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A REVIEW OF DESIGN OF FLAT SLAB & IT'S COMPARISION WITH POST-TENSIONED FLAT SLAB

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Abstract—*Beam less floor directly resting on support (column and/ wall) is known as at slab. Because of this, large bending moment and shear force is developed in the slab, near the column, these stresses produce concrete cracking and may lead to the slab failure, hence there is a need to increase the area at top of column to withstand the stresses. This enlarged truncated portion at the top of column is known as column head/ column capital.*

Flat slabs are subjected to gravity and lateral loads. Gravity load analysis of flat slab is carried out by Direct Design Method (DDM) and Equivalent Frame Method (EFM) as prescribed by different standards, however finite element analysis and equivalent frame method of at slab is carried out for gravity loads using software SAFE (Slab Analysis by Finite Element Method and Equivalent Frame Method).

Keywords- *flat slab, post-tensioning, prestressing*

I. INTRODUCTION

Although the introduction of Reinforced Concrete flat slab floors is a significant advancement in the building technology, historical literature on their development is ambiguous. Up to 1910- 1911 slab, beam and girder system reigned supreme but at this time the girderless floors sometimes called as Mushroom slab, which is also known as flat slab begin to build. Claud A. P. Turner was one of the early advocates of flat slab system known as "mushroom" system. About 1908, flat slab began and recognized as acceptable floor system. Flat slabs are being used mainly in office buildings due to reduced formwork cost, fast excavation, and easy installation. Flat slab system possesses many advantages in terms of architectural flexibility, use of space, easier formwork, and shorter construction time. One of the key aspects of successful planning is the constructability of the building. This is of paramount importance for the success of the project since constructability most markedly affects the time to completion of a turn-key project and thus the final cost to the owner. If we see the total cost of the building, only the structural cost is about 30 to 50% of the total construction cost and on the other hand more than half of the structural cost is labour cost, related mainly to formwork.

II. LITERATURE REVIEW:

A. Y.H. LUO, A. DURANI AND J. CONTE, "SEISMIC RELIABILITY ASSESSMENT OF R.C. FLAT SLAB BUILDINGS" JOURNAL OF STRUCTURAL ENGINEERING, VOL.121, NO.10, OCTOBER 1995, ASCE, PP.1522-1530

Y.H. Luo, A. Durrani and J. Conte presents the analytical approach to assess the vulnerability of reinforced concrete flat slab buildings subjected to earthquakes and the analysis was carried out for typical 3 and 10 storey flat slab building in which the detailing is made as per older flat slab buildings. Author used general purpose reliability analysis program CALREL.
The 1st and 2nd order reliability method (FORM/ SORM) were used for static loading and simulation technique such as Monte Carlo method was used for dynamic loading.

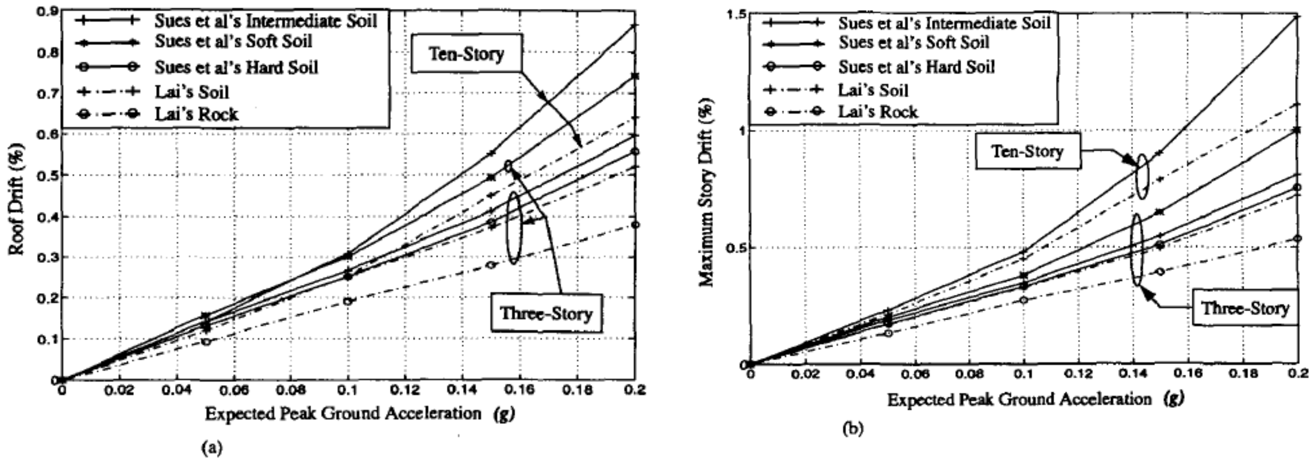

Figure 1: Expected drift levels for different ground accelerations: (a) roof drift versus ground accelerations; (b) maximum storey drift versus ground accelerations

Author concluded that low probability of failure affirms the safety of those buildings under pure gravity loads while under seismic loading probability of punching failure increased with increasing expected Peak Ground Acceleration and number of storey in buildings. Local soil conditions have also significant effect on probability of punching failure.The study indicated that probability of failure of flat slab buildings on soft soils was about 1.5 times the probability of failure on hard soils.

