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Comparative Study of Different Types of Floor System Buildings with Flat Slab and Conventional Grid Slab

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ABSTRACT

There is a scarcity of room for housing due to the fast expansion of cities. As a result, there will be a greater need for space, and we will have to construct taller structures to accommodate everyone. As a society, we've grown to rely on these multi-story buildings. Multiple structural systems may be used to create the multi-story structures. The building may be erected in one of two ways: (1) a framed structure or (2) a flat slab structure, depending on the layout of the slabs, beams or girders, and columns. Beams, columns, and slabs work together to form a framed structure, which can withstand both gravity and lateral loads. The most popular and traditional structural system is this grid design. In most cases, these structures are used to counteract the significant moments that arise as a result of the imposed stress.

Keywords: Beam, Column, Construction, Beam, Building & Structure.

INTRODUCTION

Beams, columns, and slabs work together to form a framed structure, which can withstand both gravity and lateral loads. When huge moments form as a result of applied stress, these structures are often used to counteract them. Framed buildings are prevalent in today's architecture, although not the most frequent. A concrete framework, as the name implies, forms the basis of this kind of architecture. The beams and columns are the horizontal and vertical components of this framework, respectively. Slabs are the level pieces of concrete that people use to walk on. Since it is responsible for supporting the majority of the building's weight, the column stands head and shoulders above the others. When a structure's beams are damaged, it often just impacts one level. However, if a column is damaged, the whole building might collapse.

Due to advantages of decreased floor-to-floor heights in meeting architectural and economic criteria, many newly built structures have embraced flat slab construction, in which the slab is directly resting on columns. Flat slabs of ten to twenty storeys are common in commercial construction. However, the biggest problem with employing a flat slab is the likelihood of punching shear failure when transferring an imbalanced force from the slab to the column. Its conduct during earthquakes, without beams, is another important aspect to investigate. The response of reinforced concrete flat slabs to seismic loads is primary topic of this dissertation.

However, it becomes more important to withstand lateral stresses, such as wind and earthquake, as one's height increases. The downfall of such towering buildings is an earthquake. Because earthquake pressures are unexpected and random, it is important to study buildings that will be affected by them. Therefore, in order to assess the structure's behaviour with an accurate picture of the anticipated damage, precise modelling of such earthquake loads is required. In the past twenty or thirty years, it has been standard practice to assess a building for different earthquake intensities and to examine it for different criteria at each level.

The shaking intensity of an earthquake along withdamage it inflicts on structures vary depending on where it occurs. Building an earthquake-resistant building that can absorb the shaking at a certain level of intensity is, hence, essential. Due to its variable severity, earthquakes of the same magnitude may cause various kinds of damage in different parts of the world. As a result, research into the lateral displacements, story drift, and base shear responses of multi-story RC-framed buildings at varying seismic intensities is essential. Understanding the seismic behaviour of similarly laid-out structures at varying earthquake intensity is, hence, essential. It is vital to conduct seismic analysis of the building using several available technologies in order to ascertain seismic reactions.

There has been a heightened awareness of possible seismic hazard along withaccompanying susceptibility of existing building stock, which is necessary for calculating seismic risk, due to the substantial social along witheconomic repercussions of recent earthquakes hitting metropolitan areas. Estimating and reducing the risks connected with these possible losses has received more attention.

Estimating the projected damage and related loss in urban areas caused by earthquakes with an adequate degree of confidence is crucial for effectively mitigating possible losses and aiding in catastrophe decision-making processes. Comprehensive vulnerability assessments are essential for seismic loss assessment. Assessing the seismic performances of all building types commonly found in metropolitan areas during a series of earthquakes is necessary for determining vulnerability measures, since each structural type has its own unique reaction characteristics. Due of the immense scale of the issue, the fragility research typically concentrates on generic forms of building. Therefore, all typical building types employ simplified structural models that include random features to reflect the uncertainty in the structural parameters.

