Second Thane Creek bridge - An overview

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The construction of one carriageway consisting of three lanes for the second Thane Creek bridge is nearing completion and etV. the same would be opened to traffic shortly. The article presents an overview of this over Rs 125-crore bridge project, with a brief historical background of bridging the Thane Creek. A number of measures have been taken to ensure the long-term durability of this bridge. These are also highlighted here.

Upto the 1960s, the only bridge across the Thane Creek was near Thane city where the creek width was about 200m and easy foundations were available. It was built in 1918. The site must have been chosen in those days with an eye on the economic development of the area and also keeping in view the construction techniques then available in India. This bridge, commonly known as Kalwa bridge, is two-lane wide and is of stone-arch construction. Its navigational span is 27.44-m (90-ft) wide. But for the tremendous increase and consequent congestion of traffic, this bridge had given good service till a barge plying in the creek dashed against the strengthened concrete arch in the navigational span, causing considerable damage. Currently, the Thane Municipal Corporation has taken up construction of an additional four-lane wide bridge by the side of the existing bridge. The bridge is being constructed by the Public Works Department (PWD), Maharashtra, as a "Deposit work" for the Thane Municipal Corporation.

Brief historical background

Following the recommendations made by the Barve Committee in 1960, the Government of Maharashtra undertook the construction of a four-lane wide road bridge across the Thane 4 Creek, approximately half way between the open sea and the Thane city. The aim was to open up the main land for expansion of the Bombay city, with a view to decongest the latter. The work of the first Thane Creek bridge was started through a reputable civil engineering contracting firm in 1963. The bridge was opened to traffic in January 1972. This bridge, apart from opening the main land to Bombay, also provided a saving in distance of about 20 km for the traffic between Bombay and Pune and Goa. The bridge was tolled.

The traffic on the new bridge developed very rapidly and by 1982-83, it was already carrying about 35,000 PCU/day which meant that its designed capacity had already been fully utilised. The cost of the bridge and its approaches was also recovered through toll by that time and the toll was therefore withdrawn.

CRRI study

In the year 1975, the Government of Maharashtra undertook a comprehensive study of traffic and transportation needs of the Bombay metropolitan region (BMR) through the Central Road Research Institute (CRRI). After detailed studies, surveys and analysis, the CRRI submitted its report in 1983. The study had forecast the traffic needs for the year 2001 and suggested a network of roads for the BMR. The CRRI study recommended construction of several new road links and bridges and improvements to many of the existing roads in the region.

The study predicted that the traffic across the Thane Creek bridge would cross the 1,00,000 PCU/day mark in the year 2001. This increase in traffic would be independent of whether another trans-harbour link to the south of the present Thane Creek bridge would be built or not. Hence, one of the main recommendations of the CRRI study was construction of another road bridge across the creek.

Looking to the rapid rise in traffic on the existing Thane Creek bridge, this prediction appears to be very realistic. In fact, already the traffic across the creek is in the range of 75,000 PCU/day.

