

Investigation Regarding Bridge Expansion Joints Deterioration in Pakistan and its Remedial Measures

A. Ajwad¹, L. A. Qureshi², F. Tahir³, J. Hussain⁴

^{1,2}Environmental Engineering Department, University of Engineering and Technology Taxila, Pakistan

^{3,4}Civil Engineering Department, University of Engineering and Technology Taxila, Pakistan

¹ajwad1989@gmail.com

Abstract-The Concrete bridges are a vital part of highway infrastructure in Pakistan. The main problem that exists is the deterioration of most of them over the past 20 years or so. The main reason for this is the deviation from specified construction procedures and the negligence of the maintenance departments due to several reasons. At the moment National Highway Authority (NHA) owns about 5000 bridges in number across the country and according to a survey, about 30 percent of them are either not up to the mark or are out of service. The fund that NHA reserves every year for the maintenance purposes ranges from PKR 500 to 600 million which is very limited when it comes across the scope of the work. It means that expensive testing and retrofitting techniques that need to be implemented can never be achieved practically. This research is focused on case studies involving deterioration of bridge expansion joints only. All the deficiencies with their root causes and remedial measures are discussed in detail. The research is based upon wide experience of authors and will prove to be a cherished standard and beneficial reference article for working engineers engaged in fresh construction as well as renovation & repairs of concrete highway bridges.

Keywords-Bridge, Expansion Joints, NHA, Maintenance, Wearing Surface, Deterioration

I. INTRODUCTION

Ridges are considered as the spinal column of infrastructure for any country [i]. At the moment Pakistan is facing a big bridge crisis which means actions are required as soon as possible. The main problem is that the amount of resources available to meet the rehabilitation works are not even close to do all the repairs [ii]. Thus, the need for fast devotion to the suffered problems is required which would include a broad approach to bridge maintenance. This would include better repair and restoration methods. In current investigation work, the main objective was to define the current methods being followed in the maintenance of the bridges and to come up with such

measures that will take the managing and monitoring abilities of the bridge engineers to the next level. It is well known fact that construction projects are meant to be designed as economical as possible. For this reason, design engineers have to design the bridges with taking into consideration only the reasonable loading conditions instead of designing for extraordinary one. It means that it is impossible to plan a bridge which has no risk involved at all. It can also be said that this planet has not good enough resources for such type of zero risk bridge [iii]. Any form of construction cannot last forever which includes Bridges. The consequences of degradation will start to emerge, sooner or later, it would not matter whatsoever method of construction is adopted and whichever supplies are used. There are many reasons which contribute to the type and degree of degradation which would include quality of construction, constructional materials, structural form, design and detailing, fire, scour, atmospheric environment, earthquakes, fatigue, weather, floods, intensity and nature of the traffic loading imposed upon it. Bridge management and maintenance can be defined as a method which includes going through all the necessary steps and checking each and every aspect, from the paperwork to its design, construction and finally the end of its useful life.

Bridge management approaches are being amended and enhanced to carry out required renovation and restoration work in a balanced manner. The responsibility of maintaining and managing bridge stock economically, efficiently and effectively lies on the shoulders of bridge managers so that it would effectively sustain the imposed loads without loss of structural reliability or deterioration in its physical appearance. As part of their duty, they have to make vital choices concerning numerous doubts [iv].

There is a tremendous load of pending rehabilitation works on bridges in many developing countries like Pakistan. Such problems can be seen in most of the national highways in Pakistan. But as it is a known fact that that Pakistan has not sufficient funds to be allocated for bridge repairs and hence only PKR 500 to 600 million is assigned yearly to maintain and

renovate in total over 5000 bridges. In addition to this, the lack of expertise has led the local authorities like provincial and national highway departments into flattening the depreciated bridges. At some places, this demolishing was done for only the superstructures but most of the times the whole structure was flattened.

The main aim of this research work was basically to look ahead on defining damage problems observed in expansion joints of bridges and proposing remedial measures within the available financial resources based on the personal experience of authors which would then help bridge engineers. The methodology adopted for this research was based on some case studies regarding rehabilitation works on bridges in Pakistan. National Highway Authority conducted a survey in 2006 regarding prevailing conditions of service bridges in Pakistan. The paper is based on some recommendations about expansion joints based on their field experience and code practice.

II. LITERATURE REVIEW

An expansion joint can be defined as a device which supports the surfacing, and provides a running surface by filling up the gap between the adjacent bridge deck and abutment or the area between adjacent decks. Bridge expansion joints are designed to allow for continuous traffic between structures accommodating movement, shrinkage, temperature variations on reinforced and prestressed concrete, composite and steel structures. They stop the bridge from damages in extreme conditions and allow enough vertical movement to permit bearing replacement without the need to dismantle the bridge expansion joint [v]. There are various types, which can accommodate movement from 30 to 1000 mm.

The failure of the expansion joint serves as one of the main causes of bridge superstructure and substructure damage. The main problem occurs when expansion joints fail. They have to be repaired along the pier, abutment and decks as well which adds up to almost hundred times more as compared to the actual cost of bridge joints only.

