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THE SIMULATION STUDY ON RCC SOLID SLABS INFLUENCED WITH TORSIONAL REINFORCEMENT AND DIVERSE END CONDITIONS USING ANN TECHNIQUES

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ABSTRACT: Torsion reinforcement shall be provided at any corner where the slab is simply supported on both edges meeting at that corner and is prevented from lifting unless the consequences of cracking are negligible. It shall consist of top and bottom reinforcement, each with layer of bars placed parallel to the sides of the slab and extending from the edges a minimum distance of one fifth of the shorter span. The area of reinforcement per unit width in each of these four layers shall be three quarters of the area required for the maximum mid-span moment per unit width in the slab. By providing torsion reinforcement, corners are usually prevented from being lifted up. In such cases corners have to be suitably reinforced at top and also at bottom otherwise cracks are liable to be formed at the corners Reinforcement detailing of a slab is done based on its support conditions. Slab may be supported on walls or beams or columns. Slab supported directly by columns are called flat slab. Slab supported on two sides and bending takes place predominantly in one direction only is called One Way Slab. On the other hand, when slab is supported on all four sides and bending take place in two directions are said to be Two Way Slab. The slabs having ratio of longer length to its shorter length (Ly/Lx) greater than 2 is called one way slab otherwise as two way slab. In one way slab main reinforcement is parallel to shorter direction and the reinforcement parallel to longer direction is called distribution steel. In two ways slab main reinforcement is provided along both directions. Slabs could be simply supported, continuous or cantilever. In two way slab the corners may be held down by restraints or may be allowed to lift up. Concrete slabs, however, are still common in use as floors in multi-storey buildings.

I. EXPERIMENTAL WORK

With the observation made from the I phase of the work, 6 slabs were casted and tested with the size of 1500mm x 1500 mm x 60 mm. The torsion reinforcement is provided in form or layers of reinforcement space at required interval to a distance of 1/5 of the span of the slab form the corner of the slab. Here slab with various torsion reinforcement was cast using M20 grade of concrete. Slabs with torsion reinforcement varying from 0%,20%,25%,30%, 35% and 75% of the main reinforcement required for short span bending moment were casted and tested. Slabs were tested with the end condition all edges discontinuous with varying percentage of torsional reinforcement and the corner uplift and central deflection were measured.

TESTING AND INSTRUMENTATION Preparation of specimens before testing

Each specimen was removed from the curing yard in the previous day of the day of testing manually and it was white washed. Then the slab was lifted and erected in position for testing.

Loading frame

The slabs were tested in a 100 ton capacity self straining loading frame. The applied jack load was measured by means of proving ring of 15 ton capacity. The magnitude of the applied load was obtained from the calibration chart of the proving ring.

Test set up

The test set up is shown in Figs 4.2. Each slab was simply supported on framework made of ISMC 300 with 10cm bearing on all the sides while the corners of the channels were supported by concrete cubes of size 150 mm x 150 mm x 150 mm. Three concrete cubes were placed as a column to raise the frame work to a height of 450 mm so that we can fix the LVDT under the slab to measure the central deflection of the slab. In uniformly distributed load, top surface of the slab was filled with sand to a height of 10cm to have uniform distribution of load on the slab. Over the sand filling, cubes were arranged in pyramidal shape. Load was applied through mechanically operated hydraulic jack of capacity 15 ton on the top layer of the cubes. To avoid the punching effect of the hydraulic jack, steel plates were used.

Measurement of deflections

The central deflection was measured by LVDT fixed at centre of the slab in the bottom region. And the corner lift was measured by the dial gauges of least count 0.01.Marking of the first crack

Crack patterns were observed manually during loading. The first crack was noted and the place where it initiated was marked. The corresponding loading was also noted down.

Marking of the crack patterns

The slab was removed immediately after the testing and the crack lines were marked.