B. A. C. SCORDELIS, T. Y. LIN AND R. ITAYA, "BEHAVIOR OF A CONTINUOUS SLAB PRESTRESSED IN TWO DIRECTIONS", ACI JOURNAL, DECEMBER 1959

Elastic behavior and ultimate strength of a continuous concrete slab prestressed in two directions were investigated by **A.C. Scordelis, T.Y. Lin and R. Itaya**. The slab, consisting of four panels, supported at nine points and simulated a flat slab. Prestressing was accomplished by means of unbonded post-tensioned cables. Experimental values for moments, deflections, and reactions were compared with theoretical values. The elastic plate theory and approximate theories were used for calculating the values of moment, deflection and the reactions in present design method. The purpose of this investigation was to determine the behavior, through and above the elastic range, of a continuous concrete slab prestressed in two directions.
For this study a 15ft x 15ft slab 3in. thick and supported at nine points was prestressed. The slab was post-tensioned with 12 cables in each direction, spaced at 15in. on centers. Each cable consist of a single ¼ in. high strength steel wires greased and placed in a plastic tube to provide for post-tensioning. The concrete for the slab was proportioned for a minimum strength of 35 N/mm^2 at 28 days. Cable prestress was applied by a 30-ton capacity hydraulic jack. For slab uniform load had been provided on each of the four panels independently. For that air bags and plywood sheathing supported with steel framing was used.
Uniform load is applied to the slab. The test on the slab consisted of subjecting it to an increasing uniform live load on all four panels until failure. The first tensile crack, as indicated by strain readings, seems to have occurred over the center support. Cracks were then observed at the edges of the slab. The first cracks on the bottom of the slab were began at the edges of the slab and extended inward about 2 ft. On further increasing load, the crack opened to 1/8 in. wide and extended across the width of slab. After flexural cracking, ultimate failure occurred at a further increase in the load, with the center support punching through the slab. The failure occurred directly around the edges of the 9 x 9 in. center support at a shear angle of about 45^0.
On the basis of the studies carried out, the following conclusions are made

- The elastic plate theory may be used satisfactorily to predict the behavior of a prestressed concrete slab loaded within the elastic range.
- The cracking load has little practical significance since initial cracking is localized at points of high moments. The slab can sustain large increase in load before widespread cracking takes place.
- Moments due to only equal prestress in all cables can be calculated with sufficient accuracy for design purposes by the beam method.
- A quantitative study of the results indicates that for elastic behavior under uniform load the total negative moment calculated by the beam method should be distributed approximately 75% to column strips and 25% to the middle strips, while the total positive moment calculated by beam method should be distributed approximately 60% to the column strips and 40% to the middle strips.

- Deflections under uniform load obtained by the beam method are within 15% of those obtained experimentally of by the elastic plate theory.
- For the design live loads acting on one panel only, in combination with dead load and uniform prestress, small and relatively insignificant tensile stresses are produced in the slab.

C. DOUGLAS A. FOUTCH, WILLIAM L. GAMBLE AND HARIANTO SUNIDJA, "TESTS OF POST-TENSIONED CONCRETE SLAB-EDGE COLUMN CONNECTIONS", ACI STRUCTURAL JOURNAL, MARCH-APRIL 1990

In a typical slab carrying gravity loads, shear and unbalanced moment will be present at the edge –column connections. The transfer of unbalanced bending moment causes the distribution of shear stress in the slab around the column to become nonuniform and reduces the shear strength of the connection. In tests of post-tensioned concrete slab-edge column connections by **Douglas A. Foutch** and **William L. Gamble**, they carried out experimental investigation to study the strength and behavior of prestressed slab-edge column connections with unbonded tendons under the static loading. For this they constructed four two-third scale models of slab-edge columns among which two specimens had many closely spaced tendons while the other two had only a few widely spaced tendons. Each slab consist of 1524 mm square prestressed concrete slab 100 mm thick and 300 mm square column located adjacent to and centered along the edge of slab. The geometry of each specimen is symmetrical. 10 mm deformed bars were used as bonded reinforcement in the vicinity of column for crack control as recommended by the code. After casting of specimens they were post-tensioned after seven days. The tendons were prestressed individually using 270 KN hydraulic jacks.

