Retrofitting Of Bridges Using FRP Composite System

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Abstract

The need for rehabilitation of reinforced concrete structures is rapidly increasing. Until now, for rehabilitation was used steel that was glued on concrete surface. This technology is now abandoned. Products of fiber reinforced polymer (FRP) are being used instead. FRP system is integrated system based on carbon fibers and epoxy resign. Strengthening is achieved as for composite elements, gluing lames on structural elements. The high strength and light weight FRP and the fact that they are now available in the form of very thin sheets, provide an attractive and economical solution for strengthening existing concrete bridges and structures to increase their ductility, flexure and shear capacity in response to the increasing demand to use heavier loads. In this paper we explore four cases in different areas of importance which were rehabilitated with FRP composite system.

1 Introduction

Bridges across the world are facing deterioration due to the ever increasing traffic loads and are in urgent need for repair or rehabilitation. Many of the bridges have to withstand heavier axel load then that considered for their design. The structural deficiency due to corrosion lead to deterioration of the structure. In many instances the design deficiencies come to the fore after the structure had been constructed. Furthermore, recent technological developments, revision in codal provisions and upgradation of seismic zones have necessitated strengthening and rehabilitation of bridges. Rehabilitation includes major work to restore the structural integrity of a bridge in a cost-effective and efficient manner. Strengthening of the deficient bridges can be carried out by various methods. Reinforced concrete jacketing, precast concrete segment jacket, steel plate jacketing, external post tensioning, fiber reinforced polymer (FRP) systems are some of the techniques used for strengthening of the bridges.

FRP composite system is well researched and used for strengthening owing to the many advantages it possesses. It is light in weight, have high strength to weight ratio, non corrosive, non magnetic, have high flexural strength and are relatively easy to handle. They have been applied with relatively good results in flexural strengthening of bridge decks and for flexural and shear

strengthening of girders1. Also, for the strengthening of bridge piers FRP composite system in the form of near surface mounted FRP rods and sheets have been found to yield an improvement in the flexural strength2.

R&M International Pvt Ltd uses the well researched FRP composite system3,4 for economical rehabilitation of important distressed structures in the least amount of time. The following paper provides a review of four cases in field applications of FRP composite system in strengthening and rehabilitation of important bridges across India.

2 Strengthening Of Slab Of Skew Box Bridge At Trumpet Interchange Of Bengaluru International Airport, Karnataka

Figure 1: NH7 Highway site

The two flyovers, as shown in Fig 1, originating from National Highway 7, required strengthening in the skew slabs. The deck slab of the underpass had developed distress due to the additional wheel load traffic plying over it. In case traditional retrofitting using concrete jacketing was adopted it would have reduced the clearance height of the underpass thereby making it unviable for intended traffic use. The following strengthening scheme was proposed for retrofit of the slab :-

a) Epoxy grouting was carried out as a repair measure on cracked portion of slab.
b) Removing of loose and spalled concrete from slab and replacing it with new concrete.
c) Strengthening of slab using Prestressed and Non prestressed Carbon fiber laminates

Figure 2: ***Strengthening of Skew slab using FRP laminates***

3 Strengthening Of Rail Over Bridge (Rob) At Karal Junction Of Jnpt, Navi Mumbai

The Jawaharlal Nehru Port Trust in Navi Mumbai is one of the major ports for container traffic in India. The rail over bridge at Karal junction was structurally designed for Indian Road Congress (IRC) 45R loading. Due to increase in the axel loading bridge was required to carry higher load case of IRC Class 70 R to support the container traffic over it.

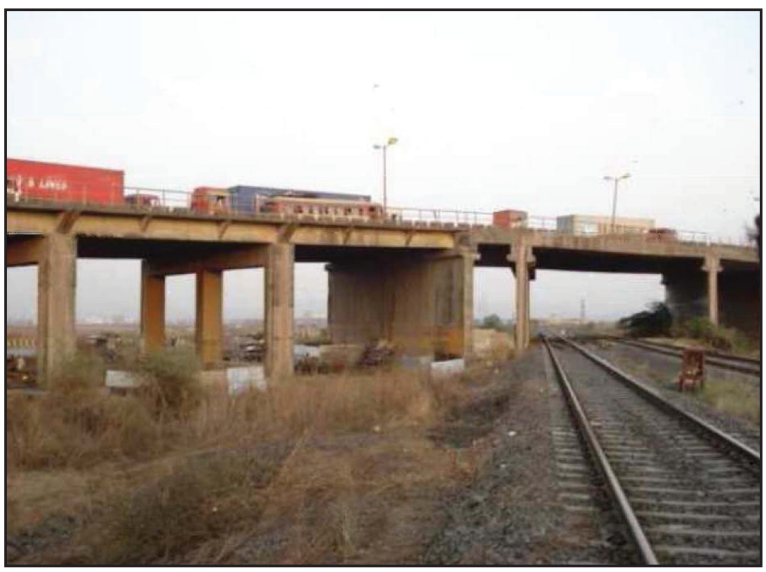

Figure 3: ***Rail Over Bridge (ROB) at Karal junction of JNPT[5]***

The major challenge in this project was to execute the job without halting the traffic as a single day disruption would have resulted in huge loss. The distress observed on the bridge is as follows:-

a) Expansion joints not functional
b) Concrete has deteriorated significantly at the expansion joint region
c) Bearings are found to be damaged
d) Structural failure cracks observed in the girders
e) Sagging of deck slab observed in many spans

The strengthening procedure adopted for strengthening of the bridge is as follows :-

a) Steel truss system was used for strengthening of the girder
b) Replacement of existing bearings by new elastomeric bearings
c) Replacement of expansion joint with new superior quality Wabocrete Strip Seal expansion joint system
d) To provide additional flexural strength to the girder and slab prestressed carbon fiber composite laminates was placed at the bottom. For enhancing the shear strength of the girders carbon fiber composite wrapping was provided.

