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Repair and Rehabilitation of a Cantilever Beam

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ABSTRACT

Rehabilitation methods currently used are reviewed on the basis of present knowledge and systematic approach. This project focuses on visible symptoms of the problem as well as possible causes behind them. An attempt has been made in this project on how to arrest the crack by the application of Rehabilitation techniques. In this project a Cantilever Beam was taken for the study. The beam was cracked at the beam-column junction due to insufficient development length. Hence the beam was extended to the adjacent column for providing sufficient development length. For extra strengthening purpose Bonded plate technique was used,, i.e. , a plate was fixed to column and to beam by using Hilti Anchors and a Built up section was connected to these plates. Thus the crack was arrested. It was also theoretically proved that the development length provided is sufficient and the stress is also evenly distributed. The deflection is also within the limit.

KEY WORDS: Cantilever Beam, Crack, Repair, Rehabilitation, Bonded Plate Technique.

1. INTRODUCTION

The term "Rehabilitation" in broad sense implies restoring a structure to its original condition. Technique developed for rehabilitation may also be used for modifying a structure to meet new functional or other requirements. In general structures may be in need of rehabilitation for one of the following

1. Normal deterioration due to environmental effect.
2. New functional or loading requirements entailing modifications to a structure.
3. Damage due to accidents.
4. Due to construction errors.

The systematic approach to deteriorate structure is necessary and there should be a balance between technology management and economics. The first task when a structure shows a sign of cracking, spalling or any other sign is to determine whether the damage is structural or non-structural.

The Repair and Rehabilitation of structures must include the following

- Inspection methods
- Assessment
- Monitoring
- Maintenance of structures

2. MATERIALS AND METHODS: Bonded Plate Technique was used to rehabilitate the beam.

Investigation:

Cantilever Beam: The Beam that is taken for my study is a cantilever beam of length 3.12m, at the free end another beam of 14m length is resting on it from both the sides .The plan and section of the beam is shown in the figure 1 & 2.The beam was provided with 450mm x 900mm size and 7 rods of 25mm diameter and 12mm at 6" stirrup spacing was provided. The beam was then concreted and left for curing; later when deshuttering was done a small hair line crack was found near the Beam-Column junction.

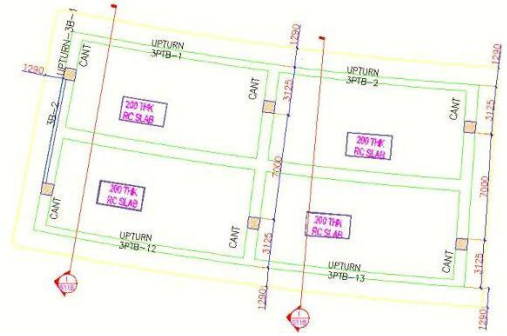


Figure.1. Plan

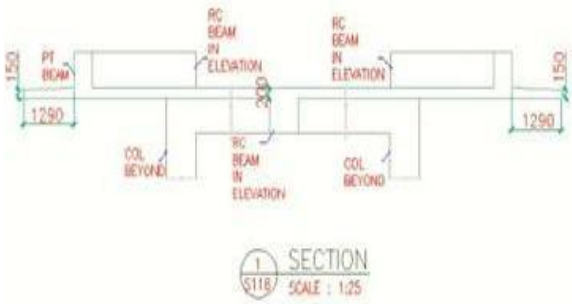


Figure.2. Section

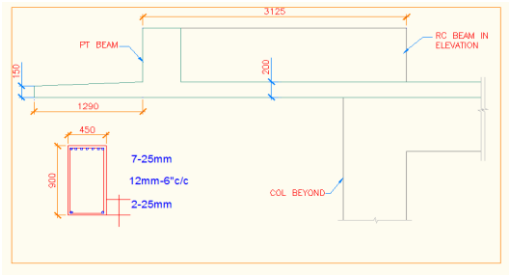


Figure.3.Beam Reinforcement

Figure.4.Crack in Beam – Column Junction

Later the crack was found to develop, and to check whether the crack is a live crack or not a paper was stuck on it .While observing that crack it was found that the paper was tearing because the crack was a live crack .Cracks in the beam are shown in figures 4.

Since the crack was developing even more wider of about 6mm in 25 days a serious problem was found in that beam .The Beam was first given support to withstand the heavy load on it. Then the beam was chipped for investigating the cause for that crack.

3. RESULTS AND DISCUSSION

After rehabilitating the beam it was checked against deflection theoretically and experimentally and proved.

Rehabilitation:

Analysis: The beam was found to be provided with insufficient development length, the top rod of the beam was terminated after just inserting the rod inside the column for 900mm.This is the reason for the development of the crack. Thus the repair was analyzed.

There are many Repair methods to rehabilitate the beam, one method, that is, Plate Bonding method was used for rehabilitating the beam.

Falsework: "It is the main vertical load bearing temporary structure, which is used to support permanent structures and associated elements during the erection until it is self-supporting."

Figure.5. Falsework **Figure.6. Chipping of Beam**

The Beam is chipped to investigate the real cause for the crack. It was found that the beam top rods were not given sufficient development length which is the main reason for formation of crack.

Rehabilitation Process: The Beam was first supported with props throughout the area as shown in the figure.5.The Beam was then roughened for new concreting as shown in figure7. The rods of cantilever beam were taken inside for counter balance.

Side face of the beam were roughened for proper bonding of old and new concrete.

