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*R*ole *o*f *B*earings *i*n *C*onstruction *o*f *B*ridges

Arnav Jain

Student at The Doon School, Dehradun, India

1. PREAMBLE & ACKNOWLEDGMENT

1.1 During the vacations of 2019, I wanted to undertake a brief project work on one of the projects of National Highways Authority of India, Government of India located near Agra, where I stay and chosen a major bridge constructed recently over the river Chambal, India, which connects the states of Rajasthan and Madhya Pradesh. During my visit to the bridge, I had observed that it is a high-rise bridge of 840 m long, completed and opened for the traffic in June 2016. I also learnt that the construction involved several important stages right from the planning, design, site investigation till installation of various safety features before commissioning. One of the items used in the construction was 'bearings' that evoked my curiosity to know more about it and its'functionsin the bridge construction and operation. This project work briefly covers my observations, learnings, study about the role/purpose of bearings in bridges. Figure 1 below shows aerial image of the bridge.

1.2 I express my thanks and sincere gratitude to Mr. R M Khanduri, HOD (Structures), PNC Infratech Limited, who has led the team involved in the construction of Chambal bridge.He has not only educated me on the topic but also provided valuable guidance, information and references throughout this project work.

Fig. 1. Bridge over river Chambal at Dholpur

2. SALIENT CONSTITUENTS OF A TYPICAL BRIDGE

2.1 It is understood that there are three main constituents of a bridge:

i) Foundation – Bottom part of a bridge below or under the ground is called 'Foundation'

ii) Sub Structure – Middle part of a bridge above the ground including pier column up to pier cap is called 'Sub Structure'

iii) Super Structure – Topmost part of a bridge above pier cap where traffic moves is called 'Super Structure'.

Generally, foundation and sub-structure parts of bridge are physically jointed orconnected to each other and the super structure unconnectedly rests on the sub structure i.e. on pier caps. The load coming over super structure is transferred through 'bearings' and eventually to foundation through the sub-structure. The Figure 2 shows part of foundation (well cap), sub-structure (pier & pier cap) and super structure of the Chambal bridge distinctly. I learnt that 'Well Foundations' are adopted for this bridge and I need to know about the Well Foundations.

3. BEARINGS

3.1 How Bearings work in a bridge and its main key functions?

Fig. 2

I understood the purpose of bearings in a simple manner that while riding my bicycle on an uneven road, though

bicycle jumps and jerks badly on the undulations, I don't experience jolts in my body to that extent as the body of bicycle gets. I noticed the springs placed below my bicycle seat absorbs the jerksto a large extent and my body doesn't experience jerks as much as my bicycle.Similarly, when traffic moves on a bridge,the bearings placed below the super-structure does not only transfer the load and forces from the superstructure to the substructure and then to foundation,but also absorbs the jerks and shocks to a great extent without causing damage to the bridge. Hence, bridge bearings are structural equipment or devices installed between bridge substructure and superstructure to transfer the applied load including earthquake loads; wind loads; traffic loads and the self-weight of superstructure (bridge deck).I understood that similar to a bicycle rider who wobbleswhile riding a bicycle, super structure of a bridge also moves, though it is not visible to our naked eye.I also came to know that bridge deck also expands during summers & contracts during winter; Bearings helps in this movement without causing any damage to the Bridge structure. In short, bridge bearing is an important component of a bridge, which typically provides a resting surface between bridge piers and the bridge deck. The main purpose of a bearing is to allow controlled movements which could be thermal expansion or contraction, or movements due to traffic, wind and seismic activities (Earthquake) so that induced stresses are minimized. Bearing allows foundation movements and also accommodatessuper structure beam rotations.

3.2 Categories of Bearings (based on movements& rotation enablement)

Bearings used in construction of bridgesare categorized into three types, based on their enablement to movement and rotation; namely - Free Bearings, Sliding Bearings and Fixed Bearings. 'Free Bearing' allows movement in all four directions andalso maximum rotation, 'Sliding Bearing' allows movements in either transverse or longitudinal direction whereas fixed bearing doesn't allow movement in any of the direction. At the same time, all types of bearings allowrotation to certain degree, whereas free and sliding type bearings enables allows maximum rotation.