***Figure 4:* Prestressing in process for the girder[5]**

Figure 5: Prestressed laminates with anchor plates at the ends[5]

Figure 6: Enclosing the girders with carbon fiber wrapping[5]

This was followed by carrying out static and dynamic load testing post strengthening of the bridge. The Testing results proved that the strengthening using FRP composite system was successful5.

4 Strengthening Of Mithi River Bridge At Mumbai International Airport

Figure 7: Plan view of runway strengthening

The bridge under the taxiway N1 of the Mumbai International Airport required strengthening as it was deficient for carrying loads of larger aircrafts. The structure was a multi cell box girder type structure. The service portion of the bridge was found to be having the following deficiencies:-

a) The webs of the box girder was found to be deficient in flexure and shear

b) The top slab portion was found to be deficient in flexure.

c) The cantilever portion was found to be deficient for the existing loads

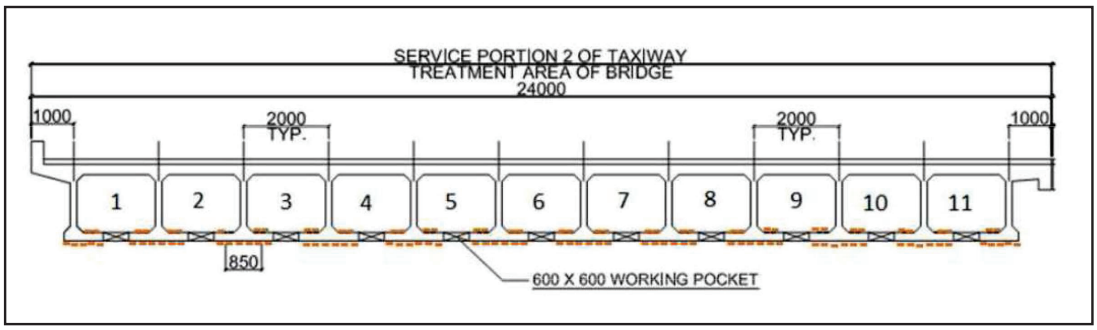

Figure 8: ***Cross sectional position of FRP laminates for flexural enhancement***

The strengthening was carried out as below:-

a) As the bridge was in Mithi River proper bunds was required to be created and diversion was made so as to provide accessibility to the strengthening portion

b) It was required to make holes inside the webs for strengthening and proper ventilation was provided for working and proper safety of the workers was maintained.

c) Carbon fiber laminates was used for flexural strengthening of girders below the web and at slab as per Figure.8 above.

d) The shear strengthening of the webs was carried out by providing CFRP fiber wrapping.

Figure 9: ***FRP laminates placed for flexural enhancement***

Figure 10: ***CFRP fiber wrapping being done for shear strengthening of girders***

The rehabilitation was carried out successfully using FRP Composite technology in a record period of 45 days which would have taken more days if was strengthened using any other conventional method of strengthening.

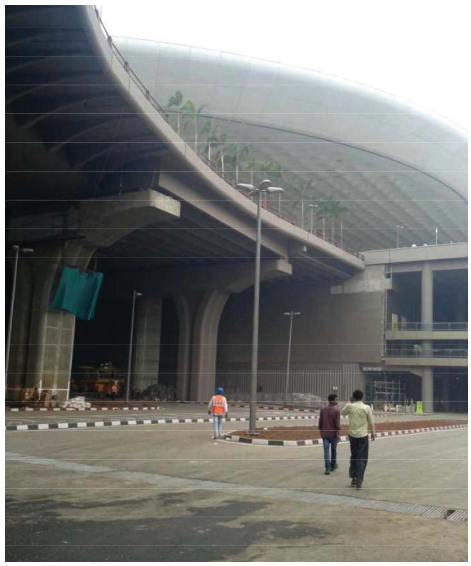

Figure 11: Chatrapati Shivaji International Airport, Mumbai

Figure 12: Strengthening of pier caps 433

5 Strengthening Of Portal Beams And Pier Caps At Chatrapati Shivaji International Airport

It was required to strength the piers and portal beams for additional loading for the 5.5 km long stretch. Hence it is proposed to strengthen the piers and portal beams with the help of FRP materials.

The main reason for selecting FRP as the repair material is due to the remarkable properties it possesses which is its high specific strength, high stiffness, low weight, easy to install and higher corrosion resistance as compared to other materials for strengthening. Also it was required to strengthen the portal beams around the piers.

The strengthening for the same was done using the following scheme:-

a) Non prestressed R & M CFK laminates was laid in the direction of longitudinal axis of piers
b) Wrapping with carbon fiber sheets along circumference of the piers
c) Prestressed and non prestressed laminates R & M CFK laminates were placed on the inner support on both faces of piercap followed by wrapping with carbon fiber on the piercaps.

6 Conclusions

The four cases of bridge strengthening highlighted in this paper demonstrate how FRP can be used effectively to strengthen bridges. Girders can be strengthened for flexural and shear deficiencies effectively with the help of FRP.

It shows that in comparison with other methods of strengthening, strengthening using FRP composite system is effective in reducing the time of for strengthening. This is particularly important in the field of rehabilitation of infrastructure where time in construction affects traffic closure.

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