.C.C. M_{25} grade concrete to a thickness of 37.5 mm on either face with minimum reinforcement.

since, the walls are in steel moulds there will be no need for plastering on either face of wall.

This is one of advantage of precast wall panels.
COLUMNS

- Many type of columns available in prefabricated system.
- Grooves are provided on the required faces to keep the walls in position.
- These grooves will act as a part of columns and since the area of column has been increased due to tibs will give addition moment carrying as well as load carrying capacity of columns.
- At the same time this grooves give a mild ornamental look to our building.
CONSTRUCTION OF ROOF & FLOOR SLABS WALL PANELS

- Precast components are 85% recyclable, levels of carbon dioxide generation is low energy efficient reduces waste during operations reduce construction cost eco friendly.
- Easy to install reduces construction time
- Stronger than cast-in-situ structures can be pre-stressed or post stressed is increase its performance longer life of structure
- Saves reinforcement and a in-line manufacturing process reduces the amount of waste generated casting.
- It can be manufactured in mechanized centralized production centres in a variety of shapes and sizes.
CONSTRUCTION OF ROOF & FLOOR SLABS WALL PANELS

- Its properties can be altered by altering the constituent raw materials like using cellular/aerated concrete or light weight aggregates etc.
- They may also be produced to have higher thermal insulating values by manufacturing sandwich panels with the integration of insulating material like polyurethane etc giving this product/technology a great advantage.
1. Appearance

- In prefabricated construction, there is better quality control shape and size of precast element.
- The concrete panels have a light gray concrete colour and have a smooth even finish due to high quality mechanized centralized mass production units.
- Reduction in the number of joints gives a neat clean image.

2. Structural Capability

- Strict quality control system can be put into place to ensure high performance in structural design full advantage of properties of cement and steel can be exploited.
A regular RCC slab of 125 mm thickness could actually be only 65mm thick to cater to the load above since on site formwork limitations do not permit such thin sections one has to cast a minimum 125mm thick slab.

A 50% reduction in the cross section area means a similar reduction in the material consumption and dead load on the structural system pre-cast element can be used efficiently for most of the building components.
PERFORMANCE OF THE COMPONENTS

- Pre-cast slabs and beams can be designed to carry live/dead loads as per requirements with safety factors incorporated.
- Additional reinforcement could be placed while filling up joints.
- In slabs provided with interlocking system to avoid independent displacement of slabs must be manufactured with M40 grade concrete.
- Pre cast waffle units provide speedy construction with overall savings up to 10% or more, besides avoiding shuttering work.
PERFORMANCE OF THE COMPONENTS

- The shape is like an inverted through with square or rectangular in plan having lateral dimension up to 1.2 m suitable for large spans beyond 6m in either direction on laying in grid pattern with reinforcement and cast-in-situ concrete joints between them.

3. Thermal Properties

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

- This thermal insulation can come as a integral part of the unit during the manufacture of the pre-cast units as a sandwich, insuring good thermal properties and ease of use or could be added on as a independent insulation layer of required value like in dry normal construction practice.
PERFORMANCE OF THE COMPONENTS

4. Sound Insulation
- Pre cast concrete units provide an acceptable degree of sound insulation.
- Their performance can be improved by the addition of sound insulating material as in sandwich during the manufacturing process.

5. Fire and Vermin resistance
- Pre cast concrete panels will not burn.
- They are readily incorporated into fire resistant rated construction with fire rating achievable up to 4 hrs.
- It has no problems of Vermin attacks or infestation and is also resistance to mold formation.
PERFORMANCE OF THE COMPONENTS

6. Durability & moisture resistance

- Due to strict quality control measures safe structural design with adequate reinforcements precast panels are highly durable and low on maintenance.
- They perform well even under high humidity conditions or constant wetting.
- Water absorption is low and most cases do not need a water proofing coat even in external applications.

7. Toxicity and breath ability

- Pre cast panels are inert non-toxic and not prone to off gassing of volatile materials
PERFORMANCE OF THE COMPONENTS

- As the production of these units takes place in a controlled environment, pollution of air, water, and site can be reduced and controlled.

8. **Sustainability (Environmental impacts)**
- There is disciplined use of scarce material like cement, steel, and timber during the production and use installation of these pre-cast panels.
- Although there would be a component of transportation involved from the production centers to the site,
- It helps in the management of raw materials in an efficient way away from the site reducing the work at the site decreasing on site pollution and keeping the work qualitatively better and reliable. In pre-cast construction similar types of components are produced repeatedly resulting in increased productivity and economy in cost too.
Home construction is a time consuming labor-intensive process.

Builders need to bring together all the materials and skilled workers to complete the project successfully within a given time frame.

One way to make the process easier is by using prefabricated components, such as Pre-built walls or large wall panels.

