REVIEW ON SEAMLESS BRIDGES

Gini Judson[1], Vidya Jose.[2]

[1]*UG Student, Department of Civil Engineering, TOCH, Arakkunnam, India*
[2]*Assistant Professor, Department of Civil Engineering, TOCH, Arakkunnam, India*

Abstract - *Bridge construction without expansion joints becomes most popular in this generation. Various techniques are developed for eliminating expansion devices. Seamless bridge system is one of the latest techniques for the above. This system approaches to the consideration of economy, maintenance cost, and life of bridges. In this paper both U.S and Australian version of seamless system are reviewed. Transition zone, microcracks are the important parameters in this system. Thermal load transferred through transition region and zero movement at the end of bridge was achieved.*

Key Words: Expansion joints, expansion devices, microcracks

1. INTRODUCTION

A bridge is a civil engineering structure mainly builds over the river, road or railways to allow people, animals, and vehicles cross one side to another. Bridges become one of the most important aid of bridging cities, countries and continents because of the great achievements and technologies. Discovery of RCC was one of the great achievements in bridge engineering field. Expansion joints (see Fig. 1) are used in about 98% of all bridge decks to accommodate longitudinal movements caused by thermal fluctuations, earth pressure, soil settlements, vehicle accelerating/braking forces, and other intrinsic reasons.

But they were identified that these expansion joints is a barrier to the smooth passage of vehicles through bridges and main reason of maintenance cost in bridges. The above mentioned situation led to concepts of implementation of jointless bridges. Uses of expansion devices are the one of the recent technique to eliminate the expansion joints in bridge decks. It has been observed by engineers that bridge expansion joints and bearings do not efficiently serve their intended purpose, i.e., translation and rotation, and lead to unusual stress build-up for the following reasons, Corrosion of bearings caused by deicing chemicals leaking through the joints, accumulation of debris and other foreign materials restricting free joint movement, and differential elevation of bridge joints causing additional impact forces on the joints and deck slab.

Additionally, high initial costs and maintenance costs of joints and bearings are major concerns among bridge engineers. A recent trend in bridge design has been toward the elimination of joints and bearings in the bridge superstructure. Joints and bearings are expensive in both initial and maintenance costs and can get filled with debris, freeze up, and fail in their task to allow expansion and contraction of the superstructure. They are also a ‘‘weak link’’ that can allow de-icing chemicals to seep down and corrode bearings and support components. These limitations have lead to the construction of bridges without joints and bearings.

Fig -1: Expansion joints in bridge

There are various techniques adopting for making jointless bridges instead of using expansion devices. Seamless bridges are the one of recent technique developed by U.S for achieving jointless bridge system. Expansion devices can be eliminating using seamless bridge system.

2. HISTORICAL EVENTS OF JOINTLESS BRIDGES

To permit thermal expansion and contraction on long multi span highways, providing expansion joints, roller support and other structural releases in earlier days. Expansion joints should be performed with characteristics of water tightness, smooth rideability, low noise level, and wear resistance etc. But performance of majority jointless system was poor. They failed in one or more important aspects when subjected to heavy traffic loads. Due to runoff through expansion joints, substructural elements like steel girders and stringers, bearings, rollers, and anchor bolts were damaged.

After 1920s the problem due to expansion joints has become noticeable because of joint related damage reached alarming proportions. In this scenario, bridge engineering field move to the concepts of eliminating joints results development of jointless bridges. The above mentioned system provides desirable characteristics, such as long term serviceability, low maintenance, economic construction and all level performance improved.

Since 1930, U.S and other countries proposed design details and construction procedure of jointless bridges. Various highway departments permitted the modification of design and construction details after a review of the performance of prototype.

South Fork Putah Creek Bridge, this bridge having 16miles build in 1974 located at west of Sacramento, California. The bridge consist of continues reinforced concrete box girders over the six span. Reinforced concrete were used the construction of bridge deck and substructure including piles, and approach slab consist of asphalt concrete. The wing walls provided separately with the abutments, and neoprene rubber water stop filled to interface joints. This bridge has to follow at least one inspection within every two year. Caltrans submitted a report in 1986, said some kind of minor patterns and transverse cracks observed in deck slabs and one spalled area at the soffit of a box girder was patched to protect exposed reinforcing steel. From these reports, they identified a fact that continues maintenance is necessary due to settlement of the approaches and erosion in abutments due to runoff through deck.