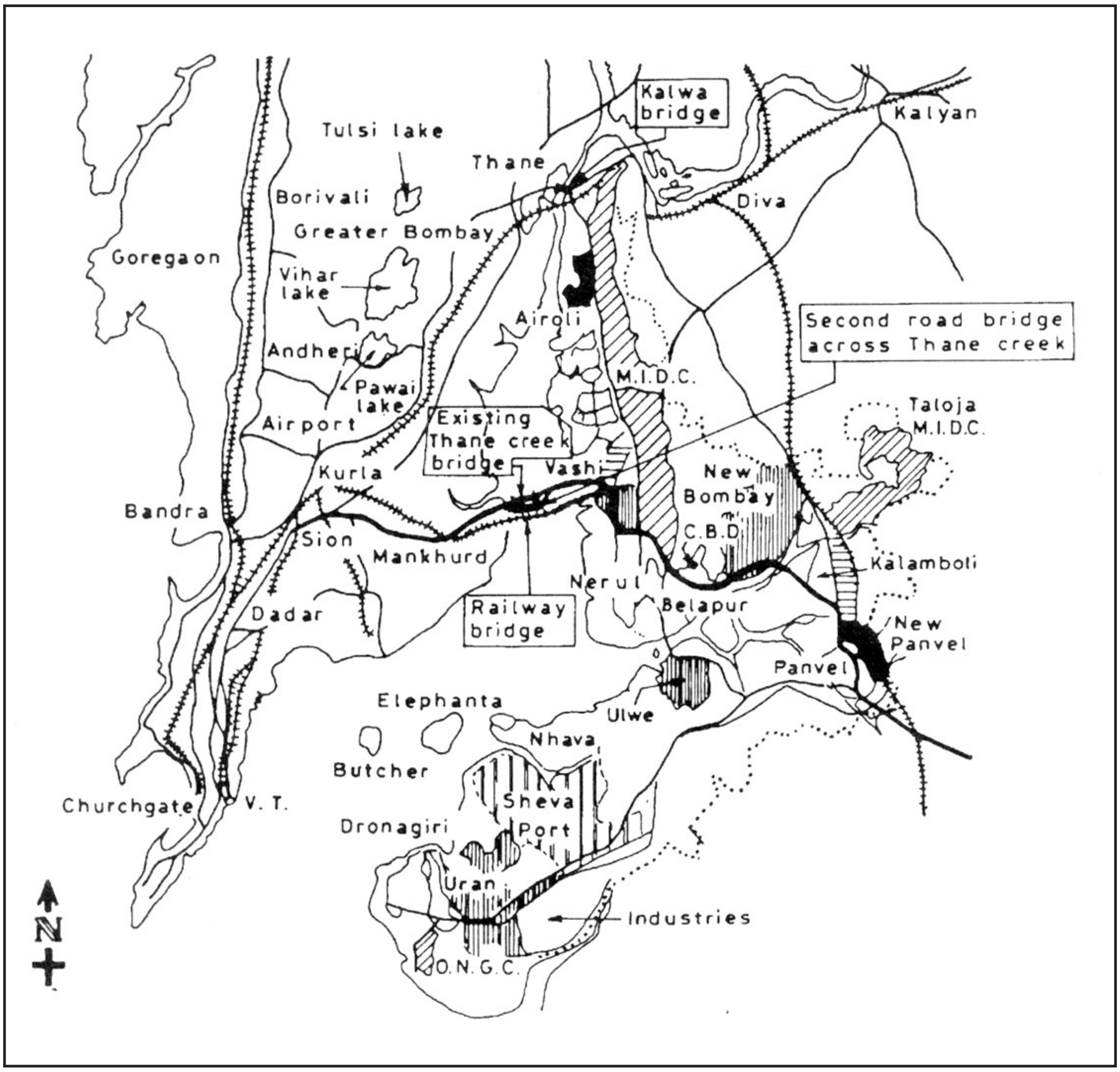

Figure 1. Index map showing locations of bridges across the Thane Creek

Need for a second road bridge

The Government of Maharashtra, therefore, decided to undertake construction of another road bridge near the existing bridge to meet the future traffic demand. Since construction of a railway bridge across the creek to serve the New Bombay area was also being contemplated, a study was carried out through Rail India Technical and Economic Services (RITES), to assess whether there could be a combined rail-cum-road bridge or separate bridges for these two modes of transportation. They were also to suggest the best locations for the bridges. A study by RITES indicated that there was no advantage in going in for a combined rail-cum-road bridge. They recommended two separate bridges and also suggested that the road bridge could be located 40 m to the south of the centre line of the existing road bridge and that the railway bridge could be 90 m further to the south of the second road bridge. Figure 1 shows an index map showing locations of the existing road bridge, second road bridge and the railway bridge across the Thane Creek.

Like many other similar world bridges located in aggressive marine locations, the first Thane Creek bridge had started showing signs of corrosion damage in 1982. While steps were taken to repair and strengthen this bridge, the P W D , Maharashtra, was keen to ensure that the second Thane Creek bridge should have better resistance to corrosion damage. The specifications and the design criteria for the second bridge were, therefore, drafted carefully. These specifications in corpora ted many additional protective features, which ultimately became precursor to the new Indian Roads Congress (IRC) specificat-ions for bridges in marine locations. The important provisions in this regard are described in the following paragraphs.

Design specifications

Foundations

A minimum diameter of 8 m and a minimum steining thickness of 1 m have been prescribed for well foundations. Pile foundations have been prohibited to ensure that the foundations are robust. In case, open foundations are adopted, the concreting work has to be carried out in dry condition to ensure better concrete quality.

Provision of liners to foundations and substructure upto high tide level is made obligatory. (The contractors have chosen liners of 6-mm thick mild steel plates, painted with two coats of coal-tar epoxy followed by one coat of epoxy zinc-rich primer).