3.3 Types of Bearings (based on functional requirement/nature of materials used/ technology etc.)

Presently three major types of bridge bearings are used based upon the functional requirement, materials & technology used and depending on span length of bridge (length between two piers is called span) as briefly described following:

- Elastomeric bearings: Elastomer bearing are manufactured from good quality synthetic or natural rubber (Neoprene), which allows both transition and rotation movements through elastomer deformation. The ability of elastomer to carry large vertical loads is due to reinforcement layers that prevents lateral bulging of elastomer. There are number of elastomeric bearing pads classified based on types of reinforcements used. Steel reinforced elastomeric bearing is the strongest and plain elastomeric pad is the weakest. Elastomeric bearing is less expensive and requires minimum maintenance and easiest to install. Its life span is considered around 25 years. Figure-3 above shows a broad detail of an elastomeric bearing.

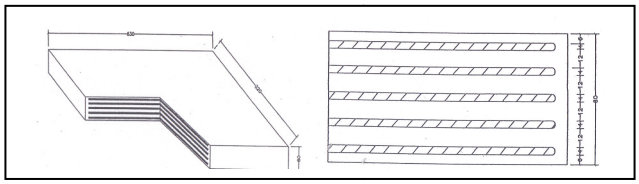

Fig. 3. Elastomeric Bearing

- Pot and Pot cum PTFE bearings: Pot bearing consists of elastomeric disk confined in a pot, steel piston that is properly tailored into the pot wall and flat sealing rings which keeps elastomeric inside the pot. Pot bearing can support significant vertical loads and it is essentially transferred through steel piston to the elastomeric disc which is highly incompressible. As transitional movement is limited in plain pot bearing, Poly Tetra Fluoro Ethylene (PTFE) material is introduced to the sliding surface to take cater for transitional movements and for ease of sliding. It is most commonly used type of bearing in India and same was used in the Chambal bridge. Figure 4 shows the typical section of a Pot bearing.

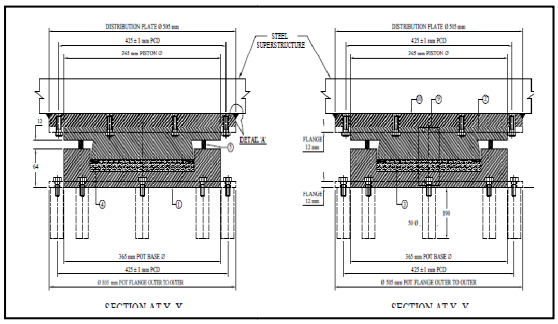

Fig. 4. Typical Pot Bearing

Curved &Spherical Bearings: This type of bearing consists of two curved plate that match each other. If curved bearing is cylindrical, then it can accommodate only rotation movements. However, both rotation and transitional movements can be enabled if the bearing is spherical. Due to the fact that both gravity loads and curved geometry generate lateral resistance against and consequently lateral movement would be limited, that is why PTFE slider is provided in the bearings for lateral movements. Theseare the most advanced bearings whose life span is around 50 years. Though these are relatively expensive, totally maintenance free. Details of Curved& Spherical bearings are shown at Figure-5.

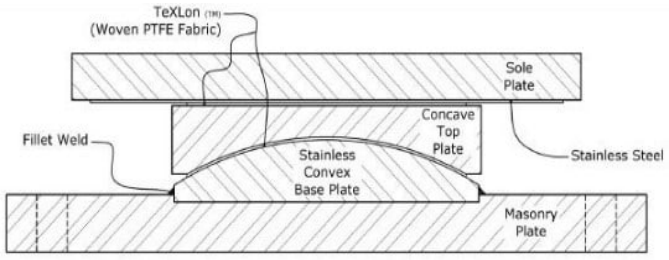

Fig. 5. Curved & Spherical Bearing

4. KEY TAKEAWAYS

4.1 My visit to the Chambal bridge, my observations and learnings as part of this project work gave me a valuable experience and perspective on construction of bridges in general and bearings used in bridge construction in particular.

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