Reference [vi] did research on expansion joints which looked at the problems and their causes. He came out with a conclusion that use of proper seals will contribute to long life of bridge joints. He also concluded that If Polymer Modified Asphalt joints are used, caution should be taken to use them in locations where there is less truck traffic and bridge movement is small. Reference [vii] inspected 150 expansion joints in Portugal and concluded that installment errors and lack of maintenance are the most frequent causes of pathology. Reference [viii] carried out research into the properties and service performance of bridge deck expansion joints and highlighted the quality of workmanship during installation as essential to ensure satisfactory performance. Reference [ix] revealed that roadway members inevitably deteriorate over time at

different rates, and the life of some components is only 5-7 years or less. The main causes of deterioration are heavy traffic, water carrying deicing salts, and weather conditions. The main defects include leaking waterproofing and expansion joints. Reference [x] investigated silicone foam as a sealant for small movement expansion joints in bridge decks and revealed that the solid sealant recovered faster than the foam sealant after being subjected to prolonged compression at elevated temperature.

Different types of bridge expansion joints can be categorized as following;

- Buried joint
- Asphaltic plug joint (APJ)
- Nosing joint (N)
- Cantilever comb or tooth joint (CT)
- Reinforced elastomeric joint (RE)
- Elastomeric joint in metal runners (EMR)
- Cantilever comb or tooth joint (CT)
- Modular joints including finger and sliding plates.

A. Functional requirements

The properly designed and installed joints should offer/fulfill the following needs;

- Outstanding traffic control
- Extended lifespan
- Less sound
- Resistant to corrosion
- No reaction especially horizontal
- The surface under the joints should be protected
- Should provide good resistance to changing loads including heavy duty loads
- Adaptableness to all sort of surface structure
- Installation process should be easy
- Low maintenance and service cost
- Can be replaceable quick and easy without imposing damage to the existing structure.



Fig. 1. View of the properly installed finger joint

III. DEFECTS NOTED ON BRIDGES IN PAKISTAN

As far as the basic requirements like low noise, comfort to the road users and durability are concerned, the best quality of expansion joints have been noted in Pakistan on Lahore-Islamabad Motorway (M2) and Islamabad-Peshawar Motorway (M1). Except these, numerous problems with expansion joints prevail on other main highways. Figures 2-10 show different problems that were noticed during the survey conducted in 2006 by NHA.



Fig. 2. Joint assembly is removed bridge without joint will not serve properly



Fig. 3. Improperly repaired joint with bituminous material has cracked and restricted the movement



Fig. 4. Joint assembly is dislodged, causing noise and damage to the deck concrete

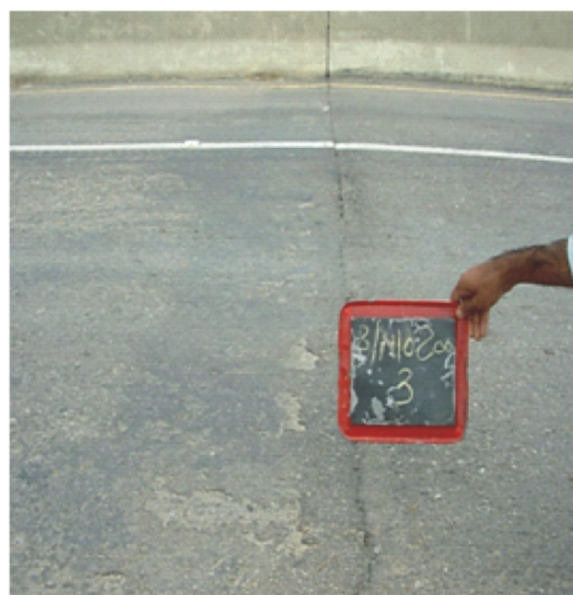


Fig. 5. Improperly repaired joint with bituminous material has restricted the movement



Fig. 6. The damaged wearing course would damage the joint



Fig. 8. Improperly repaired joint with bituminous material has cracked and restricted the movement



Fig. 7. Neoprene seal removed, gap is being filled with debris



Fig. 9. Improperly repaired joint with bituminous material has restricted the movement

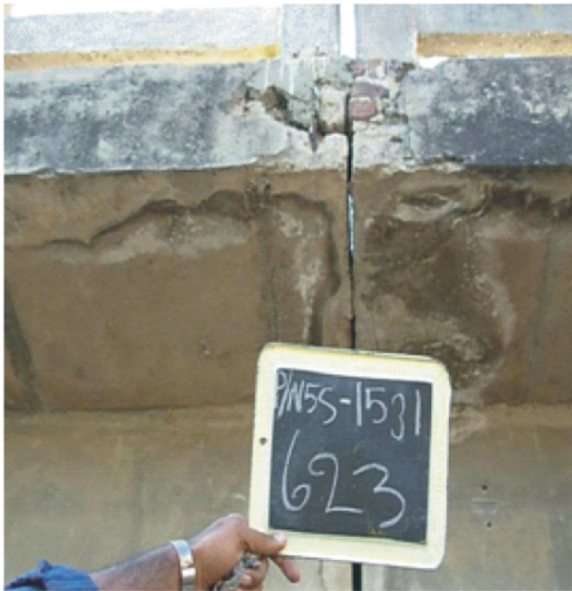


Fig. 10. Water flowing through the joint causing deterioration of the deck

IV. REASONS OF DAMAGE

The poor condition of the present joints on our national highways was found due to various reasons like:

Overloading due to single axle trucks

Rutting of the asphaltic wearing course. When the asphalt level is below the joint rail, heavy thrust / impact is transferred to the joint which tends to dislodge it.

