INVESTIGATION REGARDING BRIDGE GIRDER DETERIORATION IN PAKISTAN AND ITS REMEDIAL MEASURES

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ABSTRACT: *In highway infrastructure concrete bridges are playing a very important role. A case study of Pakistan is presented in this paper .The main problems that Pakistan is facing regarding bridges is their deterioration from last 20 years .The major reasons for deterioration is variation in specified construction methods and the lack of maintenance. National Highway Authority (NHA) Pakistan owns 6000 bridges on national highways and a number of other bridges across the country. According to a general survey about 30 percent of these bridges are not according to the ASHTOO standards. The total worth of these bridges are about 600 billion Pak rupees. The NHA budget for year 2009 was Rs 39.9 billion. This amount is insufficient to apply the standard procedures of maintenance and retrofitting in order to repair the non-functional bridges in the country. This research is mainly focused on case studies that involve damages and defects of bridge bearings only. Paper addresses all the root causes, remedial measures and recommendations regarding focused issue. This article will help nationwide engineers by providing them with basic knowledge regarding bridge flaws related to bridge bearings and will definitely help to raise the standards of bridge Construction.*

Keywords: bridge, Girder, NHA, maintenance, wearing surface, deterioration

1. INTRODUCTION

Bridges play an important role in the development of transportation system for any country. It also ensures the free flow of traffic. They not only accommodate the traffic volume but also strengthen the established transportation system. In Pakistan majority of the bridges are damaged due to overloading and use of low quality construction materials. The available resources and facilities are insufficient to repair and strengthen the existing bridges. Maintenance is required at the wide scale so that majority of these structures can be functional. Unfortunately very little information is readily available on various structures in Pakistan. The highway departments, engineering societies and universities in Pakistan are not in the habit of sharing information. This article consists of information regarding present methods that are followed for the maintenance in our country and also necessary measures that can be taken to improve the standard of existing bridges. As a matter of fact it is obvious that the main concern in design of bridges is economy which is achieved by considering nominal load rather than AASHTO specified safe loading combinations. Therefore no existing bridges have zero level of unreliability or 100 percent efficiency. Every structure needs to be maintained, as every structure loses its strength and serviceability with time. In this universe no structure is perfect. Planning a structure without any deficiency is impossible. There are majority of factors which are responsible for degree of deterioration or type of degradation. Some of them are: structural form, quality of construction, constructional materials, weather, fire, scour, earthquakes, atmospheric environment, fatigue, floods, intensity and nature of the traffic loading imposed upon it. Bridges maintenance and management is a continuous process starting from design & paperwork till the proper execution of drawing while ensuring quality control on site.

Bridge management is an art of enhancing the strength and load carrying capacity of structures through required maintenance and strengthening techniques.

Bridge manager is responsible for the proper functioning, maintenance and full restoration of bridges throughout their service life. Efficient, economical and effective performance of structures are characteristics of well and proper civil engineering design. In order to keep the structure in serviceable condition balanced maintenance and renovation is required during its design life. Investigation regarding deterioration problems observed in superstructure girders of reinforced concrete bridges in Pakistan and its remedial measures within the available resources based on the personal experience of authors is the topic of this paper.

2. PRESTRESSED GIRDERS

Prestressed girders are the most important component of the bridge superstructure, the failure of which can result the failure of the whole bridge. The most popular and the most frequently used precast pre-stressed concrete element in bridge design and construction is the I-beam section, usually available in depths ranging from 36 to 54 inches and used with a concrete deck.

3. PRACTICAL PROBLEMS SEEN IN FIELD

1. Cracks in the lower flange due to overloading and release of the pre stressing force.
2. Concrete spalling due to environmental effects or poor drainage. In flyovers, due to repeated impacts of over height vehicles the bottom flange is badly damaged and steel is exposed.
3. Corrosion of pre stressing strands due to poor grouting of ducts.