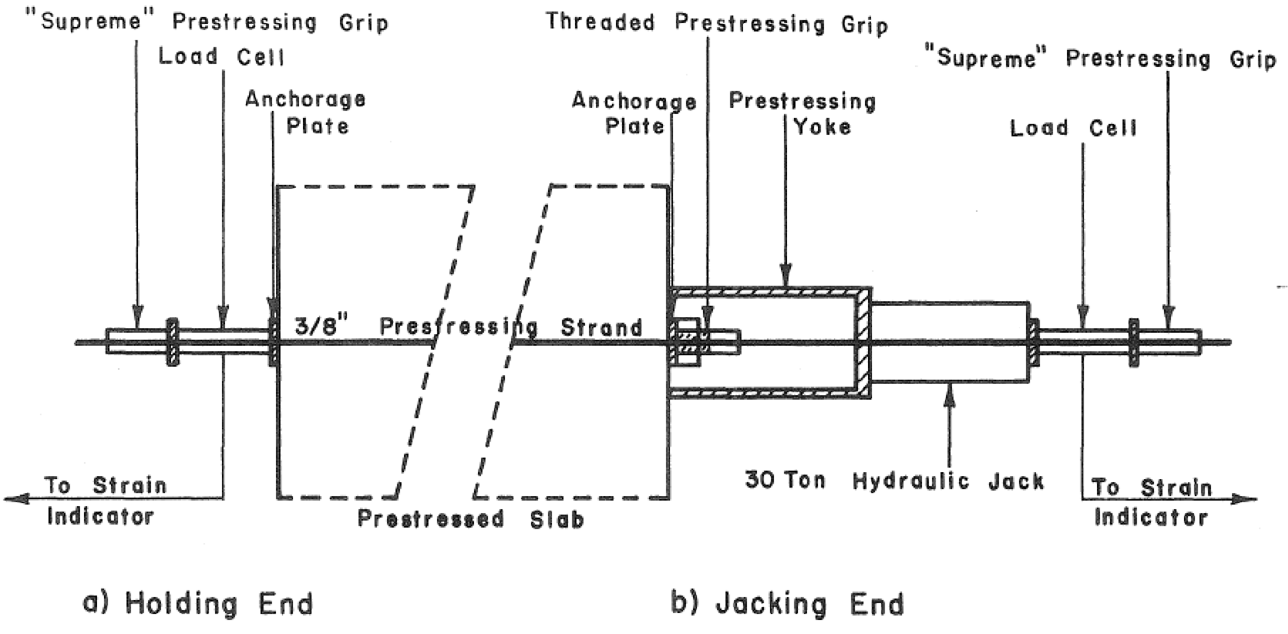

Figure 2: Prestressing setup by holding and jacking ends

By applying the loads, the specimens were tested and different readings were taken with the help of dial gauges. The moment, shear and edge deflection for each specimen is calculated from the experiment data. The moment capacity obtained by the experiment is larger than the calculated moment capacity for each specimen. The some conclusions made on the basis of the experiment are as follows

- It is apparent that considerable rotation occurs at the face of the column and this made the largest contribution to the edge displacement.
- The section contains both post-tensioned unbonded tendons and bonded 10mm reinforcing bars; these both made the significant contribution in the moment capacity.
- It has been recognized that the shear strength of a slab-column connection cannot be considered independently of the flexural behavior.
- All the specimens resisted the larger forces than predicted on the basis of limiting shear stress.
- The moment deflection behavior was linear to the first cracking point. Thereafter, the stiffness of the slab decreased gradually to the point of yielding of the bonded steel. And after yielding of steel occurred, the stiffness of the slab decreased more rapidly.

- As the ultimate moment was approached, crushing began to develop at the intersection of the bottom surface of the slab and the column face.
- The first crack was developed at the face of the column and then it increases towards the other end of the slab.
- The average stress increase across the width of slab ranged from 65 to 81% if the maximum stress increase.
- The failures of the two different specimens are different i.e. for the first two specimens (with closely spaced tendons) fail in flexure and other two (with widely spaced tendons) fail in shear.

III. CONCLUSION:

All the above reviews conclude that the flat slab has many advantages if they analyzed and successfully designed against failure and cracking for achieving high strength and it is much suitable with post-tensioning for construction and stability for large column free area comparison with other structure and also economical compared to others. The SAFE software is available in market so we can analyze the flat slab with post tensioning.

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