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Analysis of A Tall Structure Considering Precast Hollow, Flat and Pre-Tensioning Slab Considering Lateral Load Using ETABS : A Review

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ABSTRACT

A significant amount of the construction budget and national capital is spent on the construction of concrete building structures as the number of residential, commercial, and institutional buildings rises. Precast Hollow Core Slabs (HCS) have, however, proven to be more desirable than RCC slabs in recent years due to the demand for economical and quick construction, and they have been suggested as a workable substitute for RCC slabs.

In this paper presenting review of literature related to analysis of structure using analysis tool.

Keywords : Precast Hollow Core Slab, Storey Drift , Story Shear, Lateral Displacement

I. INTRODUCTION

It is the structural engineer's responsibility to make sure that the built environment can withstand strong dynamic events like wind, earthquakes and traffic. All Builders need to know how their built environment reacts to these dynamic actions. A direct result of earthquakes is that many people die from the collapse of structures and rubble, and in the long run, thousands of people lose their homes due to the collapse of buildings and the uncertainty and reconstruction process and the engineering department plan the direct consequence of these program by better the seismic response of building structures and working continuously to improve the seismic design.

A structure moves laterally and vertically during an earthquake due to surface ground motion driven on by seismic waves. Usually, the lateral motion is significantly greater than the vertical motion, and the ground is moving more rapidly (ag). This lateral motion causes the building to experience inertial forces, which are calculated as the sum of the structure's mass (m) and acceleration (a). According to Newton's Second Law (Force = Mass x Accleartion). Fundamentally, how a building structure reacts to an earthquake occurrence depends on its mass, size, and configuration.

Flat Slab

The term "flat slab" refers to a square slab known as "drop panels" that has a one- or two-sided support system, with the sheer force of the slab being concentrated on the supporting columns. Drop panels are crucial in this situation because they increase the overall strength and capacity of the flooring system beneath the vertical loads while also improving the construction's cost-effectiveness. Typically, the height of drop panels is double that of the slab.

For the majority of construction projects as well as asymmetrical column arrangements like curved or ramped floors, flat slabs are considered to be suitable. Applying flat slabs has various benefits, including flexibility in design arrangement, flat soffit, and depth solutions. Even though constructing flat slabs can be expensive, it allows architects and engineers tremendous architectural freedom. The use of flat slabs has numerous advantages, not only in terms of future design and layout effectiveness but also for the entire construction process, particularly for streamlining installation processes and cutting down on construction time. Avoid using drop panels as much as you can, and make the most of the thickness of flat slabs instead. In order to maintain the advantages of flat soffits for the floor surface and to guarantee that drop panels are cast as part of the column, this is necessary.

Fig 1 Flat Slab

II. LITERATURE REVIEW

Kamal Amin Chebo et.al (2022) The behaviour of a single span hollow core slab under sequential impact loads at the centre, edge, and close to the support under a 600 kg free falling steel ball from a height of 14 metres was examined in a study report. Investigated were the slab's structural responses to impact force, damping, acceleration reaction, and damage evaluation. A single span hollow core slab is tested in a large-scale experimental programme. The specimen has 6000 mm × 1200 mm × 200 mm dimensions with a 100 mm cast in a place topping slab. Results stated that concrete solid section behaves in a much better way than the hollow section in terms of structural damage and cracks generation. Filling material such as foam can be used to absorb a part of the energy induced in the body of the hollow core unit to mitigate the brittle fracture of the thin flanges, therefore enhancing the structural performance of the slab system. The impact load site in the hollow core slab was vulnerable, as evidenced by the damping ratio that was exhibited.

Vanteddu Satwika and Mohit Jaiswal (2022) In the research report, a flat slab was strengthened using the post tensioning approach. Comparing RCC flat slabs to post-tensioned flab slabs with various tendon profiles, both dispersed and banded tendons were used. The parameters were evaluated: thickness, supporting reactions, punching shear, and deflection as compared to conventional flat slabs. The models were constructed in accordance with ACI 318-14, and these slab models were developed using ETABS software.

The results indicate that post-tensioned flat slabs have better punching shear capacities even at deeper depths, leading to sections that are more economically sound. Lower deflection is another benefit of the inclusion of tendons.