Testing on companion specimens

Cubes of size 150mm that had been cast along with the slabs were tested on the same day on which the respective slabs were tested to ascertain the compressive strength of the concrete used in the slabs. The cube test were carried out in a Compression Testing machine of 300 tone capacity and these tests were carried out as per IS code recommendation.

II. RESULTS AND DISCUSSION

CORNER UPLIFT AND CENTRAL DEFLECTION OF SLABS WITH THE END CONDITIONALL EDGES DISCONTINUOUS

Slabs were casted and tested with the size of 1500mm x 1500 mm x 60 mm with torsion reinforcement varying from 0%, 20%, 25%, 30%, 35% and 75% of the main reinforcement required for short span bending moment with the end conditions of all ends discontinuous, two ends discontinuous and other ends continuous, one end discontinuous and other ends continuous were casted and tested and the cubic compression strength was found to be 24.35N/mm^2, 24.98N/mm^2 and 24.8 N/mm^2 respectively along with diverse load and Torsion reinforcement in order to retrieve corner uplift for all corners and central deflection. In this chapter the Slabs with torsion reinforcement varying from 0%, 20%, 25%, 30%, 35% and 75% of the main reinforcement required for short span bending moment with the end conditions of all ends discontinuous are discussed.

Load Vs Corner Uplift at Corner A

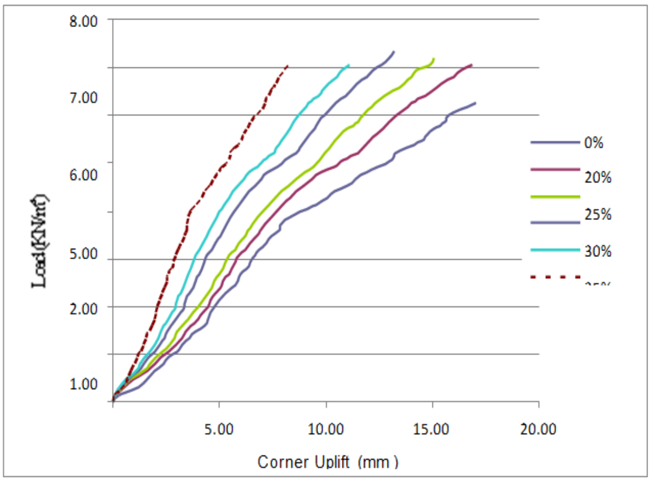

Fig Load Vs Corner Uplift at Corner A

By varying the percentage of torsional reinforcement 0%, 20%,25%,30%,35% and 75%, and increasing the load from 0 to 7.33 KN, central deflections and all corner uplift (A, B, C and D) are measured. The average cube compression strength attained from the specimens tested was 24.35 N/mm^2. In figure , it is shown that the load Vs corner uplift of the corner A varies for each torsion reinforcement percentage 0%, 20%, 25%, 30%, 35%, and 75%. The uplift of the corner starts at a load of 0.13KN/m^2 and the maximum uplift is obtained at ultimate loads. When the load increases, the corner uplift also increases. As compared, with increase in the percentages of torsion reinforcement, there is a reduction in the central deflection and the corner uplift, but when the percentage of torsion reinforcement increases, the load carrying capacity of the slab also increases. The load basics vary only when the corner uplift varies. In the corner A, the corner uplift is 0.31mm for the applied load of 0.13KN/m^2. When the variation in load is from 0.40 to 0.53 the corner uplift difference is 21% and if the load varies the corner difference also varies. As the Load increases from 6.0KN/m^2 to 6.13KN/m^2,in 0% torsion reinforcement the corner uplift difference is 56%. When the torsional reinforcement percentage is increased, the corner uplift is decreased. When the load of 0.13KN/m^2 is applied the corner uplift is 0.41mmfor the torsional reinforcement of 20%. In 25% torsional reinforcement, for the load of 0.13KN/m^2, the corner uplift is 0.12mm and from 25% to 30%, when the load is 0.47KN/m^2 the corner uplift is 2% and in 75% the load attains the minimized corner uplift.

