The high-performance, height-adjustable, load-measuring bearings of the new Route du Littoral offshore viaduct in La Réunion

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Abstract

A new highway, the "Nouvelle Route du Littoral", is currently being constructed on the French island of La Réunion in the Indian Ocean – partially on a viaduct in the sea, following the shoreline. This structure required a large number of high-capacity bearings to support its deck while accommodating movements as required. All of these "high performance" pot bearings were designed to be height-adjustable by injection of a special hardening material when required following ground movements/settlements etc. Each bearing is also equipped with a pressure sensor enabling the load it is carrying to be established at any time – a very useful feature during inspections, which enables the correct and safe distribution of loads among the viaduct's piers to be verified. The design and supply of the bearings is described.

Keywords: Bearings; load-measuring; height-adjustable, bridge; viaduct.

1 Introduction

The French island of La Réunion in the Indian Ocean, east of Madagascar and southern Africa, is located above a hotspot in the Earth's crust, and experiences frequent volcanic activity. With much of the island mountainous and largely unpassable, most of its major roads are located along its coast. The "Route du Littoral", which follows the coastline between Saint-Denis, the capital, and La Possession, the island's main port, is subject to frequent landslides and to flooding from the sea during tropical storms. Therefore, an alternative route, the "Nouvelle Route du Littoral" is being constructed – partially on a viaduct in the sea, close to the shore (Figures 1 and 2).

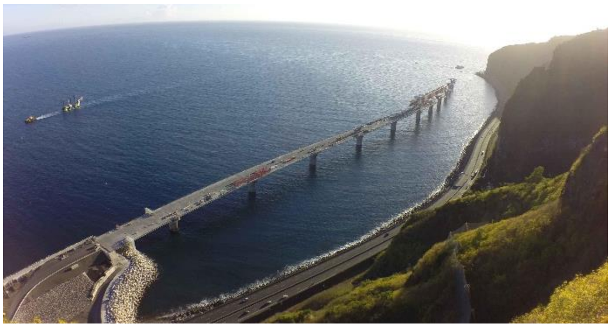

Figure 1. Part of the "Nouvelle Route du Littoral" during construction on a viaduct along the shoreline of La Reunion in the Indian Ocean

Figure 2. The new elevated highway over the water will be a more reliable alternative to the existing land highway

Figure 3. A precast segment of the box girder bridge, ready for connection to the end of the extending superstructure

The viaduct, being built by VINCI Construction, Bouygues Travaux Publics, Dodin Campenon Bernard and Demathieu Bard Construction, has a total length of 5,400 m, with a standard span length of 120 m. The project commenced in 2013, with a budget of approximately EUR 715 million, and is currently due for completion in 2019.

The superstructure is of precast concrete box girder segments as shown in Figure 3. The 48 precast concrete piers, complete with a segment of box girder on top and placed by an enormous barge, are founded at depths of between 3 m and 8 m below the sea bed. The rest of the box girder segments are then lifted into position and connected to the end of the superstructure, piece by piece, as it extends further and further towards the next pier (Figures 4 and 5).

Figure 4. View of the equipment used to extend the superstructure, segment by segment

Due to the viaducts' location in this volcanically active region and its maritime environment, particular demands arose in relation to the bearings that will support its deck, as described below.