In comparison to banded tendons, distributed tendons are more successful in reaching shallower depths. Because there was less dead weight in the post-tensioned flat slab, there were fewer support responses, which reduced the amount of construction materials needed. As a result, construction costs are lower. As a result of the lower support response for PT slabs, fewer sections and less reinforcement are required for the components that bear load from the slabs, such as columns and foundations, which lowers the cost of construction overall. By applying the post-tensioning approach, it is possible to raise the punching shear strength of a flat slab and do so even at shallower depths. By doing so, one of the main issues with the flat slab design is solved. By including post-tensioning tendons, downward deflections can be significantly decreased, resulting in good serviceability. The most efficient method, while taking into account the entire effectiveness of the flat slab, is the provision of dispersed tendons together with drop.

Dheekshith K and Prasad Naik (2021) research paper compared the response of RCC slab building and hollow core slab under the seismic load conditions for a G+9 storey structure modelled using analytical application ETABS considering shear walls on the sides. As hollow core slabs cannot be directly modelled by ETABS, Secondary Beams were adopted with the same dimensions as Hollow Core Slabs. The hollow core slab were modelled using ANSYS(Analysis of Systems software). Three models were evaluated for each RCC building in Zones 3, 4, and 5 and for each common ceiling structure.

Results stated that storey displacement increased for hollow core slab compared to RCC structure. Hollow core slab building acceleration in Storey is lower relative to the RCC building in the X direction, while it was higher in the Y direction. When compared to RCC building, hollow core slab construction takes less time and has less storey drift. In comparison to RCC construction, hollow core slab construction has a lower base shear since the building is lighter.

Omar Ahmad (2021) In a research work, a cost comparison of post-tensioned and reinforced concrete flat slabs was presented. According to the article, less concrete is needed for post-tension slabs than for flat slabs because the post-tension slabs are thinner and there are fewer columns provided. After the concrete is cast, special steel tendons that were utilised in post-tensioned slabs are extended by a hydraulic jack, and thus reduces the need for reinforcement steel bars. Although only post-tension slabs use tendons, there is less steel used in post-tension slabs than in flat slabs. The cost of the contractor's work varies depending on whether a flat slab or a post-tensioned slab is being built. The amount of concrete, steel, and contractor work costs were compared for the study.

Post-tension slabs are less expensive, according to the comparison study's findings between them and flat slabs of reinforced concrete.

E. Michelini et.al (2020) research paper conducted an experimental and numerical research on precast prestressed deep HCS subjected to flexure and shear. The work was structured

in two main phases as execution of 4 experimental tests on a 500 mm deep HCS (two in flexure and two in shear) and further, validation of the adopted numerical procedure,

which takes into account the material non-linearity by means of 2D-PARC model, through a detailed comparison with experimental results.

Conclusion stated that the adopted numerical procedure, based on fracture mechanics principles, represents a rational technique for analyzing cracking development and propagation in deep HCS.

Vinod Shukla and Dr. Pankaj Singh (2020) objective of the research was to compare depth of two- way slab, flat slab, grid slab and post tensioned slabs, compare material quantities of two- way slab, flat slab, grid slab and post tensioned slabs and the cost for various types of slabs such as two- way slab, flat slab, grid slab and post tensioned slabs. The two-way slab, flat slab and grid slab is designed according to IS 456: 2000 and post tension slab was designed according to IS1343-1987.

Results stated that grid slab requires less depth with 41mm and flat slab has high depth of slab with 365mm. Post tension slab requires less cement of 1800 kg and grid slab requires more cement with an amount of 7723 kg. Post tension slab requires less fine aggregates of 1.88 and grid slab requires a high amount of fine aggregates with 7.69. Solid slab requires less coarse aggregate of 3.72 and grid slab requires high amount of coarse aggregate with 15.38. Grid slab requires less steel of 53.26 kg and flat slab requires a high amount of steel with 1,243.306 kg. Considering the factors like depth of the slab, cement, fine aggregate, coarse aggregate and steel requirements, it was concluded that post tensioned slab requires less amount of Rs. 32,917/- for the construction and Flat slab requires high amount of Rs.1,24,106/-.