Compared to the more common moment-resisting frames, flat-slab system (Fig. 1) offers many benefits in reinforced concrete construction. Architectural freedom, clear space, reduced building height, simplified formwork,along withreduced construction time are all benefits of the old approach. But the flat-slab building method does have a few major flaws that need fixing. Because there are no deep beams or shear walls, the transverse stiffness is minimal, which might lead to considerable transverse displacements, which is one of the problems that have been found. Even in moderately intense earthquakes, this leads to excessive deformations, which harm non-structural components. Brittle punching failure as a result of shear force transmission and imbalanced moments between columns and slabs is another concern. The uneven moments might cause the slab to experience severe shear pressures when an earthquake strikes.

The cracking that happens in flat-slab systems as a consequence of lateral stresses, temperature and shrinkage effects, service gravity loads, and construction loads may also cause a substantial drop in stiffness. As a result, buildings in areas prone to earthquakes should only utilise flat-slab construction for their vertical load bearing systems, with frames or shear walls supporting the structure's lateral capacity [1]. When this happens, the main lateral load-resisting structural elements—the slab-column connections—must withstand the gravity loads by undergoing lateral deformations without punching through. Despite these issues, flat-slab systems are prevalent in seismically active areas, like the Mediterranean basin, and are often chosen as the main system for lateral load resistance. It is common practice to approach the design of flat-slab structures in these situations in the same way as those of regular frames. When the second option is used, even when the requirements for drift control are met, the reaction to mild earthquakes shows that non-structural parts get a lot of damage [2]. This finding highlights the need to study the fragility of flat-slab construction, which shows different response modes than traditional moment-resisting frames and for which there are no fragility curves in literature.

As seen in Figure 1, floors of reinforced concrete flat slab structures are directly supported by columns, eliminating the need for intermediate beams. Many commercial, institutional, and hospitality establishments employ flat slab systems. They need less time to formwork and construct. It is possible to apply the architectural finish straight to the slab's underside. They make it easy to pass and repair services, and they provide you options for where to put partitions. You may stretch the windows all the way to the bottom of the ceiling. Better fire resistance and reduced risk of reinforcement exposure due to concrete spalling are both achieved by avoiding sharp corners. More stories can be fit into a structure with a flat slab even when the building's height is limited [1, 2, 3].

Using a thorough inventory of 501 instances culled from textbooks, monographs, journals, along withconference proceedings, Cohn along withDinovitzer [4] showcased current status of structural optimisation. According to this review, most structural optimisation studies focus on optimising the design of discrete parts or very basic structures, neither of which may have much bearing on real-world problems. They came to the conclusion that additional optimisation examples, particularly for realistic structures, loading situations, and limit states, would make optimisation more appealing to practicing designers.

Notably, out of the 501 instances included in the collection, 460 pertain to steel buildings, while just 21 address reinforced concrete structures and 20 address composite structures separately. This research shows that reinforced concrete constructions have gotten less attention than steel buildings. In 1998, Sarma and Adeli [5] reviewed 35 years of reinforced concrete construction cost optimisation research. They determined that cost-optimization research in case of large-scale, realistic reinforced concrete three-dimensional structures is needed. Based on British Code of Practice (BS8110) for reinforced concrete structure design and construction, paper discusses cost-optimization strategies for reinforced concrete flat slab buildings [6]. The goal function is sum of all construction expenses, including those for concrete, reinforcement, and formwork used to construct building's foundation, floors, and columns.

A beamless slab, or reinforced concrete flat slab, is one that does not need beams but instead rests directly on columns. A panel is a section of the slab that is encircled on four sides by column's central line. To lessen amount of negative reinforcement in the support zones and to provide sufficient shear strength, it is common practice to thicken the flat slab adjacent to the supporting columns. The term "drop" or "drop panel" describes the thickened section, or projection, that lies under the slab. In certain instances, the top section of the column is enlarged where it meets floor slab or a drop panel. This is done to mainly increase perimeter of critical shear section, which in turn increases slab's capacity to resist two-way shear along with reduces negative bending moment at support. A flared portion and heading. Flat plates are uniform-thick slabs without column capitals or drop sections. Punching shear action around columns makes flat plate constructions weak and only appropriate in case of modest loads and short spans. Due to its comfort, health, along with energy efficiency advantages, several countries have embraced radiant floor heating systems. [1, 2]. It stands to reason that same floor system may also be used in case of cooling purposes, given high radiant heat production along with proximity of inhabitants to floor, which is the heat source [3]. A growing number of studies have examined radiant floor heating and cooling systems in recent years.