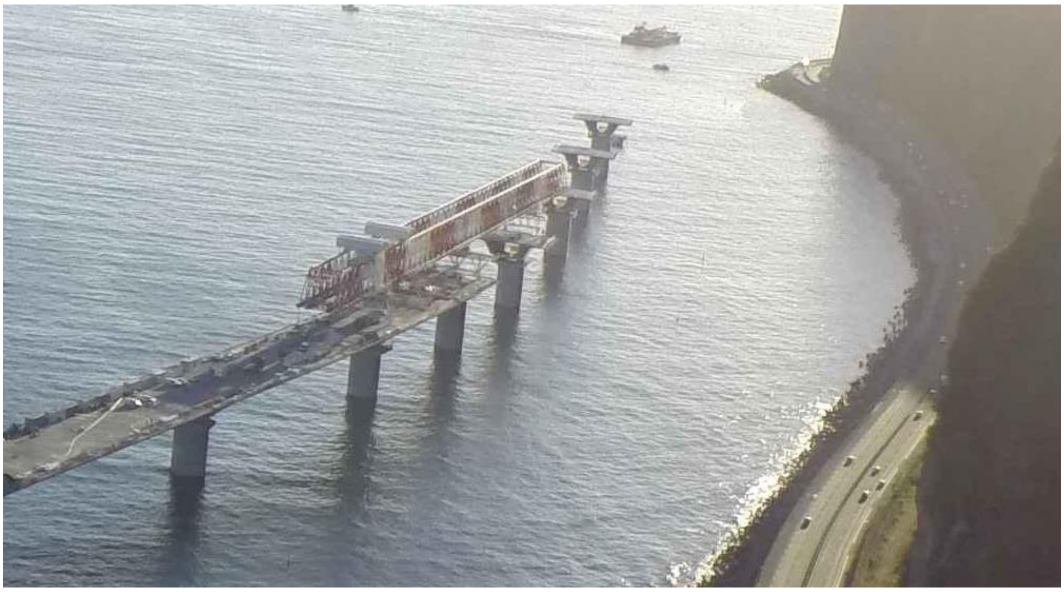

Figure 5. Placing of precast segments in the viaduct as it extends along the shoreline

2 The viaduct's bearings

The viaduct's 48 piers and two abutments required a total of 112 bearings – typically with two bearings per pier, as shown in Figure 6. The bearings are of type *Reston-Pot-Lift-Control* – a highly developed version of the more common *Reston-Pot* bearing, designed with additional lifting and load-measuring features. Most of the bearings are of the advanced "HP" ("high performance") variety, with a superior elastomeric pad at its core which enables it to be subjected to much higher pressures than a standard pot bearing – reducing size considerably. With the elastomeric pad being designed for a very high pressure of 92.3 N/mm^2, and special high-strength sliding material used instead of PTFE in the sliding bearings, the *Reston-Pot HP* bearing offers especially great benefits when used in steel structures or in structures with high-strength concrete – such as the high grade mortar (f_{ck}=70 MPa) used in this case.

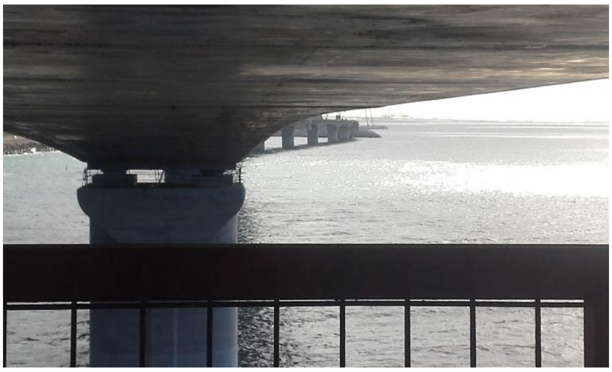

Figure 6. The viaduct's 48 piers typically have two bearings each – a guided-sliding one to facilitate longitudinal movements, and a free-sliding one that can additionally accommodate transverse movements of +/- 30 mm

All bearings are equipped with pressure sensors (located in the base of the pot, beneath the elastomeric pad), and a connection point for a portable *Robo-Control* digital display unit, delivered with the bearings, which uses the data from the sensors to indicate the vertical load on the bearing at any time.

Should the need ever arise – for example, as a result of settlement of the bridge's piers in the sea bed due to the region's volcanic nature – each bearing can be used to lift the superstructure by up to 30 mm. This can be achieved by injecting a special silicone rubber material into the bearing's pot, beneath the elastomeric pad (see Figures 7 to 9). In the absence of air and moisture, the injected material hardens and acts like the elastomeric pad above it, making the lifting action permanent. The use of a structure's bearings to lift its superstructure in this way is far easier than raising the superstructure by means of hydraulic jacks and then replacing the bearings with new ones – bearings that must be precisely dimensioned to suit the existing connection details above and below and any rotations to which the existing bearings have been subjected.

Using lifting bearings like this, there is no need to stabilise and secure the structure during lifting. The bearings retain their full ability to support and secure the superstructure during the entire lifting process, even continuing to accommodate movements. Lifting can thus be carried out without restrictions and under service conditions.

As an alternative to injection of the hardening material, lifting can also be achieved by means of hydraulics, enabling the bearing to be raised and lowered as often as desired.