Abhishek R. Pandharipande and N. J. Pathak (2019) The purpose of the research paper was to determine whether hollow plastic balls could be used in a slab of reinforced concrete. The scope of the research includes doing analytical and experimental work to compare the flexural behaviour and strength of conventional and light weight slabs. The three types of slab specimens that were cast have dimensions of 750 mm X 500 mm X 150 mm: normal slab, B.D.S. of 50 mm diameter, and B.D.S. of 100 mm diameter. Slab specimens were tested using one point line loading on a universal testing equipment. Utilizing ANSYS WORKBENCH 16.0, finite element analysis on slab specimens is also performed.

Results concluded that a Bubble deck slab of 50 mm and 100 mm diameter can be used in practice, as the deflection values of the particular slabs are within the permissible limit as stated in IS Code.

Atif Zakaria et.al (2019) research paper presented analysis of multistoried RCC buildings (4,6,8 Storey) considering building system as OMRF with ductile shear wall and adopting ribbed slab and grid (waffle) slab where the used analysis methods was Equivalent Static Method, Response Spectrum Analysis, and Time History Analysis as per IS: 1893-2002 part-I: Criteria for Earthquake resistant structure.

Results stated that Grid slab building has a better seismic response than ribbed slab building. When the total height of the structure increases the base shear, displacement, Storey shear and drift increases simultaneously. In OMRF building shear wall takes the immense percentage of the base shear and the storey shear. Approximately above 95% from the load would be withstood by shear walls.

Soubhagya Ranjan Rath et.al (2019) in the research paper, model of the Multi-storey tall structure has been created in ETABS as per architectural layout. Materials and concrete sections were defined including core walls and slabs and load cases and other parameters to the model was assigned. For the detailed slab analysis and design comparison, it has been imported to SAFE software. Assigning and checking for slab properties, load cases and design parameters for different types of slabs including Post tensioned tendons. The slab models were analysed and designed for further parametric comparison in case of PT flat slab, conventional and even for normal flat slab.

Results stated that PT flat slab system has greater flexibility than conventional system due to more quantity of story displacement in case of seismic analysis but in PT flat slab perimeter beams are provided to maintain the structure from earthquake load. Normal flat slab results in more magnitude of slab displacement than conventional slab but the post-tensioned flat slab results in 7%-10% lesser slab displacement than the conventional system. Flat slab and PT flat slab systems have an equal reaction force on columns and 28% lesser than the conventional system. Considering slab forces, PT flat slab results in almost 60% lesser force than compared to the normal conventional slab. Normal flat results even more force than a normal slab.

Umamaheswara Rao Tallapalem et.al (2019) The three forms of Beam-column connections—rigid, semi-rigid, and hinged—were created in the study paper for use in G+20 high-rise buildings. To identify the behaviour of the connections in these high-rise buildings, time histories of high seismic waves, moderate seismic waves, and low seismic waves were analysed. The results of top displacements, story drifts, and inter-storey drifts were compared for the various connections and various seismic waves. The model was prepared using staad.pro software with three types of Precast joint connection such as Rigid Connection, Semi Rigid connection and Hinged connection.

Results stated that lower earthquakes maximum inter storey drift for hinged connections are nine times higher than the semirigid connections. It may lead to nine times higher assumptions than existing one. Rigid connections were 1.81 times lesser than the Semi-Rigid connection. It may lead to lower assumptions 1.81 times than existing one. Finally in Major Earthquake affected areas and Low Earthquake affected areas Hinged connections are assumed to Approximately 10 times higher consideration than Semi Rigid connections. For moderated earthquake affected areas rigid connections and Semi Rigid connections behave nearly the same.

Jay Vekariya et.al (2018) research paper presented analysis and design of the post-tensioned flat slab with drop panel and post tensioned voided slab using the ADAPT BUILDER 2015.

According to the results, a voided slab has a lower self-weight than a solid slab, so by adding a voided portion of 35 percent to a solid slab, deflection can be reduced by up to 19 percent. 2. By offering voided flat slab system punching shear reduction up to 23 percent, the flat slab system was able to significantly reduce a major issue with punching shear. Comparing a voided slab to a solid flat slab, fewer tendons were used to manage deflection and load. By offering a 35 percent voided slab, the slab's self-weight was lowered by up to 13 percent.