When heating or cooling a radiant floor system, it is important to maintain the floor surface temperature within certain ranges to provide comfort and prevent condensation. The recommended minimum temperature for the floor surface in summer is 19 °C and in winter is 29 °C [1]. Consequently, the surface temperature of the floor is a crucial component in both the design and functioning of the radiant floor system.

Most simulation models use the finite difference, approach to derive the radiant floor temperature field, which is then used to determine the average floor surface temperature . It will take a considerable amount of time to programme and compute since solving the partial differential equations is known to be quite complex. Study proposes a technique for calculating surface temperature of a radiant floor system. Also included is a comparison of computed values to both numerical and experimental ones.

Floor Systems

The horizontal floor system transfers the force of gravity, both living and dead, to the vertical frame systems by resisting the loads exerted on it. In this operation, the floor system is mostly bent and stretched in a transverse direction, while the vertical frame parts are compressed in an axial direction and sometimes bent and stretched as well. The floor not only connects but also stiffens the several vertical frame parts, acting as a horizontal diaphragm. Because of their strong in-plane flexural stiffness, floor diaphragms respond rigidly to lateral stresses and disperse them evenly to the different vertical frame components and shear walls. The typical floor system for cast-in-situ reinforced concrete buildings typically includes the following:

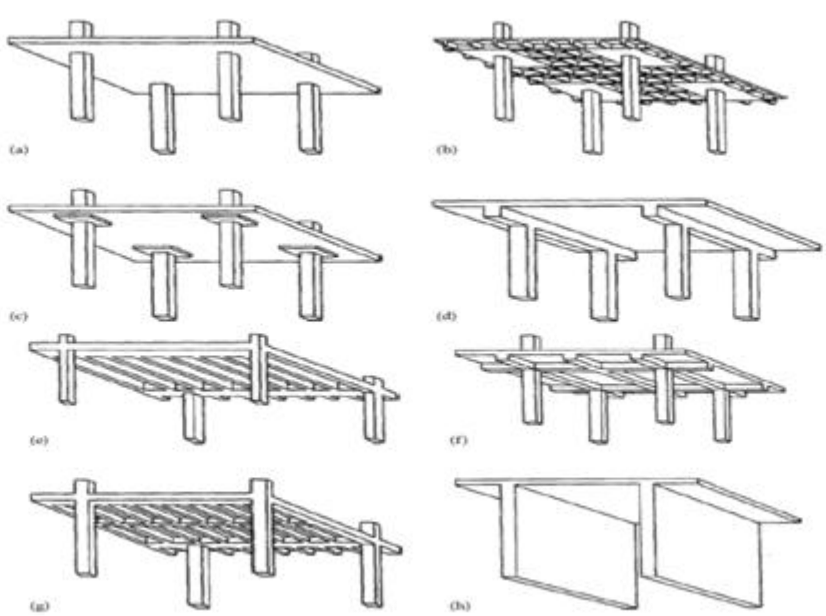

Figure 1.1 Floor Systems

Wall Supported Slab System

Masonry load bearing walls support the floor slabs in this design, which are typically 100-200 mm thick and have spans of 3 m to 75 m. Most of the time, this method is used in buildings with lower floors. There are a variety of techniques to support the slab panels, which are typically rectangular in form. The term "one way slab" describes a slab that bends in only one direction when it is supported by two opposing sides. A two-way slab is one that bends in two directions, along its length and width, and is supported on all four sides. This happens when the panel dimensions, breadth and length, are similar. Nevertheless, in the case of a lengthy rectangle (longer than twice as wide as it is wide), the longitudinal bending is much smaller than the transverse bending, and the slab action that follows is essentially unidirectional. The slab is no longer supported simply when the wall extends above floor level; hogging moments are introduced into the slab as a result of partial fixity at the support. Classical plate theory also establishes that restricted corners (those that are not free to lift up) create twisting moments. Slabs are often cast in panels that span many wall supports; the term "one way continuous" or "two way continuous" refers to the direction of bending, whereas "two way continuous" describes the direction of bending in both directions. The area immediately around the continuous support induces hogging moments in the slab.

