Rehabilitation of some major bridges

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The paper highlights rehabilitation case studies of three major bridges, namely, Sharavathi Bridge in Karnataka, Zuari Bridge in Goa and Narmada Bridge near Zadeshwar in Gujarat. With the increasing number of bridges needing rehabilitation, the author underlines the need to acquire expertise in this field.

A large number of concrete bridges built during the last 20 to 25 years and located particularly in the coastal region of India, have started showing signs of distress. These have been in the form of corrosion of high tensile steel (HTS) wires, development of cracks in the girders, potholes in deck slab and malfunctioning of bearings and expansion joints. These deficiencies have not only been due to the aggressive environment but also due to a combination of factors such as shortcomings in design, lack of quality control during construction, poor workmanship and neglect of periodic maintenance.

Case studies of three bridges

The problem of rehabilitation of a large number of bridges is becoming more acute day by day and the highway authorities have not only to find appropriate technical solutions for ensuring safety of the structure and prolonging their service lives but also the ways and means to fund such projects. Common repairs and strengthening measures such as pressure grouting with cement mortar and epoxy, jacking up of superstructure for replacement of bearings, refurbishing of spalled concrete surface and replacement of expansion joints are already being adopted for the last few years.

However, adequate experience and expertise in handling large scale rehabilitation measures for long span prestressed concrete cantilever and other types of bridges is not readily available in the country. To bridge this gap, efforts are being made to obtain expert advice from foreign consultants working in collaboration with Indian counterparts for formulating and carrying out rehabilitation measures. Some of the major bridges needing rehabilitation, where such joint venture consultancy has been taken up are discussed in the paper.

Sharavathi Bridge near Honnavar in Karnataka

Broad features

The total length of the Sharavathi Bridge is 1047.65m, consisting of 34 spans of 30.175m each. The deck consists of 7.315-m wide carriageway and 1.524-m wide footpath on either side of the carriageway. The superstructure consists of suspended spans resting on cantilever hammerheads, built monolithic with hollow concrete piers. The deck is made up of five precast prestressed concrete girders with cross-prestressed cast-insitu gap slabs between the flanges of girders.

Distress observed

The bridge, located in the coastal town of Honnavar, was constructed between 1962 and 1970 and has shown signs of distress due to the aggressive marine environment and excessive humidity.

The main distresses observed in the bridge are:

1. corrosion of reinforcement and resultant spalling of concrete where the cover thicknesses were less than stipulated
2. corrosion of prestressing wires, cable sheathing and even snapping of prestressing wires
3. rusting of steel rebars, specially in the flange of girders
4. exposure of cross prestressed cables and anchorages in deck slab

5. cracking in prestressed concrete girders and deck slab.

Investigation process

The task of detailed investigations and formulation of repair schemes has been entrusted to Indian consultants who are carrying out the work in collaboration with foreign experts. The investigation planned by the consultants includes detailed condition survey of the bridge components, in-situ tests, laboratory tests of samples collected and sensitivity analysis of data in the design office of the foreign consultants.

The main aims of the investigations carried out at site and in the laboratory were :

1. to determine the condition of the concrete members of the superstructure
2. to assess the extent of, and continuing potential for, corrosion of the steel reinforcement and prestressing tendons
3. to obtain data for assessment of structural adequacy of the bridge.

Based on the observations made during detailed physical inspection and condition survey, the following field and laboratory tests were conducted.

Field tests

The following techniques of in-situ testing were used :

1. cover meter survey
2. half cell potentiometer survey
3. inspection of prestressing ducts by endoscope in selected areas
4. extraction of 100mm and 70mm diameter concrete core samples at selected locations
5. depth of carbonation tests
6. water injection tests through holes drilled for endoscopic examination
7. Schmidt Hammer tests.

Endoscopy was used for the first time in India for ascertaining the condition of cables in the ducts as well as finding out locations where grout was not present. An endoscope consists of flexible viewing tubes which are to be inserted into holes drilled into the cable duct along its profile. Thereafter, light provided by optical fibres from external source enables a large number of photographs being taken inside the cable duct at various locations.

Laboratory-tests

Material testing : The samples collected from various concrete members during field testing were subjected to the following laboratory tests :

1. chloride content
2. sulphate content
3. alkalinity
4. compressive strength
5. petrographic examination
6. cement content.

Tests for severity of environment : Samples of air and river water collected at site were subjected to the following tests :

1. pH value (water)
2. organic and inorganic solids (water)
3. sulphate (water)
4. chloride content (air and water)
5. acidity and alkalinity (water)
6. carbondioxide (air).