Load Vs Corner Uplift at Corner B

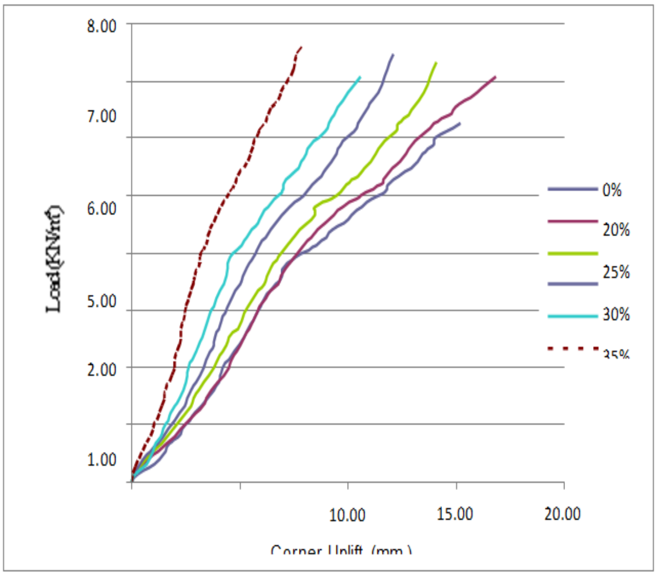

Fig Load Vs Corner Uplift at Corner B

In figure4.8, it is shown that the load Vs corner uplift of the corner B varies for each torsion reinforcement percentage 0%, 20%, 25%, 30%, 35%, and 75%. The uplift of corner starts at a load of 0.13KN/m^2 and the maximum uplift are obtained at ultimate loads. In the corner B for the load applied 0.13KN/m^2, corner uplift is 0.31mm and the load is increased to 0.27 KN/m^2, 0.40 KN/m^2 etc. When the variation in from 0.13 KN/m^2 to 0.27KN/m^2 the corner uplift difference is 54% and thus when the load varies the corner uplift difference also varies. As the Load increases from 6.0 KN/m^2 to 6.13 KN/m^2, for torsional reinforcement of 0% the corner uplift difference becomes 50%. When the torsional reinforcement percentage is increased, the corner uplift is decreased. For the load 0.13 KN/m^2 applied, the torsional reinforcement of 20% the corner uplift is 0.46mm. In 25% torsional reinforcement the corner uplift is 0.44mm and when it increases from 25% to 30% with the load 0.13 KN/m^2 the corner uplift is 30%. In 75% then the load attains only the minimized corner uplift.

