Full Scale Load Test Strengthened RCC Slab Panel Using Carbon Fiber Reinforced Polymer (CFRP)

Abstract: The objective of the load test was to verify the structural performance of RCC slab, which was strengthened using CFRP strengthening system as per the approved design. Load test was carried out on the slab panel of typical 4 m wide x 8 m long patch.

Due to change of use it was decided to put server and battery panel on RCC slab. Because of this total impose load on slab was around 750 Kg per sq.mt. Existing RCC slab was not designed for this higher loads. After checking different options it was decided to strengthen the slab using carbon fiber reinforced composites supplied by M/S SRMPL. CFRP strengthening scheme was designed by using ACI codes and analysis was done using FEM base software as per the required data.

The structural strengthening has been carried out using CFRP and their performance has been compared with that of the full scale load test.

Additional server room loading we have strengthened the slab for additional deficiency with CFRP. We check the of Slab and Beam for given loading in FEM base software,

Data taken for Design,

Grade of slab = M40 N/mm²
Grade of Steel = Fe 415 N/mm²
Depth of slab = 250 mm

Loading on slab

Self weight of Slab = 6.250 KN/m²
Live Load = 2KN/m²
Floor Finish = 1KN/m²
Other Finishes = 1.5KN/m²
Services = 0.5KN/m²
Waterproofing = 6KN/m²
IMPOSED LOAD = 7.5KN/m²

Test Parameters-

The test parameters were set as per the input data received from consultants as follows:

Analysis Results

Strengthening Area
Dead Load + 1.25 times imposed load. Therefore actual imposed test load = 1.25 x 750 = 937.5 kg/m².

Test Specimen

Load test was carried out on the strengthened slab panel of typical 4 m wide x 8 m long patch, which was mutually selected by the consultants as per the test arrangement given below.

In absence of the floor finish load, it was simulated considering single layer of brick bat coba.

The design imposed load was applied by using standard bags of cement/sand mortar and micro concrete as follows:

Test load: 937.5 kg/m²
Test patch: 4 m wide x 8 m long
Therefore, total designed imposed load = 937.5 x 8 x 4 = 30,000 kg

Actually applied bags:
Total Micro Bags used = 624nos (24960 kg)
Total Readymade cement sand mortar bags used = 202nos 
(5050 kg)
Total Actual Test Load: 24960 kg + 5050 kg =30,010 Kg

Test Equipments
The test facility consists of the following:
Test specimen 4 m wide x 8 m long patch of slab clearly demarcated.
TC-1600 FD data acquisition system
4 numbers of LSC 140 mm range linear displacement sensors.

Test Schedule
Proper precautions were exercised during testing i.e. area underneath the slab being tested was kept vacated to avoid any damages/injuries in case of any unfortunate event of failure. Load was applied gradually in such a way that rate of loading did not exceed 1m per hour. Proper care was exercised in order to avoid impact while load application. The load was applied uniformly by suitably arranging the load bags in different layers.

Material Specification used in Project-
STR wrap Strong UD 900
Tensile Strength=575 Mpa
Tensile Modulus=25 Gpa
Tensile Strength [Gpa]= 2.43 Gpa
Tensile Modulus [Gpa]= 83 Gpa
Elongation=3.1 %
Density=2.55 g/cm³

Experimental Setup

Structural Performance Test-

a) Displacement sensors were placed on the soffit of the slab panel to measure the displacements at predetermined locations as shown in annexure 1. Each sensor was checked and set to zero reading prior to testing. Initial readings at each sensor were recorded before loading and unloading.
b) Load was applied gradually. c) Displacement and residual displacements at the predetermined locations were captured by the data acquisition system and the deflection values were calculated by using in-house software. d) The test specimen was loaded to 100% design load in specific intervals. Each load interval was maintained for specific time interval. And the displacements of the test specimen were measured at each interval. Each interval was considered upon completion of loading of single layer of load bags in the given test patch.

Objective of the Test
The RCC slab was strengthened for additional load of 750 kg/m² by using carbon fiber reinforced system. Thus, with the load test, the structural performance of the strengthened slab was thoroughly verified as per Clause No. 17.6 of IS:456 2000.

2. Test Arrangement

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[Diagram of test setup]
Conclusion

- As per the Indian standard IS456: clause 17.6.3 the deflection due to imposed load only shall be recorded. If within 24Hr of removal of the imposed load the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72Hr. If the recovery is less than 80%, the structure shall be deemed to be unacceptable. In the load test it was found that within 24 hours of removal of the imposed load, much more than 75% of the recovery observed in the structure as described in the graphs presented above.

- As per the Indian standard IS456: clause 17.6.3.1 If the maximum deflection in mm, shown during 24hr under load is less than \( \frac{40l^2}{D} \) where \( l \) is the effective span in m and \( D \) the overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery provisions of clause 17.6.3 shall not apply. In the load test, the recovery of the structure took place with the generous margin as mentioned above. Moreover, the recovery requirements are not really applicable as the maximum deflection observed in the slab panel = 8.008 mm, which is less than 40*12/D as described below.

- The test slab was subjected to a load equal to full dead load of it plus 1.25 times the imposed load for a period of 24 hours and then the imposed load were removed. It was found that the maximum deflection during 24 hour load period is 8.008 mm which is less than the limit value of i.e. 10.24 mm. Also the average recovery observed in the load test is much higher than 75%.

Thus, the strengthened structure suitably meets the IS code requirements as per clause 17.6.3 of IS 456:2000.

References


2. MANCARTI, G. D. Strengthening of California steel bridges by pre-stressing, Transportation Research Record No.950, Transportation Research Board, 1984, 3-187.


