Program : **B.Tech**

Subject Name: **Construction Technology**

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Semester: **4th**

Unit V

Construction of Earthquake Resistant Building: - Planning of earthquake resistant building, Construction of walls – provision of corner reinforcement, construction of beams and columns, Base isolation.

- **Introduction: -** the fabrication of a building or structure that is able to withstand the sudden ground shaking that is characteristic of earthquakes, thereby minimizing structural damage and human deaths and injuries. Suitable construction methods are required to ensure that proper design objectives for earthquake-resistance are met. Construction methods can vary dramatically throughout the world, so one must be aware of local construction methods and resource availability before concluding whether a particular earthquake-resistant design will be practical and realistic for the region.

There is a fundamental distinction between the design of a building and the construction methods used to fabricate that building. Advanced designs intended to withstand earthquakes are effective only if proper construction methods are used in the site selection, foundation, structural members, and connection joints. Earthquake-resistant designs typically incorporate ductility (the ability of a building to bend, sway, and deform without collapsing) within the structure and its structural members. A ductile building is able to bend and flex when exposed to the horizontal or vertical shear forces of an earthquake. Concrete buildings, which are normally brittle (relatively easy to break), can be made ductile by adding steel reinforcement. In buildings constructed with steel-reinforced concrete, both the steel and the concrete must be precisely manufactured to achieve the desired ductile behavior.

Building failures during earthquakes often are due to poor construction methods or inadequate materials. In less-developed countries, concrete often is not properly mixed, consolidated, or cured to achieve its intended compressive strength, so buildings are thus extremely susceptible to failure under seismic loading. This problem is often made worse by a lack of local building codes or an absence of inspection and quality control.

- **Planning of earthquake resistant building**

i. Symmetry: The building as a whole or its various blocks should be kept symmetrical about both the axes. Asymmetry leads to torsion during earthquakes and is dangerous; Symmetry is also desirable in the placing and sizing of door and window openings, as far as possible.

ii. Regularity: Simple rectangular shapes, behave better in an earthquake than shapes with Tensional effects of ground motion are pronounced in long narrow rectangular blocks. Therefore, it is desirable to restrict the length of a block to three times its width. If longer lengths are required two separate blocks with sufficient separation in between should be provided.

iii. Separation of Blocks: Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block. For preventing hammering or pounding damage between blocks a physical separation of 3 to 4 cm throughout the height above the plinth level will be adequate as well as practical for up to 3 storied buildings. The separation section can be treated just like expansion joint or it may be filled or covered with a weak material which would easily crush and crumble during earthquake shaking. Such separation may be considered in larger buildings since it may not be convenient in small buildings.

iv. Simplicity: Ornamentation invo1ving large cornices, vertical or horizontal cantilever projections, facia stones and the like are dangerous and undesirable from a seismic viewpoint. Simplicity is the best approach. Where ornamentation is insisted upon, it must be reinforced with steel, which should be properly embedded or tied into the main structure of the building. Note: If designed, a seismic coefficient about 5 times the coefficient used for designing the main structure should be used for cantilever ornamentation.

v. Enclosed Area: A small building enclosure with properly interconnected walls acts like a rigid box since the earthquake strength which long walls derive from transverse walls increases as their length decreases. Therefore structurally it will be advisable to have separately enclosed rooms rather than one long room. For unframed walls of thickness t and wall spacing of a, a ratio of a/t = 40 should be the upper limit between the cross walls for mortars of cement sand 1:6 or richer, and less for poor mortars. For larger panels or thinner walls, framing elements should be introduced.

vi. Separate Buildings for Different Functions: In view of the difference in importance of hospitals, schools, assembly halls, residences, communication and security buildings, etc., it may be economical to plan separate blocks for different functions so as to affect economy in strengthening costs.

- Construction of walls – provision of corner reinforcement

Earthquake resistant design is inadequate to prevent collapse of masonry buildings due to out-of-plane failure of walls. Two important aspects of any earthquake resistant feature are ductility and integral connectivity of the various structural components of the building. It is rather easy to derive both these in the case of reinforced concrete framed structures than in load bearing masonry buildings.

Unreinforced brick masonry, generally has poor flexural strength and practically no ductility in flexure. The masonry wall behaves like a plate in two-dimensional bending, when subjected to lateral load during earthquakes. Hence there is a need to reinforce the wall in both horizontal and vertical directions to impart ductility to the wall. It is rather easy to introduce reinforcement and embed it in a thin layer of concrete in the horizontal direction through the bed joints of the masonry, which results in horizontal bands at various levels. These R.C. bands also integrally connect the various walls of the building together.

The provision of vertical reinforcement poses certain difficulties. The conventional approach is to provide reinforcement in the middle of the wall enclosed by concrete. This will be inefficient since half of the wall thickness will be ineffective during the bending of the wall and the ductility of the wall will be limited to compressive strain capacity of the masonry. Further, the interface between the concrete enclosing the vertical steel and the masonry will create a vertical joint which is contrary to the concept of masonry construction. Such an interface between two materials having significantly different elastic properties will facilitate formation of vertical cracks. In order to overcome the above difficulties a new and an innovative way of providing vertical reinforcement on the surface of masonry wall has been developed which is called as “containment reinforcement”.

In this technique the steel rod is wrapped around the wall in the vertical direction with reinforcement anchored at the top and bottom to the roof and plinth R.C. bands. Further the rods on either faces of the wall are held together at intermittent levels by steel ties/links passing through the bed joints of the masonry. The links are necessary to prevent the buckling of the steel rod present on the compression side of the wall. For the containment reinforcement to be effective, it is essential for it to remain hugged to the wall at all times during an earthquake.