Load Vs Corner Uplift at Corner C

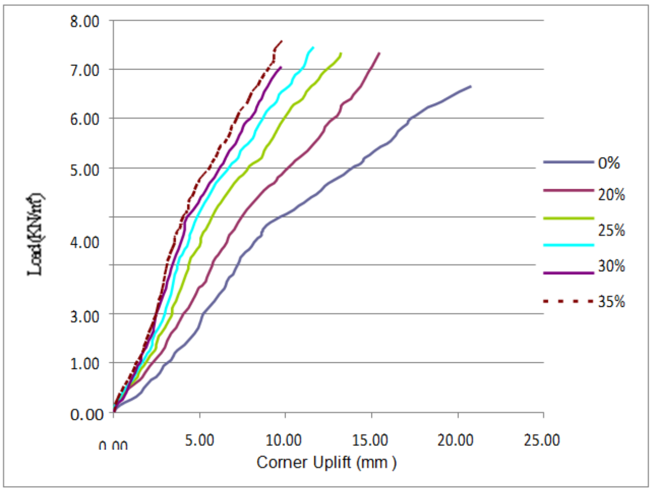

Fig Load Vs Corner Uplift At Corner C

In figure, it is shown that the load Vs corner uplift of the corner C varies for each torsion reinforcement percentage 0%, 20%, 25%, 30%, 35%, and 75%. The Uplift of corner starts at a load of 0.13KN/m^2 and the maximum uplift are obtained at ultimate loads. In the corner C for the load applied 0.13KN/$m^2$the corner uplift is 0.34mm, then the load is increased as 0.27KN/m^2, 0.40KN/m^2, 0.53KN/m^2, 0.6KN/m^2 etc. When the variation in load is from 0.13KN/m^2 to 0.27KN/m^2 the corner uplift difference is 67% and if the load varies the difference also varies. As the Load increases from 6.0KN/m^2 to 6.13KN/m^2, in 0% torsional reinforcement the corner uplift difference becomes 54%. When torsional reinforcement percentage is increased, the corner uplift is decreased. For the load 0.53KN/m^2, the torsional reinforcement of 75% the corner uplift is 0.58mm. When torsional reinforcement is varied from 25% to 30% and the load is 0.93 the corner uplift is 21%. In 75% the load attains the minimized corner uplift.

Load Vs Corner Uplift at Corner D

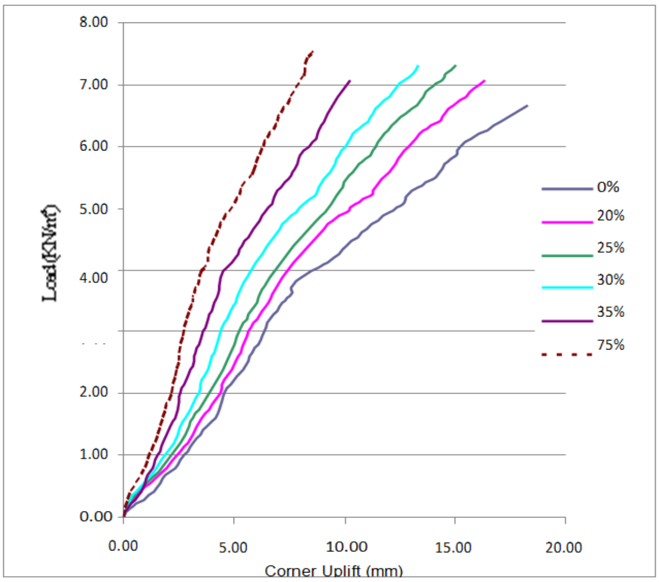

Fig Load Vs Corner Uplift at Corner D

In figure 4.10it is shown that the load Vs corner uplift of the corner D varies for each torsion reinforcement percentage 0%, 20%, 25%, 30%, 35%, and 75%. The Uplift of corner starts at a load of 0.13KN/m^2 and the maximum uplift are obtained at ultimate loads. In corner D, for the load applied 0.13KN/m^2 the corner uplift is found to be 0.30mm and the load is increased. When the variation in load is from 0.13KN/m^2 to 0.27KN/m^2, the corner uplift difference is 67% and if the load varies, the difference also varies. As Load increases from 6.0KN/m^2 to 6.13KN/m^2 the corner uplift difference becomes 52%. When the torsional reinforcement percentage is increased, the corner uplift is decreased. For the load 0.53KN/m^2applied at the torsional reinforcement 75%, the corner uplift is 0.58mm and for 25% to 30% of torsional reinforcement with the load at 0.93KN/m^2, the corner uplift is 23%. In 75% then the load attains only the minimized corner uplift.

