Strengthening of D-block of Commercial Complex in a NMSEZ, Navi Mumbai by using FRP strengthening systems.

Dr Gopal Rai
R&M International Pvt. Ltd

Abstract

The new proposed Commercial Complex in the Navi Mumbai SEZ had to undergo strengthening to reach the required loading conditions. Considering various factors like Time, Usable Space and Money the strengthening was decided to be carried out with the new technology using FRP systems. These systems had provided many added advantages for the completion of the structure. In this paper we discuss that how more than 300 beams alone in the D-Block which were deficient in its shear and flexural capacity for its use as a commercial complex were strengthened using Carbon Fiber Laminates for flexural enhancement, Glass and carbon fiber wrapping on beams for shear enhancement. After successful completion of D-block now subsequent blocks are also strengthened using the same techniques.

INTRODUCTION:

To develop a Special economic zone covering a land area of 2140 hectares in Uran, Navi Mumbai next to JNPT, Port “Navi Mumbai SEZ” was established with colabration of Reliance Industries Ltd., CIDCO and Jaicorp who are jointly responsible for NMSEZ and has the right to plan, design, construct, market, operate & maintain, administer & manage the SEZ.

A already existing building complex in the Dronagiri node belonging to CIDCO was taken up for revival to convert it into a major commercial complex.

The complex has 4 Major blocks. A detailed study was carried out for conversion of this complex into a commercial hub. It was found that the structures designed and built were not capable enough to sustain the loading requirements needed for the change in usage.

Fig.1 D-block of SEZ Commercial complex

The beams and columns of the RCC structure were found to be deficient in their shear and flexural capacities.

R & M International Pvt. Ltd. was approached for providing strengthening services to the structure.

The Structure consisted mainly 3 types of Beams

1) Waffle beams: These are the beams present in the wings of each block and had a cantilever portion over it.
2) Frame Beams: These are the beams present in the wings of each block with out any cantilever portion.
3) Core Beams: These beams are present in the centre of the block which had the staircases and lift.

In the 1st phase of the project whole D block was taken for strengthening.

Due to less head-room present because of which increasing the size of beams was not desirable. It was finally decided to go ahead with the Latest FRP products for strengthening beams. Before carrying out any strengthening detailed design of the strengthening was to be carried out. All calculations were done according to ACI 440 and the proposed designs were approved by the consultants and IIT Bombay as third party approval.

There were many advantages of using FRP technology in the present scenario. Following are some of the advantages of using FRP systems.

1. Corrosion proof.
2. Easy in application and do not need large number of people.
3. Easy in transportation, can be easily rolled and stored.
4. Negligible and practically no extra weight or volume is added which helps in space management.
5. Higher UTS and young's modulus
6. High fatigue resistance
7. Light weight. Hence, very high strength to weight ratio.
8. Joints can be easily avoided as they are available in desired length.

STRENGTHENING PROPOSED

The following was proposed to strengthen each beam.

1) Waffle beams: According to calculations these beams were coming out to be unsafe for bending moment capacity at midspan and in shear when revised loadings were considered. It was found to be safe when bending moment capacity at the supports was calculated. Proposed strengthening according to ACI 440.2R were
    a. 50mm wide and 1.4mm thick Pre-cured Carbon Fibre laminates with proper Anchorage at the ends.
    b. 1 Single Layer of glass fibre at L/3rd portions at the end for shear enhancement.
2) Frame Beams: According to calculations carried out with revised loading conditions these beams were coming unsafe when bending moment at the supports and in shear was considered. These beams were safe with the bending moments generated at the midspans. The following was proposed according to ACI 440.2R
    a. 2 or 3 8mm dia Carbon fibre Rods or 20mm wide 1.4mm thick laminates on the top in L/3rd portion from both ends with proper Anchorages as negative reinforcements.
    b. Single layer of glass fibre wrapping in L/3rd portions from both ends for shear enhancement.
3) Core beams: These beams were present in the lift area where they are subjected to higher loads. These beams were found to be deficient in shear and also in some cases at the supports and in some cases in the midspan. Following was proposed according to calculations as per ACI 440.2R.
    a. Full wrapping of the beams by Single layer of Carbon Fibre Wrapping.

b. Appropriate no's of 8mm dia rods or 20/1.4 mm carbon laminates for support bending moment enhancement. And 50/1.4 mm laminates below for midspan bending moment enhancement.

STRENGTHENING METHODOLOGY

The following is the step by step description of the work being carried out.

1. Surface preparation

Basic treatment must be given to the surface prior to strengthening with GFRP system.. Surface is very well chipped out to remove all loose concrete up to the hard strata. The surface to be repaired is typically rubbed off to get smooth surface and remove all irregularities, contaminants and radius sharp corners. This can be performed by Grinder Machine, If any patches or honey combing is found it will be repaired with Polymer modified mortar.

Fig 2: Surface preparation of beams

2. Applying of primer

In order to promote adhesion and prevent the surface from drawing resin from the FRP, a low viscosity epoxy primer is applied with a roller until the surface is locally saturated and the curing time will be at least 12hrs also depends on the atmospheric temperature until it becomes tacky.

Fig 3: Primer application

3. Leveling mortar

After the Primer work is Over, wherever the surface noticed is in uneven condition, the surface is well prepared with leveling mortar to level-up all irregularities (or) unevenness.