Suggested repair measures

Based on the investigatory data and analysis of the work, short and long-term repairs have been recommended by the consultants. These include grouting of transverse cables, provision of new reinforced concrete wearing coat with waterproofing membrane, replacement of expansion joints, provision of external prestressing in the suspended spans as well as for the hammerheads, gunniting of piers, readjustment of bearings and replacement of worn out drainage arrangements. These proposed measures are currently under examination.

Consultants

Indian : STUP Consultant (India) Ltd.

Foreign : ACER Consultants Ltd. (U.K.)

Zuari Bridge in Goa

The total length of the bridge is 807m, comprising six spans for the main bridge totalling to 627m and five viaduct spans having a total length of 180m. The superstructure of the main river span is 122-m long, each made up of prestressed concrete box girder built by cantilever construction method. The viaducts are of simply-supported spans. The bridge was constructed in 1983 and is situated in marine environment. The condition survey of the bridge was done in 1989 and the following main distresses were observed :

1. poor grouting of cables
2. spalling of concrete and honeycombing
3. some cracks in suspended span girders
4. leakage through construction joints
5. damages to wearing coat.

The phase I consultancy of the rehabilitation work involving condition survey, collection of samples and testing, has

already been undertaken by the Indian consultants in collaboration with their foreign counterparts. A selective sampling has been carried out to determine variability in the strength, stiffness and durability characteristics of concrete in the main box, the deck slab, the footpath and the parapets. Aspects like cover to reinforcement, depths of carbonation, chloride content in the prestressing grout and theconcrete and voids in prestressing ducts have been ascertained. Petrographic tests on concrete core have been undertaken for assessing the general quality of concrete with regard to porosity, voids, segregation or inadequate compaction. Data on the composition of cement, the hydration products and deterioration in the fine and coarse aggregates have also been obtained.

Corrosion tests are being planned to assess moisture level and resistivity. All these data would be analysed to assess the overall reserve strength of the structure and suggest repair and rehabilitation measures for restoring the structure to its original condition.

Consultants

Indian : Engineering Consultants Pvt. Ltd. (India)

Foreign : Mott Macdonald Consultants (U.K.)

Narmada Bridge near Zadeshwar in Gujarat

The bridge constructed in 1977 has 13 main spans of 96.16m and two end spans of 98.08m length each. Segmental cantilever method of construction was adopted for single cell hollow prestressed concrete box girder in the superstructure having monolithic junction with reinforced concrete pier heads. Continuity of cantilever tips of the main span is through cast steel hinge bearings with finger-type expansion joints, 100-mm wide at deck level.

The following major distresses were observed in the bridge :

1. deformation in the plunger and top and bottom plates of the hinges resulting in abnormal increase in clearance/ play to 40mm from about 3mm originally provided. This caused heavy knocking of the cantilever tips wherever vehicles passed over them
2. cracks in the superstructure just behind the assembly of the hinges
3. horizontal cracks in the rib parallel to the bottom starting from the pier and extending on both sides.

Temporary remedial measures were carried out by fixing special alloy plates of varying thickness to reduce the gaps formed by wear and tear of the plungers. Further studies have been undertaken for assessing the following :

1. concrete quality by Schmidt Hammer and ultra sonic pulse velocity
2. measurement of cover to reinforcement by covermeter
3. assessment of corrosion by surface potential measurement
4. depth of carbonation by phenolphthalein test
5. chloride content by photometric method
6. mapping of cracks
7. evaluation of condition of hinges, bearings and free movement at the expansion joints
8. ascertaining the condition of wearing coat, railings and kerbs.

Permanent rehabilitation measures are being finalised by the Indian consultants in collaboration with their foreign counterparts, who will analyse and decide the need to correct or altogether replace the present hinges and redesign them in addition to carrying out other necessary repairs of the bridge.

Consultants

Indian : Consultants Engineering Services (India) Pvt. Ltd.

Foreign : Dywidag Systems International (Germany)

Conclusion

With the growing stock of bridges and increase in the age of the older bridges, more and more bridges will now be requiring repair and rehabilitation. Rehabilitation of bridges is, therefore, bound to assume greater importance in the coming years, both in terms of financial outlays as well as technical inputs.

There is a dearth of experienced agencies and technical know-how in the country for carrying out detailed investigations and preparation of adequate repair plans as well as for actually executing the repair works. Efforts are being made to encourage consultancy in this field to be supplemented by transfer of technology from reputed foreign consultants having access to latest techniques and materials used in bridge rehabilitation.

It is noteworthy that for the three cases mentioned above three different foreign consulting firms have been engaged so as to gain maximum advantage from the transfer of technology. Already the results achieved in the case of these three rehabilitation works which have recently been allotted to Indian consultants with foreign collaboration have proved to be quite encouraging and it is hoped that the experience gained by Indian consultants and engineers will be extremely useful in tackling such cases of bridge rehabilitation in future.

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