Load Vs Central Deflection

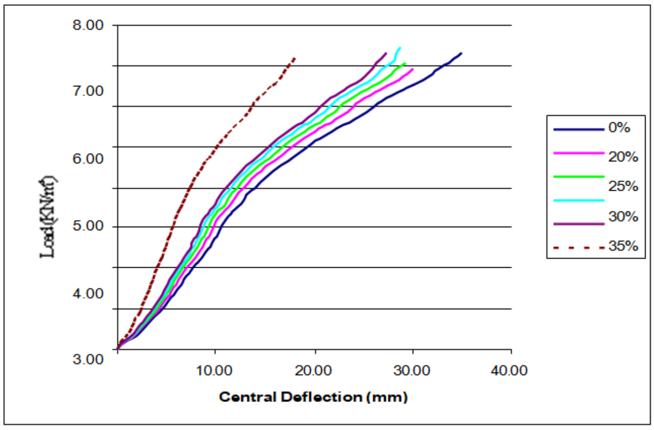

Fig Load Vs Central Deflection

Figure shows the Load Vs central deflection of the slabs with end condition of all ends discontinuous. If the load increases, the central deflection also increases. Maximum central deflection of 28.76 mm is reached at ultimate load. As the percentage of torsion reinforcement increases there is corresponding decrease in central deflection. Central deflection of a slab starts from the load 0.13KN/m^2. As the percentage of torsional reinforcement increases, the central deflection decreases. For load applied 0.13KN/m^2, the central deflection is 0.50mmin 0% torsion reinforcement, whereas in 75% the central deflection is 0.26mm for the same load. For the load applied 7.33 KN/m^2, in 0% the central deflection is 34.90mm. As Load increases from 6.0KN/m^2 to 6.13KN/m^2 the central deflection difference becomes 79%. When the torsional reinforcement percentage is increased, central deflection is decreased. In the load 0.53KN/m^2 applied with the torsional reinforcement of 75% the central deflection is 1.40mm. In torsional reinforcement 25% to 30% and the load of 0.93KN/m^2 the central deflection is 12%. In 75% the load attains only the minimum central deflection. It is found that, as the percentage of torsion reinforcement increases there was corresponding decrease in central deflection.

Comparison of the corner uplift (A, B, C, and D) and central deflection of Slabs with the end condition - All edges discontinuous

For the torsional reinforcements varying from 0 to 75 %, the corner uplift and central deflection are compared for different corners A, B, C, D. The corner uplift is taken along the X axis and the central deflection along the Y axis. The performance is found to be high in corner B when compared to the other corners A, B and C.