Beam Supported Slab System

Beams, rather than walls, support the floor slabs in this system, which is otherwise comparable to the wall-supported slab system. The beams, which have spans between 3 and 7.5 metres, are cast in one continuous piece with the slabs arranged in a grid pattern. Both low-rise frame construction and high-rise building construction often use this technology. The system of beams transfers the weight of the slabs under gravity to the columns. Primary beams (or girders) are those that attach directly to the column and make up the vertical frames; secondary beams are those that are supported by other primary beams rather than columns.

The beam deflections become very insignificant and slab supports behave almost like wall supports if the beams are extremely stiff; the action may be in either a vertical or a horizontal direction, depending on the size of the panels. On the other hand, beam deflections become significant and impact slab behaviour if the beams are sufficiently flexible. In a system with many two-way secondary beams, the slabs do not only "rest" on the beams; rather, the whole slab-beam system is responsible for bearing the weight of the building due to gravity. This is especially true in large-column free-space "in grid floor" configurations.

Grid Slab System

Structures with a monolithic slab and beams placed at regular intervals in each direction make up a grid floor. Large rooms, especially those without columns, are ideal for their use in architecture, and they are often seen in auditoriums, vestibules, theatre halls, and retail showrooms. Concealed architectural lighting makes good use of the square or rectangular hole in the ceiling. In most cases, the dimensions of the beams that run perpendicular to the ground remain constant. The beam grid is diagonal rather than rectangular.

Flat Slab System

A beamless slab, or reinforced concrete flat slab, is one that does not need beams but instead rests directly on columns [1]. Panels are sections of slabs that are encircled on four sides by the column's centerline. To lessen amount of negative reinforcement in support zones and to provide sufficient shear strength, it is common practice to thicken the flat slab adjacent to the supporting columns. A drop panel or thickened section is the protrusion that lies below the slab. In certain instances, the top section of the column is enlarged where it meets floor slab or a drop panel. By primarily increasing the circumference of critical shear section, the ability of the slab to withstand two-way shear is enhanced, and the negative bending force at the support is reduced. A segment that has been flared or enlarged, together with a heading. Without column capitals or drop panels, flat plates are uniformly thick slabs. Flat plate constructions are often only appropriate for light loads and short spans due to their poor strength, which is caused by punching shear action that happens around columns.

Multiple regions of the Andes can attest to the tectonic effects of the late Cenozoic flat subduction of the Nazca plate. In a recent assessment, Gutscher et al. (2000a) covered the Bucaramanga section in northern Andes (north of 5°N latitude) and Peruvian and Pampean segments in Central Andes (27°00′-33°30′S latitude). Figure 1 shows that the Central Andes of Argentina and Chile have greater documentation of the geological processes associated with the subductionzone'sshallowing. This section has gone through intense weathering due to the fact that flat subduction began here between 18 and 12 Ma, suggesting a more developed structural stage of evolution, and because the eastern side of the Alps at these latitudes is very arid. Jordan et al. (1983a, 1983b), Jordan et al. (1993), Jordan et al. (1997), Kay et al. (1988), Allmendinger et al. (1990), Kay and Abbruzzi (1996), Ramos et al. (1991, 1992a), and many more studies have investigated the region's magmatic, tectonic, and sedimentary histories. The primary objective of this research is to analyse the structural, magmatic, and sedimentary responses to the late Cenozoic Pampean slab flattening.

The subducting slab's shape and bathymetric relief are linked to the Pampean flat-slab component of the broader Andean orogenic system, specifically to subduction of the Juan Fernandez Ridge. Along this section, you may see deformation, a rift in the main Andes caused by active arc volcanism, and the Sierras Pampeanas, where arc volcanism occurred in the late Cenozoic.

