Indian railway bridges – adoption of new bearing technology to support the progression towards long span bridges

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Summary

The Indian railway network has a proud history of rapid expansion to meet the needs of an enormous population across an extensive territory – an expansion which has relied on developing bridge construction technology in traversing ever greater obstacles such as rivers and valleys. An important aspect of modern bridge technology is the bearing which forms the vital link between a bridge's deck and its supports, facilitating movements and rotations, and resisting loads, as required by the structure's design. As bridge spans increase, the demands on bearings also increase, requiring constantly improving design and manufacturing capabilities. Fortunately, state-of-the-art bearings of the highest quality are now being manufactured in India, ensuring that the needs of even the most ambitious bridge designs can be met in supporting future network expansion and improvement.

Keywords: Indian railways, bridges, bearings, increasing demands, developing technology.

1. Introduction

As bridge construction technology develops and demand increases for structures to bridge wider obstacles with fewer intermediate supports, the spans of new bridges across the Indian railway network continue to increase, year after year. This progression is made possible by a number of factors, not least among which is the bearing technology which must develop with the general bridge construction technology, hand in hand. As bridge spans increase, so do the demands on the bearings which must support the bridges' superstructures – accommodating larger movements and rotations, resisting larger forces and perhaps being subjected to more severe vibrations, dynamic loading or uplift forces. A continually improving bearing supply industry can thus be considered to play a significant role in the rail industry's ongoing development, as shall be described.

2. Progressing bridge designs and early bearings

The history of rail transport in India began more than one and a half centuries ago, with India's first service running between Mumbai and Thane in 1853. Bridges became an immediate need for the Indian railways, in crossing the rivers and valleys that traversed the vast land. The first bridges were of masonry arch type and required no bearings – but this would soon change. The country's railway network expanded quickly in the early decades, with thousands of bridges constructed – many from structural steel, enabling spans to be increased. As bridge spans became longer and effects such as thermal expansion and contraction could not any longer be facilitated simply by deformation, a need developed for bridge bearings to form the links between the bridge deck and its supports, facilitating such effects by translation and rotation. The bearings of early metal bridges were relatively simple metal constructions which could typically accommodate movements in one direction and rotations about one axis only, and which were susceptible to high point-loading at contact surfaces and corrosion at sliding interfaces. More advanced types thus had to be introduced.

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3. The use of pot bearings in Indian railway bridges since the mid-1990s

Pot bearings have been successfully used in numerous structures across the Indian rail network since they were first used by the Konkan Railway in the mid-1990s. A pot bearing consists primarily of a steel pot with a lid, inside of which is placed an elastomeric pad. The load from the superstructure is transferred to the elastomeric pad which supports the lid. Under high pressure, the pad behaves like a fluid, and allows rotations of the lid, and thus of the superstructure to which it is connected, about any horizontal axis – in contrast to the earlier metal bearings which could only accommodate rotations about a single axis.

4. The recent introduction of spherical bearings

An alternative type of modern bridge bearing, the spherical bearing, has been recently introduced to the Indian railways after proving its value elsewhere around the world. Spherical bearings are based on the principle of a steel calotte, with the shape of a spherical cap (part of a sphere cut off by a plane), located within a concave-shaped lower steel part with a matching radius. The calotte can rotate freely within the lower part, thus enabling the bearing to efficiently facilitate large bridge deck rotations about any horizontal axis. Like other types, they can be designated fixed, free sliding or guided sliding, depending on their ability to accommodate movements or resist forces. Spherical bearings are very strong and durable, consisting entirely of carbon steel, stainless steel and a sliding material such as PTFE above and below the calotte. The weakest part is the sliding material (which facilitates the movements and rotations of the bearing), so the strength and durability of the entire bearing depends on that of the sliding material (unlike, for example, a pot bearing, the strength of which is also limited by the elastomeric pad at its core). The use of an alternative high-grade sliding material can thus substantially increase the load carrying capacity of the bearing.

Spherical bearings have already been proposed for a number of major railway bridge structures in India, including Kolkata's New Jubilee Bridge, the Bogibeel rail-cum-road bridge over the Brahmaputra river, Assam and the Chenab Bridge in the state of Jammu and Kashmir. The Chenab Bridge will be the longest steel arch bridge in the world, with a span of 485m, and also the world's tallest railway bridge, with a height of 359m.

5. An alternative for the future - Disc bearings

Another type of modern bearing which has the potential to be of great use in Indian railway bridges of the future is the disc bearing. This type of bearing features a highly durable moulded polyether urethane rotation element at its core, which can be subjected to very high stresses while facilitating significant rotations. Disc bearings, manufactured in Kolkata, were used in a major Indian bridge for the first time in the recent construction of Mumbai's Bandra-Worli Sea Link, designed for vertical loads of up to 14,000 kN [1].

6. Conclusions

Developing bearing technology has played an important role in the constant expansion and modernisation of India's extensive railway network, facilitating the construction of ever more impressive bridges to overcome wider and deeper obstacles. It does this by improving the functionality of the bearings which can be supplied to meet growing demands, such as to accommodate increasing multi-directional movements and multi-axial rotations while withstanding uplift forces, vibrations and dynamic loading. And at all times, the durability and maintainability of the bearings must improve, to ensure that life-cycle costs are minimised. Happily, a local manufacturing capability has also developed, which is capable of manufacturing state-of-the-art components such as pot, spherical and disc bearings of the highest quality, helping to ensure that the future of the Indian railways can be as proud as its past.

References

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