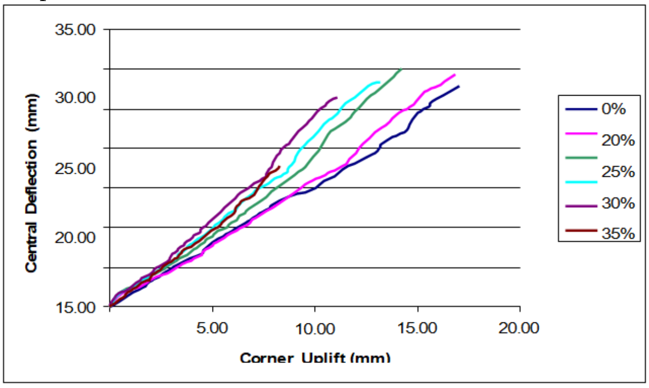

Fig Central Deflection Vs Corner Uplift At Corner A

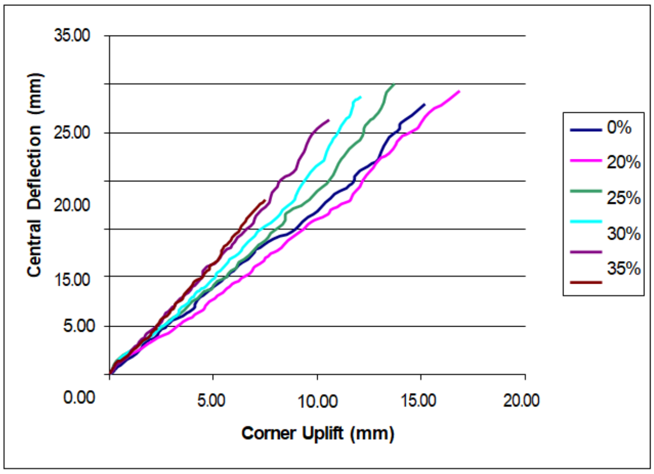

Fig Central Deflection Vs Corner Uplift at Corner B

Figure shows the central deflection vs. corner uplift of the slabs with end condition of all edges discontinuous. In all corners A, B, C and D the performance is to be analyzed for different torsional reinforcement. As per the code, the torsion reinforcement provided will be 75% of main reinforcement at free edges and 50% of this reinforcement should be carried over to other discontinuous edge. As compared to the solid slab, with increase in the percentages of torsional reinforcement, there is a reduction in the central deflection and the corner uplift, but when the percentage of torsional reinforcement increases, the load carrying capacity of the slab also increases.

III. SUMMARY AND CONCLUSIONS

The present investigation is intended to study the influence of torsion reinforcement in reinforced concrete slab along with diverse load and Torsion reinforcement in order to retrieve corner uplift for all corners and central deflection. Slabs with various torsion reinforcement were cast using M20 grade of concrete. Initially, Slabs with torsion reinforcement varying from 0% to 30% were casted and tested for slabs with the size of 1000mm x 1000 mm x 60 mm, to study the influence of simply supported slab without torsion reinforcement and torsion reinforcement in reinforced concrete slab with end condition of two ends continuous under uniformly distributed load with torsion reinforcement varying from 10%, 15% 20%, 25% and 30% and then the percentage was increased up to 75%. The reinforcement was provided in the form of 6 mm diameter Grade I steel 125 mm centre to centre spacing. The corresponding corner uplift and central deflection were noted for each incremental load up to ultimate load and the results were plotted. The behavior of torsion reinforcement from 0% to 30% was compared **with 0% and 75%** and the graphs were plotted. The average cube compression strength attained from the companion specimens tested was 35 N/mm^2.

Increasing in the torsion reinforcement controls the deflection of the slab element. The corners are being held down based upon the quantity of torsion reinforcement provided. Increasing the torsion reinforcement controls the deflection of the slab element. Due to increase in torsion reinforcement there is a considerable decrease in central deflection also. At the maximum of 30% of main reinforcement was provided as torsion reinforcement corners are not held down completely and there is a considerable decrease in central deflection also and hence the load carrying capacity of the slab increases.

* The size of the square slab specimens was 1500 x 1500 x 60 mm (thickness). The clear cover to the reinforcement is 15 mm. The torsion reinforcement was provided in the form of 6 mm diameter Grade I steel 125 mm centre to centre spacing and both 6 mm diameter Grade I steel and weld mesh made up of mild steel having yield strength of 252 N/mm^2 which was used as a main reinforcement Slabs with torsion reinforcement varying from 0%, 20%, 25%, 30%, 35% and 75% of the main reinforcement required forshort span bending moment with the end conditions of all edges discontinuous, two ends discontinuous and other ends continuous, one end discontinuous and other ends continuous were casted and tested and the cubic compression strength was found to be 24.35N/mm^2, 24.98N/mm^2 and 24.8 N/mm^2 respectively.

CORNER UPLIFT AND CENTRAL DEFLECTION OF SLABS WITH THE END CONDITION ALL EDGES DISCONTINUOUS

- The uplift of the corner starts at a load of 0.13KN/m^2 and the maximum uplift is obtained at ultimate loads. When the load increases, the corner uplift also increases.
- As compared, with increase in the percentages of

torsion reinforcement, there is a reduction in the central deflection and the corner uplift, but when the percentage of torsion reinforcement increases, the load carrying capacity of the slab also increases.

- For the torsional reinforcements varying from 0 to 75 %, the corner uplift and central deflection are compared for different corners A, B, C and D. The performance is found to be high in corner B when compared to the other corners A, B and C.
- While providing 75% of torsional reinforcement it is observed that the central deflection was about 47% whereas at 35% central deflection was about 30%.

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