We can learn more about the connections between tectonics in the overriding plate, slab flattening, and ridge subduction if we look at late Cenozoic deformation in four structural transects that are spread out equally. Their positions are marked by the Sierras de Córdoba and Sierra de San Luis, respectively, in the southern and central Sierras Pampeanas, at 33°S and 31°S, and by 27°S and 29°S, in the northern and central Sierras Pampeanas, respectively. In order to connect the past of the Sierras Pampeanas to the general development of the Andes, the results are included into a transect that traverses the whole Andean belt at 33°S. This corresponds with the southern boundary of the present flat-slab sector.

Figure 2 shows the deformed and faulted foreland, which is part of the present-day tectonic framework of the Pampean flat-slab section. This foreland is located outside of the arc volcanism. The first research of Barazangi and Isacks (1976) and Barazangi and Isacks (1979) confirmed the form of the subducted slab under Chile, as had been assumed by Stauder (1973). These studies recognised the Pampean portion of subhorizontalsubduction located between 27 and 33°30′S latitudes. The absence of an asthenospheric wedge to interfere with the dehydration of the oceanic crust was deduced by Isacks and Barazangi (1977) from the fact that the volcanic arc had gaps in it.

Studies conducted by Jordan et al. (1986), Ramos et al. (1991), and Kay et al. (1996) supported the theory put out by Isacks et al. (1982) and Jordan et al. (1983a) that flat-slab section was associated with creation of Sierras Pampeanas. To sum up, the foreland area underwent shortening in late Cenozoic period and basement was uplifted as a consequence of intraplate seismicity in top 50 km of continental plate. This deformed foreland's chronological and geographical evolution provides indirect evidence of processes associated with the oceanic plate's shallowing.

Ramos (1994) states that the master faults that rose the blocks of Sierras Pampeanas in a divergent fashion originated and were shaped by previous crustal discontinuities in foreland.Toselli et al. (1985) found that fault zones, namely sutures and shear zones, were formed during the early Paleozoic when foundation terranes were compressed. As part of the orogenic collapse, master faults were reactivated by extension during the development of the intracratonicPaganzo basin in the late Paleozoic (Salfity and Gorustovich, 1984).

There was a second instance of extensional deformation during generalised Triassic to early Jurassic rifting (Ramos et al. Kay, 1991; Schmidt et al., 1994; Ramos, 2000) before the final stage of crustal extension associated with the opening of the south Atlantic Ocean in the Cretaceous period.

The basement rocks of Sierras Pampeanas were raised due to Andean compression in the late Cenozoic epoch. As shown by Jordan et al. (1986) Introcaso et al. (1987), corollaries at different depths of the basement's brittle-ductile transitions controlled the tilting and rotation of the mountain blocks, supporting the suggestion of González Bonorino (1950).

Components Of Flat Slabs

The "drop panel" is created when the slab is locally thickened near the supporting column. The primary function of drop panels, or drops, is to decrease shear stress around the column supports. Additionally, they contribute to lowering steel needs for negative moments at column supports.

Drops are required by regulation to be rectangular in shape and to extend at least one third of the panel length in each direction. Panels on the outside must have a width of half the width of panels on the inside, measured from the center-line of the columns, at right angles to non-continuous border. The point of localised expansion where a column meets the slab is called its head.

There is a certain amount of negative moment passed from the slab to the support column. By adding column capital/heads, the area at support may be enlarged, which helps to resist this negative moment. A panel is the section of a flat slab that is delimited on four sides by the centre lines of neighbouring columns. You may split a panel into centre strips and column strips.

Any design strip that encompasses a drop panel or beam (along the column line) and has a width of 0.25 L1 or 0.25 L1 on each side of column centerline is called a column strip. The widths of rectangular panel, measured from centre to centre of column supports, are denoted as L1 and L2f, respectively.The design strip in centre is determined by the column strip on both sides.