Non adherence to the specified installation precautions as recommended by the manufacturers.

V. REMEDIAL ACTIONS

The following sequence of actions were successfully followed for the above narrated problems;

- 1) **Laying the asphalt:** The asphalt should be laid without any delay and in a continuous manner over the bridge gap and then compaction is to be done.
- 2) **Cutting out:** With the help of an asphalt cutting machine, cutting in the asphalt surface should be done according to the given width of the expansion joint.
- 3) **Levelling:** The break should then be sandblasted and the edge profile is mounted and shuttering placed.
- 4) **Installing:** To form a smooth carriageway surface, the polymer concrete should be mixed, poured and cured without leaving any cavities behind. No further compaction will be required.
- 5) **Inserting:** The sealing profile should be inserted which would make the expansion joint 100% impermeable to water.

Mageba (Switzerland) and Freyssinet (France) are manufacturing the quality expansion joints with variety and all requirements and are available in Pakistan easily. If all five steps mentioned above are followed and quality expansion joints are used, there will be less chance of expansion joints failure.

VI. CONSTRUCTION PRECAUTIONS

- 1) While installing the expansion joints, it has been observed with experience that its top levels should be kept below the existing elevation of asphaltic wearing course by at least 2 to 3 mm as an allowance to accommodate the settlements in wearing course. This provision is made while pouring the bedding concrete.
- 2) Thickness of the slab is increased at the ends of the slab by at least 2 inches for better installation of the joint assembly and spacing of reinforcement is reduced in the design as shown in the below figure.

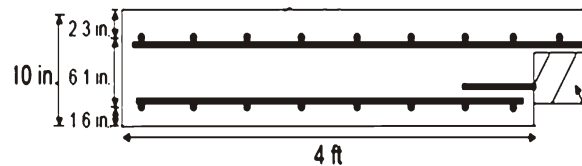


Fig. 11. Bridge deck Slab Cross-section

- 3) Literature and recommendations of the manufacturer should be strictly followed.
- 4) The process of installing the expansion joints should work as a team effort which means all the people related to the work e.g. engineer, main contractor and installer should work as a team. All of them should have complete access to the information and design details and it should be made sure that the whole procedure is followed in a professional and competent manner.
- 5) There should be a provision in the design of making the joint accessible from underneath the deck for inspection. Routine inspection of carriageway surfacing and the joint would mean that the different faults which occur such as rutted surface and blocked drainage can be detected in time and treated as soon as possible. This would help in avoiding the extra remedial work charges. The site engineer should be aware of different joint types and the defects it can have. For maximum service life, the interval between inspections should not exceed a time of one year and maintenance should be done accordingly for minimum disruption.
- 6) Another important aspect to be kept in mind is the adequate deck drainage. Water is believed to be a foe to any structure and hence the joint should be designed in such a way that water is removed from within and below the surface through drainage units placed in the decks.

- 7) The materials that should be used for the repairs should be according to NHA standards and should have good durability.

VI. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- 1) The main reasons of weakening of bridges in Pakistan are due to meager and inadequate workmanship which mostly results in less concrete cover, honey combed concrete, improper drainage or water management. Another major cause of damage to concrete is the rebar corrosion which can take place in the presence of chlorides, carbonates and water.
- 2) A structure of decent features cannot be built without selection of appropriate supplies. The service life of a bridge can significantly be enhanced with the selection of proper and suitable materials.
- 3) The use of advanced construction methodologies is another way of increasing the safe service life of a bridge. If adequate concrete cover to reinforcement is provided, it can act like a key hurdle to the deterioration procedure.

Recommendations

- 1) The local establishments should give some devotion to the non-destructive analysis and the electrochemical investigation also.
- 2) Weekly or monthly assessment is necessary so that the problem can be controlled before it is too late and it reaches the point of no return. The rapid catastrophic event is the one that requires immediate action. Some of such events can be avoided if excellent systematic precautionary repairs are implemented.
- 3) Water is believed as a foe for any concrete structure and bridges are no different. It is the cause of many of the wears that affects our bridges. Not only does it precipitate corrosion directly if in the presence of oxygen, but it may carry destructive de-icing salts in solution to all parts of bridge through seepage. It tides over expansion joints, and it can seep through to bridge bearings.
- 4) One cheap and efficient way of guarding prevailing bridges from wear is consistent use of coatings. Such coatings can add up a life of up to 5-20 years depending on its kind and method of usage.
- 5) There are also numerous corrosion-inhibiting methods available in the market. These include rebar coatings, concrete admixtures and coatings applied to the concrete surface.

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