The photographic evidence of the above mentioned problems which was noted during the visual survey conducted by National Highway Authority is as below;

Figure 1 Exposed Reinforcement

Figure 2 Damage to the Girder

Figure 3 Pre-Stressed strands exposed

Figure 4 Concrete Deterioration in Girders

3.1 Case 1, Concrete deterioration due to poor drainage facilities

3.1.1 Proactive remedies

1. The scupper pipes should be located at 4m spacing and should not discharge over the lower flange of the girder as well as transom / abutment.
2. The lower edge of the scupper pipe should be projected a few inches from the soffit of the deck slab.

3.1.2 Reactive remedies

1. Accumulation of debris to be avoided on the deck slab.
2. Remove the deteriorated concrete.
3. Apply the bond coat to support the bond amongst the repair work done and the old concrete.
4. It is a usual tradition to use spray-based procedures if the topping of the repair material is between 20-40mm, such as Gunite with the help of highly skilled workers to certify both good bond and compaction of the material.
5. Cure the material by any appropriate method per recommendations of the manufacturer of the repair material.

3.2 Case 2, Damage to the lower due to impact of over height vehicles in flyovers

Figure 5 Damage to the Girder

Figure 6 Pre-**Stressing Strands Exposed**

Figure 7 Damage to the Lower side

3.2.1 Proactive remedies

1. The minimum recommended clearance under the flyovers is 5.1m in NHA specification. But this clearance should never be less than 6.0m i.e. an allowance for resurfacing of the underneath roads should be kept in mind.
2. Maximum height of the vehicles should be restricted and warning signs be installed.

3.2.2 Reactive remedies

1. Remove the deteriorated concrete, clean and straighten the bent bars. If the desired splice lengths are not achieved, the additional bars can be welded.
2. Apply the bond coat to promote the adhesion between the repair and the parent concrete.
3. Use formwork if the thickness of the repair is more than 40mm. It is common to use spray-based methods if the layer of repair material is between 20-40mm, such as Gunite by the help of highly skilled workers to certify both good bond and compaction of the material.
4. Cure the material by any appropriate method per recommendations of the manufacturer of the repair material.

3.3 Case 3, Cracks in the lower flange and web

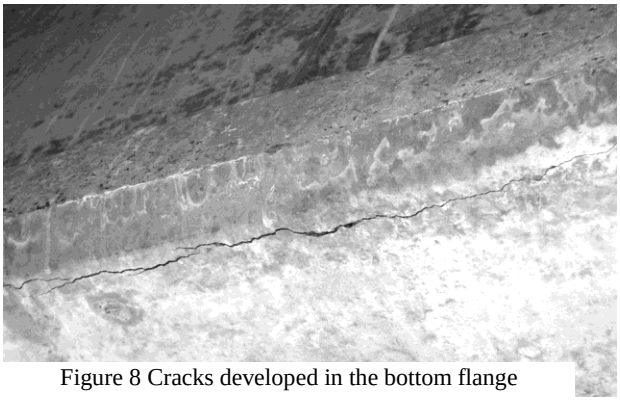

Figure 8 Cracks developed in the bottom flange

Figure 9 Cracks developed in the web

4. EXTERNAL POST-TENSIONING

The solution to this problem is external post-tensioning. This would reduce the deflection in the middle and hence reduce the cracking in the girder in both web and flange section. A typical way of doing so can be seen in figure 5.

Figure 10 External Post-Tensioning

5. SUGGESTED CONSTRUCTION PRECAUTIONS

As far as the deterioration of the girder is concerned, most of the defects are attributed to non-adherence of adequate and prescribed precautions during the construction. The above mentioned problems can be avoided if the following measures are adopted:

5.1 Preparation of the bed

In order to achieve the smooth surface on the bottom of the girder, there should be no imperfections on the surface of the bed (not more than ± 1 mm).

In order to increase the contact area between girder and the elastomeric bearing, thin MS sheets can also be placed before commencing the steel fixing.

5.2 Profile of tendons

In Pakistan, a seven wire strand is used and each tendon consists of 9 ~ 12 strands encased in a sheath pipe, joints of the sheath pipe must be sealed properly to stop intrusion of the cement slurry during concrete pouring and vibration.

The coordinates of each tendon are always mentioned in the construction drawings at normally 7.5m interval. After fixing the tendon rigidly to the design coordinates, the intermediate irregularities are rectified visually to create a regular curvature both in horizontal and vertical plans.