Jnanesh Reddy R K and Pradeep A R (2017) In a research report, the economic effectiveness of reinforced concrete and post-tensioned flat slab systems were examined. Both systems were examined using the design methodology-based analysis tools RAPT and ETABS, respectively. The building was designed using the ETABS, and the model used has a basement, ground level, and four stories with measurements of 38.13 m by 28.85 m with the biggest spans of 9.44 m by 6.16 m. (flat slab). The column is 750*750 mm in size. For columns, beams, and slabs, M30 grade concrete and Fe415 grade rebar are taken into consideration. Slab has a live load of 5 kn/m2 and is loaded for self-weight (as per IS 875 part 2).

According to the results, 330 m3 of concrete was required for the construction of a R.C.C. flat slab with edge beams and 247 m3 for a PT slab with drop panels. The cost of the steel needed for the construction of the R.C.C. Flat Slab was Rs. 3915751, and the cost of the steel and tendons needed for the construction of the PT Slab is Rs. 3445148. Additionally, the outcomes showed that Post Tensioned flat slabs are less expensive than RCC slab systems.

Kamal Padhiar et.al (2017) in the research paper, two different floor post-tensioning floor systems was considered, they were flat slab and flat slab with drop panels. Four spans were considered for the equivalent frame system to evaluate structural parameters like concrete grade M35 to M50. Two different span to depth ratio used for flat plate slab and flat slab with drop panel. Dead load due to self weight of the structure, live load and post- tensioned load was considered for the analysis. Grade of concrete directly influencing the deflection &Non PT steel(conventional steel) of flat plate. With changing grade of concrete, effect of punching shear ratio, factored moment at mid span and PT quantity was investigated and the design was conducted using the computer analysis program ADAPT-PT.

Required quantity of PT steel in case of flat plate slab is 5-10% more than flat slab with drop panel for different span. But it is not increased by changing the grade of concrete for each span. In both types of geometry for the same span with increasing grade of concrete, the quantity of non PT steel is reduced by 5-10%. But for the same grade of concrete having the same span, the quantity of non PT steel in case of flat plate slab is 40-50% more than the flat slab with drop panel. Conclusion stated that that flat plate slab was suitable and economical up to 8.0 meter span. If necessity of span more than 8.0 meter and above up to 13 meter flat slab with drop panel gives economy.

Mohammed Imran et.al (2017) The goal of the research paper was to examine and evaluate the seismic behaviour of RCC flat slabs and post-tensioned slabs using the linear time history analysis methodology that is a core component of the Etabs 2015 programme in India's Zones 2 and 3. Various types of Buildings with G+9, G+11, G+14, G+19 and G+24 storeys were considered with differences in geometrical properties and material properties. The goal was to examine how these constructions behaved for various factors, including lateral displacement, interstory drift, axial force, and storey shear.

Results showed that post tensioned flat slabs performed better under seismic loading than flat slabs, although post tensioned slab construction is becoming more and more common since it shares many of the same advantages. The weight reduction, speed, economy, and most crucially, shorter building time, are all much enhanced; it is highly popular, especially for commercial spaces. The thickness of the slab and the size of the columns may be increased to further enhance the results of the flat slab under seismic and thermal loads.

Prasad Bhamare et.al (2017) Research paper investigated many precast concepts in depth, read a lot of literature, and discovered relevant data. One building was used as an example, and designs for both traditional cast-in-place buildings and precast buildings were taken into consideration. On the basis of price and duration, a feasibility check and cost analysis were conducted.

The precast concrete technology was found to be more cost-effective than the traditional cast-in-place approach, although there are still some considerations when utilising precast, such as the volume of construction and the site's distance from the manufacturing facility. Precast is the ideal alternative to select for routine and repetitive work, regardless of the type of construction, etc. The most crucial aspect of precast construction to be evaluated in an observational study is how quickly it can be built. It needs trained contractors and skilled workers, and the beginning cost is lower for bigger projects. Precast's biggest drawback is transportation from the manufacturing location to the installation site.