Development length, L_d of the beam is 47Φ as IS 456-2000 L_d = 47 x 25 =1175mm

For a cantilever Beam L_d = 1.5 x 1175 =1762.18mm

The rods were overlapped for 1500mm and welded with 8mm weld as shown in the figure 8. Since there are two cantilever beams on either sides, the beams were taken 3500mm as shown in figure 9 .Before concreting NITOBOND a bonding agent, was used (fig . 10)

The beam was then concreted and left for curing. (Fig. 11).

Figure.7. Beam side face roughened **Figure.8. Lapping and Welding**

The rods of Beam were lapped as per requirement and the rods were welded for strengthening of the rods

The two Beams are connected for counter balance as the crack are formed in both beams. The rods of the existing beam itself are extended for counter weight purpose.

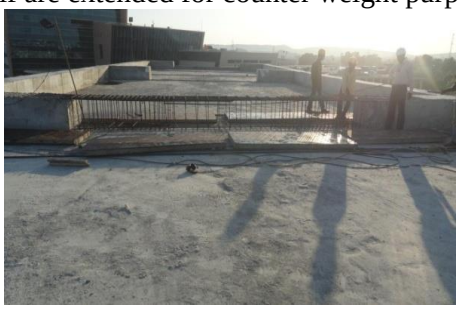


Figure.9. Connecting the Beams **Figure.10. Bonding agent Nitobond**

Nitobond: Epoxy resin concrete bonding agent is used for bonding fresh wet cementitious materials to existing cementitious surfaces.

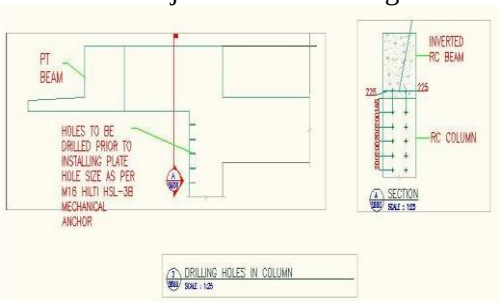
Curing: After concreting the beam was left for curing for 28 days as shown in the figure 11

Figure.11. Curing

Plate Bonding Technique: For extra strengthening purpose Plate Bonding Technique was used. The steps followed in this method are as follows,

- The sides of the Beam and column were drilled with Hilti Anchors for their requirement.(fig .12,fig .13)
- Steel Plates were designed to withstand the load acting at the beam-column junction.(fig .14)
- Built up sections were provided connecting these plates .(fig 15)

Thus the beam-column junction was strengthened.



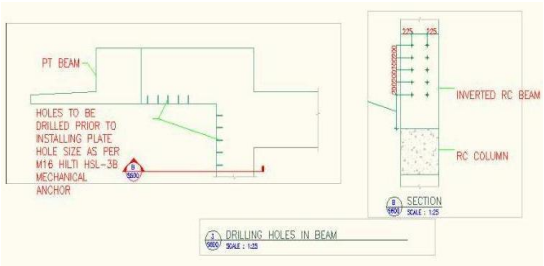


Figure.12. Holes drilled in column **Figure.13. Holes drilled in Beam**

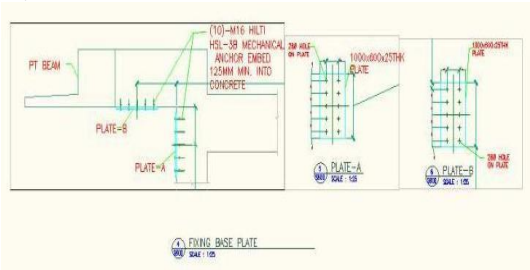


Figure.14. Plates added to Beam and Column

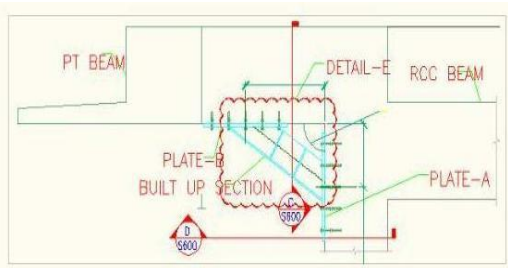


Figure.15. Built up section

Check for Deflection: Retrofitted Beam is checked for deflection theoretically.

Deflection Check :(Theoretically)

Deflection for cantilever beam = $WL^4/8EI$

W = 12.35 + (31.4 x 2.8)

W = 89.2 kn/m

L = 2.8m

$E=5000\sqrt{fck}$ (40 N/mm^2)

$= 5000\sqrt{40}$

E = 31622.77 N/mm^2

$I = bd^3 / 12$

= 450 x 750 $^{/}$12

I = 1.58 x 10^{10} mm^4

Deflection = 89.2 x $(2800)^4$ / 8 x 31622.77 x 1.58 x 10^{10} = 9.2mm

Allowable Deflection = L / 250 =2800/250 = 11.2mm

Hence safe.

4. CONCLUSION

- Different techniques of Repair and Rehabilitation were studied in detail. The Beam that was taken for the study was investigated thoroughly. The reason for the crack was analyzed and it was found that it was due to insufficient development length at Beam- Column junction
- The Beam was then Rehabilitated by providing sufficient development length
- For extra strengthening Plate Bonding Technique was used

Finally the beam was checked for deflection theoretically and experimentally and it was proven that the beam can carry sufficient load without further distress**.**

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