Holston River Bridge(1978). The bridge was the longest structure in the United States and located near Kingsport, Tennessee. The structure crosses two highways, two railroad tracks, and the Holston River. Finger joints provided at each abutments to eliminate expansion joints, where upto 177.8mm of movement is expected to occur. In the case of Holston River Bridge, consist of prestressed concrete box-beam girder fixed to concrete hammerhead piers, which are enables to accommodate localized displacements due to thermal changes. Prestressed concrete girders are 105ft (32m) in length, 48in. (1.22m) in width, and with thickness of 54in. (1.37m). The inspection report on April 1986 showed that bridge functioning properly. But some of deck slab were infected by shrinkage cracks near negative moment region above pier. The preliminary report submitted by University of Tennessee reported that elongation and superstructure stresses of deck slab have not reached predicted theoretical levels

U.S Route 129 South Interchange, this bridge constructed near Knoxville, Tennessee having 400ft (122m) span. The bridge consists of two spans, continuous rolled steel beams cast into the abutments and post-tensioned hammerhead piers. After the detailed inspection on bridge, noted that it has performed properly. There were no symptoms of leakage and distresses at the girder abutment interfaces. But some problems noticed on the approach slab junction at end of bridge.

Route 9W over Coeyman's Creek, the bridge situated at the outskirts of Albany, New York. The structure is 107ft (32.6m) span with prestressed concrete box girder integral abutment. The abutments provided with riprap for slope protection. Wing walls are oriented perpendicular to abutments. A continuous bottom layer of reinforcement steel provided to deck slab and approach slab. A few feet behind the abutment have a deep saw-cut joint. At the top of deck allowed runoff water through creek. Inspection on 1982 concluded that bridge has performed well. There were no symbols of settlement in the approach slab or erosion of fill was apparent. But minor cracks were observed parallel to saw-cut joints

3. SEAMLESS BRIDGE

United state was initially proposed the concept of seamless system which helps to eliminates expansion devices from the end of approach slab and bridge deck. By using this system maintenance cost due to other system that provided for eliminating expansion joints can be avoided. The studies regarding seamless system were started before 2015. The proposed system consists of transition zone beyond each end of bridge abutments. Thermal compression forces are transferred to the base soil, and microcracks in transition zone were transfer thermal tensile forces. The expansion or contraction due to the thermal changes in bridges eliminated through these transition zone. The transition zone consists of two slabs connected between small piles. Gap between the slabs is filled with compacted soil. End joint is one of the major parts situated interface of transition slab and road pavement. Top slab of transition zone is called transition slab and bottom slab is secondary slab. There is no consideration of expansion joint devices or grade beams if the end joint movements are limited. Only dowel bars are required to transmit bridge loads to transition zone. Additionally, development of crack and its width are important parameters of this practise.

According to the results from the studies of U.S practise of seamless system identified that, proper connection of piles to slab should be provided for better transition of load to transition zone over entire life of bridge. Because, the induced stresses within piles should be remain in the elastic range and ease of construction should be maintained. Necessity of diagonal reinforcement around the pile is avoiding diagonal cracks around transition slabs. The observed yield lines and their patterns were indicated the information about stresses beyond yield stress over the height of small piles.

Australia proposed a modified version of seamless bridge with the concept of continuously reinforced concrete pavement (CRCP). In the case of CRCP, transition region and continuously reinforced concrete pavement seamlessly connected. The level of forces generated should be almost zero at the end and the movement should be very small(less than 6mm) at the end of transition region in flexible and the case of jointed pavements. All bridge movements are dissipated throughout the transition zone via friction between the paving and base soil with CRCP. During bridge construction, opening and closing of microcracks in the transition zone helps to reduce end- joint movements in both case of Australian and U.S practices.