Piers

Only solid wall-type piers with a minimum thickness of 2 m are permissible. The bridge has been designed to resist barge impact and seismic forces. Special care has been taken to guard against the aggressive environmental effects observed in the splash zone.

Superstructure girders

The adoption of box girders is made obligatory. This will avoid concentration of prestressing cables, reinforcement and prestressing forces in the small space of the bottom bulbs of the girders. Such concentration is known to cause transverse cracks in the bulbs and is also a hindrance to good concreting work, leading to possible corrosion damage.

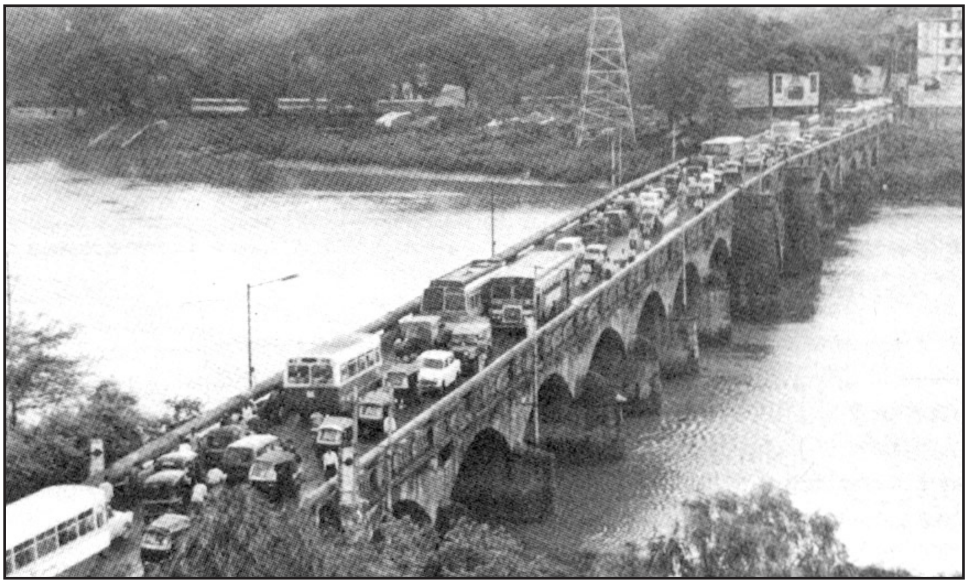

Figure 2. A view of old bridge across the Thane Creek near Ka lwa. But for the tremendous increase and consequent congestion of traffic, this bridge had given good service till a barge plying in the creek dashed against the strengthened concrete arch in the navigational span, causing considerable damage

Neoprene bearings are permissible only upto 40m spans. For larger spans, the bearings are required to be of cast steel/PTFE type. Bi-metallic bearings are prohibited. In order to reduce the number of joints in the deck --- which are points of access of rain water to the anchorages of prestressing strands and also source of discomfort to the traffic --- it has been specified that the expansion joints cannot be closer than 145m on centres. This reduces the vulnerability of anchorages and strands to corrosion and incidentally leads to better riding quality. The expansion joints are to have an arrangement for collecting rain water and lead it away. This virtually eliminates simply supported type of superstructure.

Deck

There is a provision for a water-proofing layer to prevent ingress of moisture from the top. Minimum thickness of deck slab has also been prescribed.

Railings

Usually, concrete railings are the first component of the bridge to be affected by corrosion. Hence, railings of a robust design with rich mix of concrete have been included as an obligatory part in the specification. However, later on, it has been decided to provide steel post and pipe railings which can be painted periodically.

Protective coatings

The exposed parts of substructure are to receive three coats of coal-tar epoxy and the exposed surfaces of the superstructure are to be painted with an epoxy paint with dry filling thickness of 240 microns. The inside of the box girder is to be painted with a water-proof cement paint.

Concrete

Minimum cement content of 360 kg/m^3 of concrete has been specified for the substructure in the splash zone. For the reinforced concrete and prestressed concrete components in the splash zone, the prescribed minimum cement content is 400 kg/m^3. The maximum water-cement ratio permitted is 0.45 for the plain and reinforced concrete works and 0.40 for the prestressed concrete work. The minimum permissible grades of concrete are :

Plain concrete	:	M 25
Reinforced concrete	:	M 30
Prestressed concrete	:	M40

Cover

Minimum cover of 75mm is obligatory for the untensioned reinforcement in the foundations, substructure, soffit slabs and webs of the superstructure. For the deck slab it is 50 mm. Cover to the prestressed concrete ducting is to be 75 mm.