Fig 4: Filling uneven surface with leveling mortar

4. Fixing of carbon rods and laminates

In case of Carbon rods or Laminates are proposed in the design, grooves on top of the beams with the help of cutting machine as per design are prepared. Further these grooves are thoroughly cleaned with blower machine. Then Carbon rods or laminates are glued with Adhesive & fixed on top of the beam surface, and pressure is applied with the help of Fiber Roller so that it should properly fit inside with good bonding.

Fig 5: Fixing of Carbon rods over the beams as negative reinforcements

5. Fixing of carbon fiber laminate at the bottom

In case of beams with proposed strengthening by laminate at the bottom of beam, markings are done for proper placement of laminate. Laminate is then measured and cut in a clean area and it is then layered with laminate adhesive by passing through glueing machine. This is then carefully lifted in a coordinated way and fixed in the marked area. Pressure is applied with the help of rollers for proper contact. In the end Anchor plates of appropriate sizes are fixed at the end so that laminate is fixed and does not peel-off from ends.

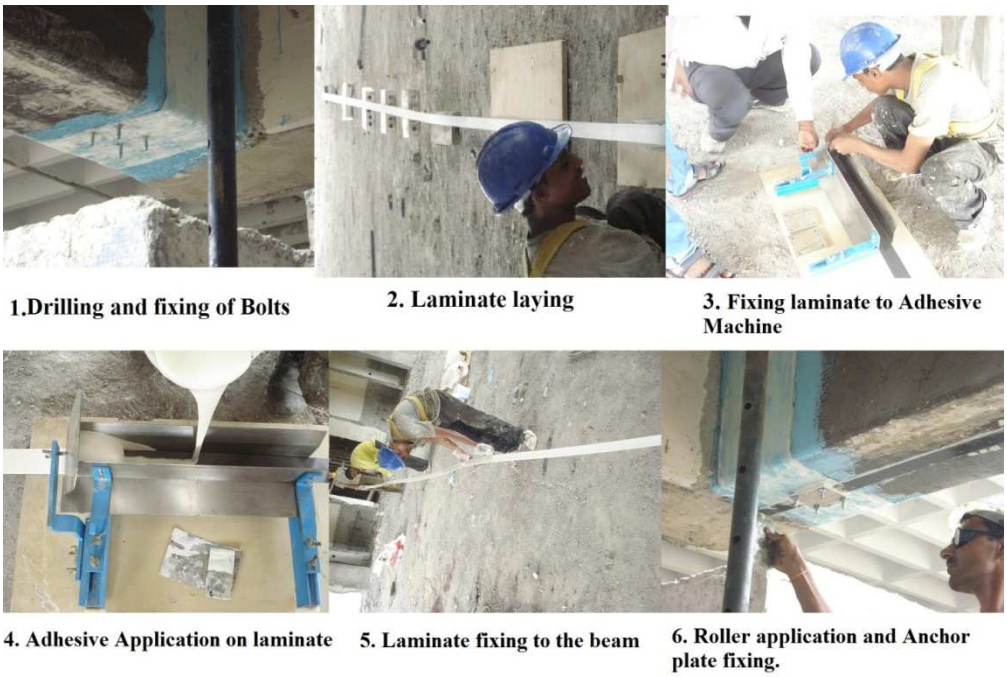

Fig 6: Fixing of laminate below the beams for flexural enhancement

5. Cutting fabric

In a clean area away from the resins, the fabric is carefully measured and cut in accordance with the specifications in a very precise manner.

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Fig 7: Measuring and Cutting of Fiber.

5. Saturating fabric

The fabric can be either saturated on a table, or the surface can be coated with resin and the dry fabric is applied on the beam surface.

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Fig 7: Saturation of surface with epoxy matrix

6. Applying fabric

The pre-wetted or dry fabric is carefully laid onto the surface and smoothed out to remove air bubbles by applying pressure with Fiber Rollers and ensure that the fibers are straight and free of Air pockets.

Fig 8: Fiber application and roller application.

7. Second coat of epoxy

Once the Fiber wrapping is over we have to give a time gap of at least 3-4 hrs for good bonding of saturant, thereafter the second coat of Epoxy layer is repeated on top of first layer for making rough.

Fig 9: Application of second Coat of Epoxy matrix.

8. Sand sprinkling

After completion of Fiber Wrapping the second coat of Epoxy Layer is performed on top of first layer and immediately the sand is sprinkled to convert the Smooth Surface of fiber into Rough Surface for Over Plastering.

Fig 10: Sand Sprinkling for making surface rough for plastering and other finishing.

There were over 300 beams which were strengthened alone in D block of the commercial complex. After completion of the project testings were carried out to make sure the strength is increased in the desired manner.

Fig.11 View of the building after strengthening of beams by using FRP Wrapping. It is visible on the beams as blue color.

Fig 12: Final Building of the D-Block of the commercial complex after completion of all works.

CONCLUDING REMARKS

FRP Strengthening systems are slowly becoming very popular in structural applications. The high strength, high fatigue resistance, lightweight, and corrosion resistance of composites are highly desirable characteristics for any structure. Currently, these new materials are a direct technology transfer from the aerospace industry, and they are far more advanced than those required by civil applications. Most of the advanced composite materials that are cured at high temperature produce high quality components and possess excellent characteristics.

After the success of the FRP system in the present D- block, Subsequent Blocks are now taken for strengthening. It is a very encouraging and excellent example of how these FRP systems are proving to be fruitful in civil infrastructure.