Main advantages of seamless bridge are low maintenance cost, elimination of grade beams at the end of the approach slab, longer service life, reduced load on bridge structure, and elimination of moisture leakage to bridge elements below deck. The system is good to resisting lateral loads in the pavements. Seamless bridge system is suitable to seismic application, because of the continuity between bridge deck and pavement.

4. COMPONENTS OF SEAMLESS BRIDGE SYSTEM.

4.1 Micropiles

Micropiles are the one of the important design requirement in this system. Load transfer should not diminish during life of the structure because of the repeated expansion and contraction of the bridge. Micro piles that tie to the transition slab is the one of the method considered. That is, if the soil of surrounding piles gets compacted, the tie with transition slab should not be lost. Design of piles is done such a way that, they do not undergo rigid body rotations because of lateral top movement.

4.2 Approach Slab and Bridge Deck

There is a necessity of additional reinforcement in area of bridge deck, approach slab, and transition zone to control cracking, and to achieve desired crack spacing and width. Because there is a resistance against thermal contraction due to the presence of transition zone will create tensile forces and hence concrete cracking in the deck, approach slab, and transition zone. The axial strength of the approach slab should be adequate to resist compressive thermal stresses to avoid concrete crush. The approach slab is designed for the differential settlement between abutments and transition system.

4.3 Transition Slab

Design of transition slab includes the consideration to avoiding concrete crush in compression and also to gain uniform cracking pattern in tension. Transition slab should have the capacity to withstand punching shear due to heavy wheel. It should be transfer moment from small piles to slabs. Punching shear requirement and connection to the small piles is the major aspect to determine the thickness of transition slab. Slab is designed for both two-way punching shear and one way shear.

4.4 Secondary Slab

The length of secondary slab is most likely greater than or equal to the top slab. Punching shear and connection to small piles is major consideration to determine the thickness of slab. Secondary slab is designed for the bending moment and one way shear exerted from the small piles to the slab. Secondary slab checked for sliding in order to prevent the transition zone from moving. Friction between the bottom surface of slab bottom slab and underlying soil, and the soil passive pressure at the end of transition slab are the two forces resisting sliding of bottom slab.

4.5 Small Piles

Design of small piles considered with moment, shear, and maximum drift between the two top and bottom slabs. Base plates and shear studs use to perfect connection requirements. The strength of steel used in small piles should be greater than strength required by the designer, to achieve yielding before the connection fails due to extra strength.

5. SUMMARY AND CONCLUSION

The seamless system is an advanced technology used for eliminating expansion joints in bridges. It is a modified version of the Australian seamless system that was developed to be used with CRCP. Long service life and lowered maintenance cost by eliminating the expansion devices and preventing water leakage to bridge elements are the main advantages of seamless bridge systems. Additionally, it improves smooth ride, elimination of drainage system, elimination of grade beams etc. This system can be used for any span of bridges. Seamless system is the one of the excellent system for making jointless bridges. This system can be very cost effective in the long term process.

REFERENCES

[1] Nima Ala and Atorod Azizinamini " Experimental Study of Seamless System for U.S Practice." Journal of bridge engineering- Volume 21 (2016)

[2] Nima Ala and Atorod Azizinamini "Proposed Design Provision for a Seamless Bridge System: Case of Flexible and Jointed Pavements." Journal of bridge engineering- Volume 21 (2016)

[3] Anide M. Wolde-Tinsae "Performance of Jointless Bridges" Journal of Performance of Constructed Facilitie-Volume 2 (1988)

[4] Jung, Y. S., Zollinger, D. G., and Tayabji, S. D. "Best Practices of Concrete Pavement Transition Design and Construction" journal of transportation engineering- Volume 138 (2012)

[5] Oesterlie, R. G., Tabatabai, H., Lawson, T. J., Refai, T. M., Volz, J. S., and Scanlon, A. "Jointless and integral abutment bridges." (2012)

[6] Y.ZhengL.F.Zhang and L.P.Xia. "Investigation of Behaviour of Flexible and Ductile ECC Link Slab Reinforced with FRP". Construction and building material- Volume 166 (2018)