- **Construction of beams and columns**

Beam-column joint is an important component of a reinforced concrete moment resisting frame and should be designed and detailed properly, especially when the frame is subjected to earthquake loading. Failure of beam-column joints during earthquakes is governed by bond and shear failure mechanism which are brittle in nature1. Therefore, current international codes give high importance to provide adequate anchorage to longitudinal bars and confinement of core concrete in resisting shear2.

Since joints are subjected to large shear force during earthquake, shear strength in this region should be adequate to carry this large amount of shear force. Therefore, the current code needs to be upgraded to incorporate shear design provisions of beam-column joints. Moreover, under cyclic lateral loading, The overhead tank can however be eliminated if water is supplied directly from underground tank to kitchen toilet outlets, there comes the need of pumps which can give uninterrupted supply of water with required pressure to outlets so that when one opens the tap he gets continuous supply of water. Such pumps are called hydro-pneumatic system.

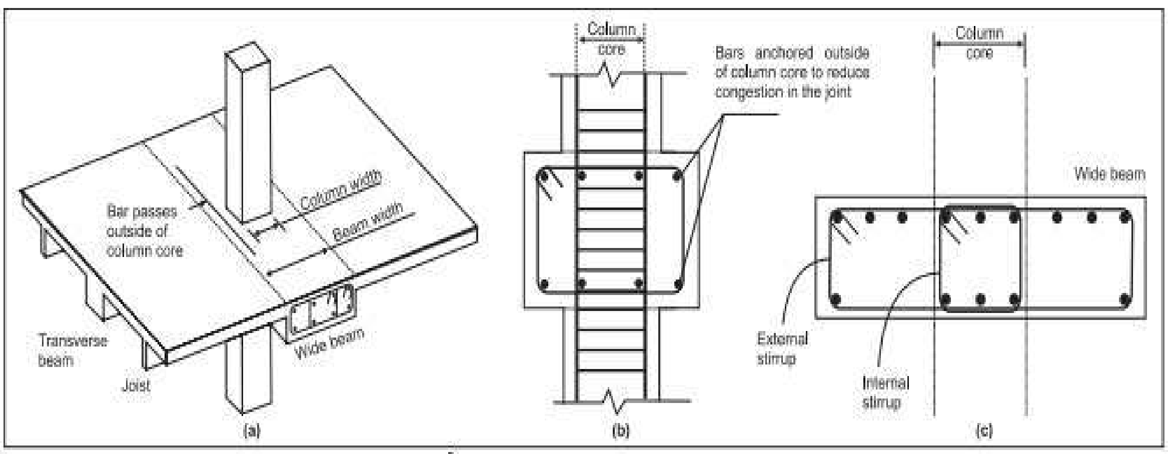

Fig 2 Connection between wide beam and column[8]

Such pumps consists of small steel tank with water on one side and air on another separated by a rubber membrane .As the pump starts it supplies water to the wet side thus causing rubber membrane to expand and air compresses on other side thus causing extra pressure on wet side which is connected to water supply line. So as one opens the tap , gets the required quantity of water. This causes the pressure to drop and the pump is automatically switched on again thereby maintaining the pressure of water and at same time supplying the water to outlets.

For an interior joint this anchorage length can only be provided through adequate column width and depth. Therefore, the code must have a provision for minimum dimension of column. The current code should also include confinement provisions on connection between columns and wide-beams, which are often found in one-way concrete joist systems and in buildings where floor-to-ceiling heights are restricted.

- Base Isolation

Base isolation, also known as seismic base isolation or base isolation system, is one of the most popular means of protecting a structure against earthquake forces. It is a collection of structural elements which should substantially decouple a superstructure from its substructure resting on a shaking ground thus protecting a building or non-building structure's integrity.

Base isolation is one of the most powerful tools of earthquake engineering pertaining to the passive structural vibration control technologies. It is meant to enable a building or non-building structure to survive a potentially devastating seismic impact through a proper initial design or subsequent modifications. In some cases, application of base isolation can raise both a structure's seismic performance and its seismic sustainability considerably. Contrary to popular belief base isolation does not make a building earthquake proof.

Base isolation system consists of isolation units with or without isolation components, where:

1. Isolation units are the basic elements of a base isolation system which are intended to provide the aforementioned decoupling effect to a building or non-building structure.
2. Isolation components are the connections between isolation units and their parts having no decoupling effect of their own.

- Isolation units could consist of shear or sliding units.
- This technology can be used for both new structural design and seismic retrofit. In process of seismic retrofit, some of the most prominent U.S. monuments, e.g. Pasadena City Hall, San Francisco City Hall, Salt Lake City and County Building or LA City Hall were mounted on base isolation systems. It required creating rigidity diaphragms and moats around the buildings, as well as making provisions against overturning and P-Delta Effect.

- Base isolation is also used on a smaller scale—sometimes down to a single room in a building. Isolated raised-floor systems are used to safeguard essential equipment against earthquakes. The technique has been incorporated to protect statues and other works of art—see, for instance, Rodin's Gates of Hell at the National Museum of Western Art in Tokyo's Ueno Park.

- Base isolation is one of the most widely accepted seismic protection systems in earthquake prone areas.

Seismic isolation is a design strategy, which uncouples the structure for the damaging effects of the ground motion.