The precast wall panels are classified as...
TYPES OF PRECAST SYSTEMS

Precast wall panel

- **Size**
  - Small
  - Large

- **Function**
  - Structural
  - Non-structural
    - Large panel system
    - Frame systems
    - Slab-column systems with walls
    - Mixed systems

- **Location**
  - Exterior
  - Interior

- **Material**
  - Bricks
    - Hollow clay block
  - Concrete
  - Light weight metal
  - Plastic & Timber

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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 and panel (frameless) building.

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.

Frameless buildings are assembled from panels that perform the load-bearing and enclosing functions simultaneously.
1. Large panel structure for exterior wall

- Large-panel structures for exterior walls consist of panels one or two stories in height and one or two rooms in width.
- The panels may be blind (without openings) or with window or door openings.
- In terms of design, the wall panels are single-layer (solid) and multilayer (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 concretes, and hollow ceramic stone.
- Sandwich wall panels are made with two or three layers, their thickness depends on the climatic conditions of the region and the physic technical properties of the materials used for the insulating layer and for the exterior (supporting) layers.
2. Large panel structures for interior walls

- They may be non-load bearing and load-bearing
- They are made from gypsum-slag concrete or from other material that act as enclosures
- In the case of load-bearing structures, the wall panels, which combine enclosing and load bearing functions, are made from heavy or lightweight, silicate or cellular concrete.
- The dimensions of the panels are determined by the dimensions of the rooms, their height is equal to the height of a story, the width is equal to the depth or width of a room.
- The thickness of the walls between rooms is usually 10-14cm.
3. Large panel structures for floor slab

- They are made from reinforced concrete.
- The area of the floor slabs in apartment buildings usually equals the area of one room and may be 30 sq m. Flagging panels are 5-8 sq m.
- The large-panel floor slabs of housing, public and administrative buildings are of both the solid and sandwich types and in the latter provision is made for a sound insulation layer to reduce air and impact noise.
4. Large panel structure for roof element

- They are used in housing and public buildings mainly in the form of combined atticless roofs, and in industrial buildings the roof panels have a span up to 12m.
- The weight of large panel structure is usually 1.5-7.5 tons.
- Large panel structures of a high rise apartment building consist of foundation slab, exterior and interior wall panel, floor slab, deck (blind area), exterior panel in the process of installation.
Classification of precast large panel

Structural scheme with precast large panel wall can be classified as

- Cross wall system
- Longitudinal wall system
- **Cross wall system**
  - In this scheme the cross wall are load bearing walls where as the façade 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 buildings. A combination of the above systems with all loads bearing wall can also be adopted.

a) **Homogeneous wall:** The homogeneous wall should be solid hollow or ribbed.

b) **Non-homogeneous wall:**

   - These could be composite or sandwich panel based on the structural functions of the walls, the wall could be classified as
     - Load bearing walls
     - Non load bearing walls
     - Shear walls
Shear walls are vertical elements of the horizontal force resisting system.

Shear walls are constructed to counter the effects of lateral load acting on a structure.

In residential construction shear walls are straight external walls that typically form a box which provides all of the lateral support for 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 to the ground foundation in a direction parallel to their planes.

Lateral forces caused by wind, earthquake, and uneven settlement loads.

In addition to the weight of the structure and occupants, create powerful twisting (torsion) forces.

These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it maintains that shape of the frame and prevents rotation at the joints. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces.
In the last two decades shear walls became an important part of mid high rise residential buildings.

As part of an earthquake resistant building design these walls are placed in building plans reducing lateral displacements under earthquake loads. So shear wall frame structure are obtained.
PURPOSE OF CONSTRUCTING SHEAR WALLS

- Shear walls are not only designed to resist gravity/vertical loads due to its self-weight & other living moving loads), but they are also designed for lateral loads of earthquakes/wind.
- The walls are structurally integrated with roofs/floors (diaphragms) and other lateral walls running across at right angles.
- Shear wall structural systems are more stable because their supporting area (Total cross sectional area of all shear walls) with reference to total plans area of building is comparatively more, unlike in the case of RCC framed structures.
PURPOSE OF CONSTRUCTING SHEAR WALLS

- Walls have to resist the uplift forces caused by the pull of the wind.
- Walls have to resist the shear forces that try to push the walls over.
- Walls have to resist the lateral force of the wind that tries to push the walls in and pull them away from the building.
COMPARISONS OF SHEAR WALL WITH CONSTRUCTION OF CONVENTIONAL LOAD BEARING WALLS.