Anchorage of prestressed concrete cables

No anchorages are permitted in the deck slab because rain water can find access to the cables through such anchorages.

Provision for future strengthening

Provision has to be made in the design and detailing to enable application of an external force equal to 20 percent of the prestressing force in future.

Materials

Cement

Mildly sulphate-resisting ordinary Portland cement with C_3A content between 5 to 8 percent has been prescribed for foundations and substructures which are either subjected to submergence in creek water or a salt spray and alternate wetting and drying in creek water. Since the creek water contains both chlorides and sulphate, the C_3A content can neither be very low nor be high. Hence this provision. The cement has to be procurred very specially from prequalified factories. Since high-strength concrete is required, the agreement provides for the supply of grade 43 cement

Sand

The sand used around Bombay is obtained from the adjoining creeks by dredging and is found to contain deleterious materials including chlorides beyond permissible limits. Hence, the agreement specifies washing of sand in potable water.

The chloride content of sand has to be below 1,000 ppm. Rapid testing kits are used at site to check the chloride content of sand frequently.

High tensile steel (HTS) strands are supplied by the department and are required to be coated with water-soluble oil, wrapped in HDPE wrapping, covered with bituminous jute and the coil strapped at six places with metal straps as it comes out of the factory. The strands are to be stored off the ground in an air-tight shed where humidity is controlled within specified limits. Electric heaters and dry-and-wet bulb thermometers are installed in the shed. For humidity control in the godown, porous pouches of desiccant powder are suspended from the roof. Just enough supply of the strands is to be kept at the site. A dry location up-ghat has been selected for reserve stock of strands.

Untensioned reinforcement

The untensioned reinforcement is to be treated with anticorrosive treatment as per the patent of the Central Electrochemical Research Institute (CECRI), Karaikudi.

Water

Water for construction and curing is being obtained from the piped potable water supply of the Maharashtra Industrial Development Corporation (MIDC). The elevated storage is being used to supply water for construction as well as for domestic use of contractors' staff colony. Besides water is tested periodically.

Vapour-phase inhibitor

For the protection of mild steel sheathings during storage and construction and the HTS strands during the period between threading to grouting, dicyclohexyl ammonium nitrite powder and liquid of the same chemical composition, which acts as vapour-phase inhibitor, are being used as per the advice of National Chemical Laboratory, Pune. The sheathings arc coated by the liquid during storage and, if necessary, while protruding from the cast segments. The vapour-phase inhibitor powder is applied inside the sheathings, which are then sealed from both the ends with plastic sheets for protection during storage and the construction period. This protects the sheathings and the HTS strands till grouting. It is seen that this arrangement is very effective and the protected materials remain totally corrosion-free.

Expert control for durability

The contractors are required to appoint a specialised experienced and reputed agency selected by the department to supervise and control the quality of work such as prestressed concrete.

The contractors are to supplement the strength of their consultants by appointing a foreign consulting organisation to review both their structural design as well as construction methods.

Since grouting of sheaths containing prestressing strands plays a very important role in ensuring the durability of prestressed concrete structures, great stress has been laid on proper grouting methods. The water-cement ratio for grout has been restricted to 0.4 and the temperature of grout is kept around 12°C by using ice. This ensures better workability. Admixtures are also being used for improving the workability. The use of electrical rotary pumps has been insisted on to ensure a continuous flow of grout. Presence of senior supervisory officers on both sides is also insisted during grouting operations.

Even during concreting operations, use of ice is being insisted on to keep down the temperature of concrete and to ensure better workability over a longer period in the face of the low-water cement ratio. Admixtures are also being used in the concrete mix to improve workability.

Stressing of all the strands of a cable at the same time by the use of a large-capacity, single-pull prestressing jack is also insisted on.

The work of second Thane Creek bridge was awarded to Messers U.P State Bridge Corporation Ltd., after keen competition amongst several major reputed bridge construction companies. The time limit prescribed was 5 years and the work was started in February 1987.

Appointment of proof consultants

With a view to ensuring that the second Thane Creek bridge would be to the latest international standards, and also to ensure its long-term durability, the Government appointed Messers Rendel Palmer Tritton, an internationally-reputed and experienced consulting firm from U.K. to act as proof consultants. They were to examine the design criteria, the specifications and the construction practices and advise the State Government suitably. The consultants have made a number of useful suggestions to improve the design practices, safety during construction and long-tern durability of this bridge. Some of the important recommendations made by them are as below.