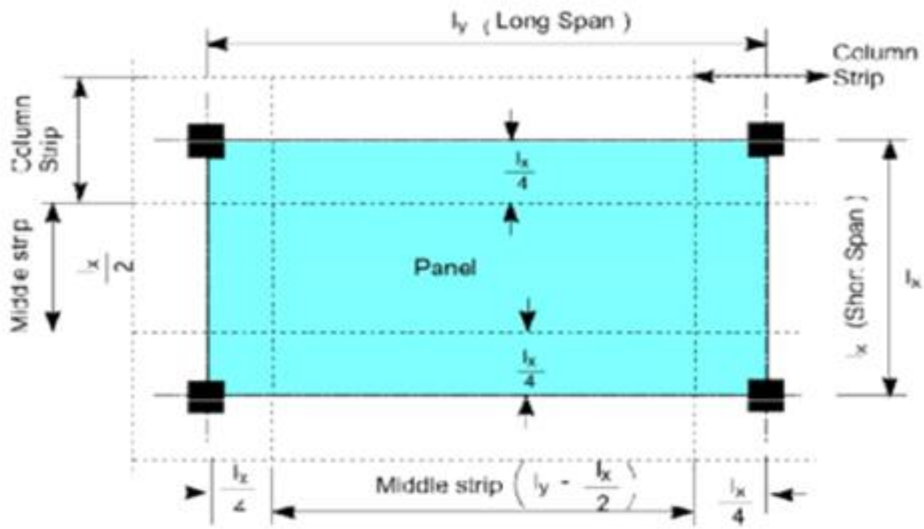

Figure 1.2 Column strip and middle strip plan

Advantages Of Flat Slab Construction

1. Flexibility in room layout: The occupier has a lot of leeway with flat slab construction since they may adjust the interior layouts to fit different uses. Architects may install dividing walls wherever they're needed in flat slab building. Room sizes and layouts may be easily altered with flat slab construction. Bypassing the fake ceiling and finishing the slab's soffit with skim coating are also options available in flat slab construction.
2. Faster construction: More and more people are starting to see the value of flat slab construction. With less and simpler formwork, may be produced quicker. Next, the total building pace will be limited by how quickly vertical parts may be cast. Big table formwork may be more easily used with flat plate designs, leading to increased production.
3. Reduced Services and cladding costs: When a deep false ceiling is not needed, floor-to-floor heights may be minimised using flat slab construction, which does not limit the placement of horizontal utilities and walls. Consequences such as shorter building heights, cheaper cladding, and prefabricated services are possible outcomes of this.
4. Reduction in floor height: As a result, the building's total height is further reduced by lowering the distance between floors. Because there will be less walls and cladding to the façade at lower storeys, the building's overall weight will be reduced. Saves about 10% on foundation load reduction due to vertical members.
5. Maximum flexibility is achieved in the architectural design.
6. Better acoustical characters are obtained with flat slabs.
7. By using post tensioned slabs clear spans is to 10m or so can be achieved, which are very much required in office buildings.
8. The primary economy factor of the flat slab construction is the simplicity of formwork erection. This increase speed of construction.
9. Flat slabs also are turned out to be very economical with respect to volume of concrete and the amount of reinforcement required when the slabs are provided for large spans.

Beam analysis, a crucial engineering topic, determines beam response, shear, moment, deflection, along with rotational parameters. Boundary value issues, integral calculus, along with differential equations are used.
Beam analysis predicts beam behaviour under external loads and pressures. Beam analysis informs structural design and construction, assuring safety and stability.

Functions of Slab:

- Its principal role is to distribute the weight by bending in one or two directions. Its functions include providing a flat surface, acting as an insulator against sound, heat, along with fire, and providing a covering shelter or working flat surface in structures.
- It is the higher slab that serves as ceiling for storey that is located below it.

Construction process of a slab:
A structure is made up of a number of different parts of construction that are connected to one another, such as walls, beams, columns, foundation, slabs, and so on. It is of the highest significance that slab is one of them. Because of this, the other components of the structure are better able to bear the various loads.