V. G. Mutalik Desai and Mohammad J. Shaikh (2016) In a research paper, analysis and behaviour of a post-tensioned flat slab were given. SAFE was used to model and analyse both flat slabs and PT flat slabs. The PT slab was examined using 12.7 dia and 9.5 dia 7 ply high tensile steel strands for post-tensioning. A slab panel measuring 8 by 12 metres was modelled for several scenarios and given the appropriate attributes. The slab was separated into centre and column segments. Drops were placed along the column strip in both flat slab and PT flat slab, and the results were compared in terms of deflection, punching, moment, and stresses.

In terms of project cost, stability, and longevity, PT flat slab demonstrates that it might be a superior choice than flat slab.

Supriya T J and Praveen J V (2014) Precast hollow core slab behaviour in high rise buildings was examined in a study article. Using the equivalent static approach and the Response spectrum method, five models of hollow core slab buildings with various member sizes are examined for seismic zone IV. These structures feature a specific moment-resisting concrete frame with ductile shear walls as their structural system. There have been five different hollow core slab construction models tested using various member sizes. According to the advice of IS: 1893(Part 1):2002, static analysis was performed using the equivalent static approach, and dynamic analysis was performed using the response spectrum method.

According to the results, for various seismic zones, hollow core slab buildings had lower base shear than solid slab buildings. In comparison to solid slab buildings, storey drift is higher in hollow core slab buildings. As a result, hollow core slab construction uses less material than solid slab construction. As a result, hollow core slab construction is preferable to solid slab construction.

Renee A Lindsay et.al (2004) A full-scale precast concrete super-assemblage was built in the lab and tested twice as part of the study report. The investigation of existing structure in the first stage revealed significant flaws in construction technique that would result in very poor seismic performance. The findings from the second stage, which examines the impact of improved construction details on seismic performance, are presented in this paper. The new details include a straightforward (pinned type) connection system with compressible material for the supporting beams and a low friction bearing strip, as well as a 750 mm wide timber infill between the perimeter beams and the first precast floor unit.

According to test results, the new connection detail performs significantly better than the current standard construction details, with relatively little damage to the frame and flooring system at high lateral drift levels. The findings demonstrate that, with the increased detailing, interstorey drifts more than 3.0 percent may be maintained without losing support for the floor units. Hysteretic performance is used to gauge the super-overall assembly's performance, while drift damage is used to categorise fragility implications.

III. Conclusion

The seismic behavior of multi-storied building frame during an earthquake motion depends upon the distribution of strength, mass and stiffness in both horizontal and vertical planes. All models are analyzed by using design and analysis software ETABS or SAP and designed as per IS 456:2000 and IS 1893:2002. Push over analysis is a non linear static analysis had been used to obtain the inelastic deformation capability of frame. Only non-linear dynamic analysis is more accurate than pushover analysis; where non-linear dynamic analysis is time taking to perform. In order to obtain dynamic response of the structure, Time history analysis is carried out. So we can conclude that pushover analysis is the appropriate method to use for performance based design to get the response of the structures. Boskey Bahoria gives the idea about the post tensioned flat slab building structure having four cases depending upon by varying the span length by 0.5 m interval and discuss the comparative study of four cases with respect to economy.U. Prawatwong makes a two models one with drop panel shows the connections between slab-column and another is without drop panel shows connection between interior columns with PT flat plate and bonded tendons having seismic performance on two three fifth scale pattern under constant gravity load to investigate the seismic performance. Using the RAPT and ETABS softwares, Jnanesh Reddy RK examines the cost effectiveness of the post-tensioned flat slab with respect to the RCC flat slab, concluding that the PT flat slab is preferable to the RCC flat slab since it lowered the dead load by reducing slab thickness.

The drop panels and columns only provide a direct support for the slab in certain construction styles, according to the summary. Floor to floor height of the building decreases as a result of direct support from drop panels and building columns, making more space accessible for our usage. When we compare a flat pt slab to a regular slab, the results show that the cost and reinforcement are both 30% higher for the conventional slab. Due to the beam's ability to handle a greater load, the post-tensioning slab required more reinforcing. Formwork can be removed early when post tensioning with a reinforcement beam, however it cannot be removed earlier in a usual situation. More concrete is needed for one level in a PT slab with a reinforced concrete beam than in a PT slab alone.

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