1. Conversion of the twin-cell box girder into single-cell box girder, resulting in thicker deck slab and thicker webs, the latter, in particular, improving the concretability of the webs.
2. Increase in the thickness of the sheets used for manufacturing the sheaths for prestressing strands from the usual 0.3 mm to 0.5 mm.
3. Increased thickness of waterproof mastic asphalt layer on the deck from the prescribed 6 mm to 12 mm.

4. Use of concrete pumps for conveying concrete as against the earlier method proposed by the contractors envisaging the use of buckets.

5. Construction of a full-scale trial segment of the superstructure. This provided an advance experience of concreting on dry ground and also proved to be a training ground for both the contractor's staff and the departmental staff. Difficulties regarding reinforcement detailing, concrete mix design, concreting methods, etc. were known before the work was taken up in the creek.

6. Preparation of a quality-assurance manual containing quality plan, the organisational structure to ensure quality, and model documentation on various aspects.

7. Insistence on designing the substructure and foundations for out-of-balance force equal to 15 percent of the dead weight of the superstructure at every stage of the cast in-situ construction operations as well as unequal wind pressure and uplift on the two arms of the cantilever. Earlier, there was no such practice in Maharashtra, and the designs were based on a much smaller construction load and a certain tip load as out-of-balance force.

8. Designing the pier with fixed bearing for full earthquake force without allowing any deductions for distribution of that force to other piers. The practice existing till then was to design each pier with a free bearing for a force equal to the coefficient of friction multiplied by reaction and to design the fixed bearing for the balance force.

9. Insistence on a detailed analysis of the vast data on concrete testing to draw conclusions regarding control and to be able to improve it on a continuing basis.

10. Provision of valuable advice on grouting.

11. Advice regarding general performance of the contractor at site regarding quality and programme.

12. Insistence on cubic parabola for the soffit profile to ensure greater stiffness for the superstructure.

13. Insistence on a minimum depth of 7 m for the deck at the support.

14. Insistence on a "tree chart" for profile monitoring of the cantilever during construction.

Present status

Needless to say, construction of such a huge bridge across a creek with variable foundation conditions is indeed a difficult job. Looking to the size of the project, the work has been relatively accident-free. The quality of work done so far has generally been appreciated by knowledgeable engineers. The lines of profiles and the profile control has also been satisfactory.

The work has taken somewhat longer than expected due to the need to redesign some components and to the increased quantum of work to incorporate the suggestions of the proof consultants, other factors like transporter's strike, riots, foundation difficulties etc. After passing through various difficult phases, which included labour agitation, the work of one carriageway of three lanes is now nearing completion. This carriageway is being opened to traffic shortly. Thereafter, all efforts will be concentrated on the second carriageway and in about two years time, the second carriageway will also be completed. Opening of even one carriageway is going to provide considerable relief to the travelling public. The long delays experienced now during peak hours will reduce dramatically.

The railways have constructed a magnificent bridge 90 m to the downstream of this second Thane Creek road bridge as already mentioned above. That work was started in 1986 and has already been completed. Quantities of work involved in the road bridge, which is six lane wide and is in effect equal to two bridges, are about two-and-half times the quantities of work in railway bridge. Hence some extra time for completion of the road bridge was inevitable.

The expenditure incurred on construction of this bridge is proposed to be recovered by introducing a system of toll. With the present high volume of traffic, which is rising rapidly every year, it is anticipated that the toll may not have to be continued for very long.

The question constantly asked by the lay public is about the relatively high road level on the second bridge as compared to the first bridge. Actually, the soffit level of the two bridges in the navigational span is more or less the same, since both comply with the same navigational clearance requirements. However, the span of the second bridge is double that of the first bridge and the construction is by cantilever method and hence the depth of the superstructure at the supports is 7 m, which has raised the road level of the second bridge. It may, however, be noticed that the road level at both the abutments is the same for both the bridges.

Long-term monitoring

The performance of the bridge is proposed to be monitored closely to gauge the extent of corrosion damage over the years. It is also proposed to observe the temperature gradient across the cross section of the box girder to serve as a guidance for future designs. It is also proposed to observe, in one or two cases, how effective the grouting of cables has been. To this end, the bridge is being instrumented with the help of the Structural Engineering Research Centre, Gaziabad.

Cost

The total cost of this bridge when completed is likely to be Rs 125 crores.

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(Source: ICJ September 1994, Vol. 68, No. 9, pp. 445-449)