When building a concrete floor slab, following steps are involved: -

- Assemble along with Erect Formwork,
- Prepare along with Place Reinforcement,
- Pouring, Compacting along with Finishing concrete and
- Removal of Formwork along with Curing of Concrete slab

Assemble and Erect Formwork:

- The formwork has to be strong enough to endure weight of operators, workers, along with machinery, in addition to pressure of newly mixed concrete.
- The formwork must be positioned correctly, lined along withlevelled, joints must be adequately sealed, along withit must be prevented from protruding nails into the concrete, among other things.

The site engineer should be aware of the below formwork deficiencies so that the final slab will be laid properly

- Formwork examinations that are inadequate or nonexistent before and after the laying of concrete in order to discover unusual deflections or other signs of potential failure that might be remedied after inspection
- Nails, bolts, welding, or other methods of fastening that are improper
- An incorrect use of lateral bracing
- A failure to conduct enough field inspections to guarantee that form builders have correctly understood the design of the form

Prepare and Place Reinforcement:

- Check forms for concrete floor slab reinforcement installation to ensure dimensions and locations align with structural designs.
- In addition, the forms must be well cleaned and lubricated.
- Design drawings include reinforcing details, requiring just bar size recognition, length cutting, and hook/bending creation.
- Upon completion of preparation, steel bars are put with prescribed spacings and concrete cover.
- Wires provide primary reinforcement, shrinkage, and temperature reinforcement.

It is well-known that concrete structural failures may occur due to improper installation of reinforcing steel

- Consolidating, Pouring, and Finishing Concrete:
- The appropriate coordination of mixing, transporting, along with handling of concrete with putting and finishing operations is essential.
- If you want to keep concrete from separating, you should pour it at or near its ultimate location.
- The horizontal transfer of massive, unconnected heaps of concrete to their ultimate location is, therefore, strictly forbidden.
- The site engineer is also responsible for keeping a close eye on the concreting process and reporting any issues that may arise.
- In order to shape the concrete inside the moulds and around embedded objects and reinforcement, it is important to compress it thoroughly. This will minimise air pockets, honeycomb, along with stone pockets.

Internal or external vibration is the most common way to consolidate concrete

- Curing the Concrete Slab along with Removing the Formwork:
- The concrete must be properly cured when the slab is finished (i.e., after pouring, compacting, and finishing).
- Water curing, ponding, or misting the concrete are all examples of slab curing procedures.

- Additional methods for keeping water include chemical membranes, waterproof paper or plastic film seals, and covers like sand or canvas that keep the slab surface moist continually.
- After 14 days, remove the formworks to allow the material to cure

CONCLUSIONS & FUTURE SCOPE

In a flat slab design, the beams are not used in the building process. Because the slab sits directly on the column, the weight is transmitted from the slab to the column and subsequently to the foundation. Columns sometimes have expanded heads called column heads or capitals, or the slab thickness at the supports with the column is raised, to sustain enormous loads. However, the need to withstand lateral stresses, such as wind and earthquake, grows in proportion to the building's height. Such towering buildings are a disaster waiting to happen. Because earthquake pressures are unexpected and random, it is important to study buildings that will be affected by them.

In this dissertation, we use STAAD Pro V8i software to conduct a response spectrum analysis on a fifteen-story building's structural systems in the event of an earthquake. In accordance with IS 1893(Part 1):2002, seismic measures will be performed.

The current task is associated with a particular strategy. Changes may be made in accordance with the following blueprint. The chosen plan is basic, rectangular, and does not have any openings. Accessible in both flat and standard slabs. Modifies slab behaviour significantly. Therefore, it is possible to study changes in behaviour by creating an aperture in the slab.The impact of plan imperfections on slab behaviour has been studied. The majority of structures with an uneven arrangement of columns often use re-entrant corners.

The ability of the slab to withstand punching shear is enhanced by adding column heads with drop panels, which also make the column more rigid. It is possible to study its influence on the slab's behaviour under lateral loads.

Since its behaviour under seismic pressure is unpredictable, research into flat slabs covers a lot of ground. So, research into various IS codes.

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