- Load bearing masonry is very brittle material.
- Due to different kinds of stresses such as shear, tensile..etc. Caused by the earthquakes the conventional unreinforced brick masonry collapses instantly during the unpredictable and sudden earthquakes.
- The RCC framed structures are slender.
- When compared to shear wall concept of box like three-dimensional structures.
- Though it is possible to design the earthquake resistant RCC frame it requires extra-ordinary skills at design detailing and construction levels which cannot be anticipated in all types of construction projects.
On the other hand even moderately designed shear wall structures not only more stable, but also comparatively quite ductile.

In safety terms it means that during very severe earthquakes they will not suddenly collapse causing death of people.

They give enough indicative warnings such as widening structural cracks yielding rods etc offering most precious moment for people to run out off structures before they totally collapse.
COMPARISONS OF SHEAR WALL WITH CONSTRUCTION OF CONVENTIONAL LOAD BEARING WALLS.

- For structural purposes we consider the exterior walls as the shear resisting walls.
- Forces from the ceiling and roof diaphragms make their way to the outside along assumed paths enter the walls and exit at the foundation.
FORCES ON SHEAR WALL

Shear wall resist two types of forces
- Shear forces
- Uplift forces

Shear Forces
- Shear forces are generated in stationary buildings by accelerations resulting from ground movement and by external forces like wind & waves.
- This action creates shear forces throughout the height of the wall between the top and bottom shear wall connections.

Uplift Forces
- Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall.
FORCES ON SHEAR WALL

- These uplift forces try to lift up one end of the wall and push the other end down.
- In some cases the uplift force is large enough to tip the wall over.
- Uplift forces are greater on tall short walls. Uplift shear walls need hold down devices at each end when the gravity loads cannot resist all of the uplift.
- The hold down device then provides the necessary uplift resistance.
CLASSIFICATION OF SHEAR WALLS

✓ Simple rectangular types & flanged walls
✓ Coupled shear walls
✓ Rigid frame shear walls
✓ Framed walls with in filled frames
✓ Column supported shear walls
✓ Core type shear walls
TYPES OF SHEAR WALLS BASED ON MATERIALS

- RC shear wall
- Plywood shear wall
- Midply shear wall
- RC Hollow concrete Block masonry wall
- Steel plate shear wall
It consists of reinforced concrete walls and reinforced concrete slabs. Wall thickness varies from 140 mm to 500 mm depending on the number of stories, building age and thermal insulation requirement.

In general, these walls are continuous throughout the building height; however, some walls are discontinued as the steel front or basement level to allow for commercial or parking spaces.

Floors slabs are either cast in-situ flat slabs or less often, Precast hollow core slabs.

Buildings are supported by concrete strip or mat foundations; the latter type is common for buildings with basements.
PLY WOOD SHEAR WALL

- Plywood is the traditional material used in the construction of shear walls.
- The creation of pre-fabricated shear panels have made it possible to inject strong shear assemblies into small walls that fall at either side of a opening in a shear wall plywood shear wall consist of
  - Plywood to transfer shear forces
  - Chords to resist tension/compression generated by the overturning moments.
  - Base connections to transfer shear to foundations
The midply shear wall is an improved timber shear wall that was developed by redesigning the joints between sheathing and finishing members.

So, that the failure modes observed in standard wall testing are virtually eliminated at lateral loads levels high enough to cause failures in standard walls.
RC HOLLOW CONCRETE BLOCK MASONRY WALLS (RHCBM)

- These walls are constructed by reinforcing the hollow concrete block masonry by taking advantage of hollow spaces & shapes of the hollow blocks.
- It requires continuous steel rods (reinforcement) both in the vertical & horizontal directions at structurally critical locations of the wall panels packed with the fresh grout concrete in the hollow spaces of masonry blocks.
- RHCBC elements are designed both as load bearing walls for gravity loads and also as shear walls for lateral seismic loads to safety withstand earthquakes.
STEEL PLATE SHEAR WALL

- In general steel plate shear wall system consists of a steel plate wall boundary columns and horizontal floor beams.
- Together the steel plate wall and boundary columns act as a vertical plate girder.
- The column act as flanges of the vertical plate girder and the steel plates wall act as its web.
- The horizontal floor beams act more or less as transverse stiffeners in a plate girder steel plate shear wall systems have been used in recent years in highly seismic area to resist lateral loads.
Thus shear walls are one of the most effective building elements in resisting lateral forces during earthquake.

By constructing shear walls damages due to effect of lateral forces due to earthquake and high winds can be minimized shear walls construction will provide larger stiffness to the buildings there by reducing the damage to structure and its contents.

Hence it is preferable to have all these prefabricate approximately of some weight very near to the lifting capacity of the equipment.
8. However, from the point of view of strength of the structure, it is desirable to position construction joints at points of minimum shear.

9. Shear keys, diagonal dowels, or the shear transfer method (ACI Code 318-11, Section 11.7) may be used.

Construction joint used as contraction joint in slab or wall