Place small pieces of steel around the tendon and weld to the girder reinforcement to eliminate the chances of any movement of the tendon during concrete pouring and vibration. Any irregularity in the profile will never produce the designed elongations while stressing thus increasing the friction losses.

5.3 Formwork

The formwork should be true to the dimensions and rigid enough to achieve desired surface finish.

Special attention should be given to the sealing of the joints to avoid any leakage of cement slurry which may create honey combed surface.

5.4 Concrete pouring

Concrete of approved mix design with high cement content is always placed in layers not increasing 30 cm depth.

When concrete reaches half depth, the bunch of strands is periodically moved to and forth manually to ensure that if some slurry has intruded into the sheath pipe unexpectedly, it should not bond to the strands. We have noted this as a very serious problem while tensioning the tendons.

5.5 Post tensioning

The equipment (pump and Jack) should be calibrated first with some standard and reliable gauge.

After applying the design force, the lock off pressure (normally 150 bars) should be applied with utmost care and precision essential to preserve the design force.

5.6 Grouting

Grouting is a method of repair in which gaps for tendons are filled with mortar of cementitious materials in order to protect the prestressing steel against the environmental effects such as corrosion and to certify satisfactory adhesion between concrete and prestressing steel. Poorly grouted gaps decrease the durability of prestressed concrete structures. Any NDT-method like impulse thermography can be used to detect voids in the ducts of prestressed.

The ducts should be flushed with clean water to remove any dust /debris inside the duct and the air vents too.

The grout of specified viscosity / w/c ratio be filled into the duct with a pressure of at least 5 bars to eliminate all the air voids.

- When the clean grout comes through the vent pipes placed at the mid of the girder should be ensured. Voids are mainly found at high points.
- An interesting alternative to the conventional techniques such as X-Ray testing, impact-echo and ultrasonic testing is the Impulse thermography for detecting voids inside of ducts [3].

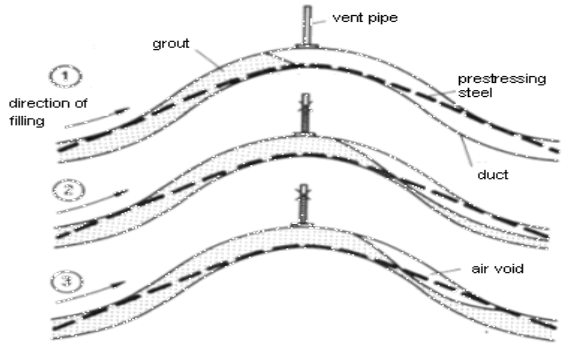

Figure 11 Development of an air void at a high point

6. CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusions

1) The main conclusion that can be made from the comprehensive research and looking through all perceptions is that the bridges start to weaken after sometime, due to miserable and scarce workmanship. All these short-comings can result in
   a. Inadequate or less concrete cover addition,
   b. Honey-combing of concrete,
   c. Improper drainage and water management.
2) Rebar corrosion is another problem that tends to happen when chlorides, water and carbonates are present. This can also cause damage to concrete in forms of cracks.
3) As a matter of fact, every structure that has to be built with decent features would require use of appropriate materials. That's why use of suitable and proper materials would count as major in determining the service life of a bridge.
4) Another way to increase the safe service life of a bridge is to implement advanced methodologies of construction.

6.2 RECOMMENDATIONS

1) Non-destructive analysis of buildings should be practiced more by the local authorities as compared to destructives ones which can damage the building elements.
2) Time to time assessment should be made which can be either weekly or monthly basis. This practice is necessary because if there are any problems with the structure, it can be monitored and dealt with efficiently. If anything comes up that requires fast response, it can be dealt with systematic repairs over a certain span of time.
3) Consistent use of coatings can act as a barrier against wear and tear and can actually add up 5 to 20 years of service life to a bridge.
4) Corrosion-inhibiting methods which are locally available in Pakistan's market can also be used which

include concrete admixtures, rebar coatings and different types of coatings that can be applied on concrete surface.

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