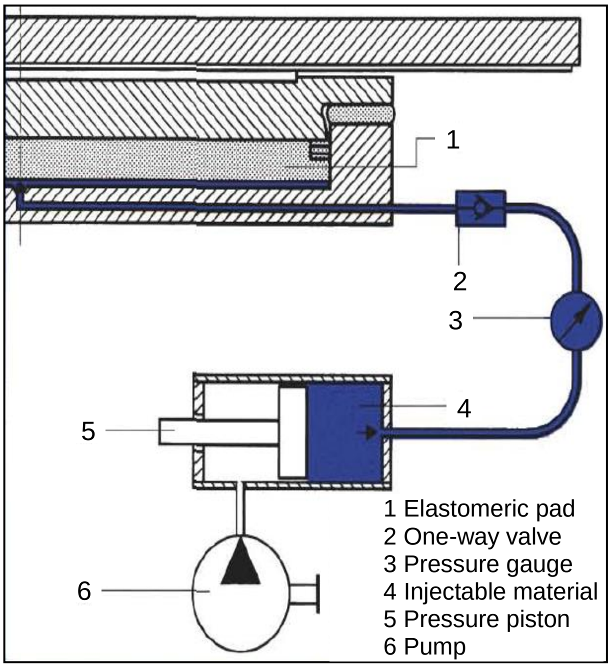

Figure 7. Schematic representation of injection method for increasing the height of a Reston-Pot bearing, thereby raising the structure it supports

Figure 8. Injection of special hardening material into the pot of a Reston-Pot bearing, beneath its elastomeric pad, to raise the superstructure

Figure 9. The injection method can be used with suitably designed Reston-Pot bearings in any situation, e.g. to adjust distribution of loads among the bearings of an arch bridge

3 Design and fabrication

The design of the bearings was in accordance with the European standard EN 1337 [1], and European Technical Approvals 08/0115 [2], 11/0453 [3] and 13/0039 [4], with loads according to EC 1 / EN 1991-2 [5]. Adherence was additionally required as specified to further French standards relating to design calculations and other factors. In the case of corrosion protection, the applied system was required to comply with the specifications of ACQPA (the French Association for the Certification and Qualification of Anticorrosive Paint), with corrosivity category C5Mm ANV 1031, with expected durability H (High).

The bearings have an average weight of approximately 10,000 kg, including the anchor plates that will enable the bearings to be more easily replaced should the need ever arise. They are designed for vertical loads of up to 125,000 kN, longitudinal movements of up to +/- 400 mm, and transverse movements of +/- 30 mm or transverse loads of up to 17,500 kN.

The design and fabrication of the bearings is illustrated by the photographs showing various stages in the manufacturing of different bearings in Figures 10 to 18.

Figure 10. Early stage in the production of a large free-sliding pot bearing, with holes etc. as required for pressure sensors and injection process

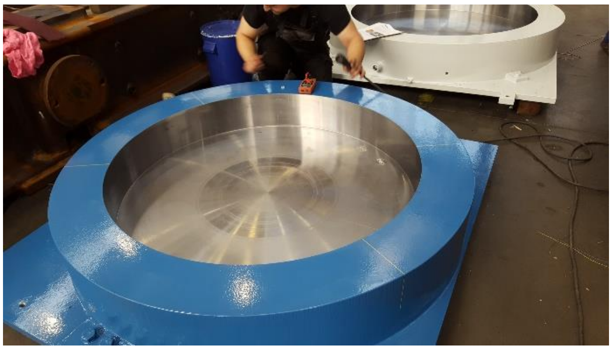

Figure 11. The pot of a pot bearing following connection of anchor plate and application of corrosion protection

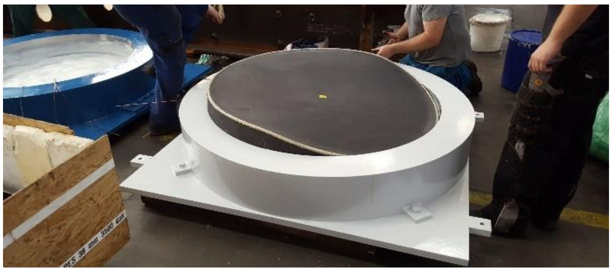

Figure 12. Insertion of elastomeric pad into the pot of a pot bearing, following insertion of pressure sensors in the pot's base

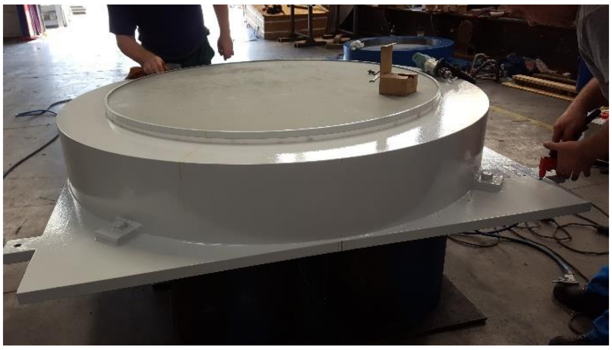

Figure 13. Pot bearing following placing of piston into pot, above elastomeric pad

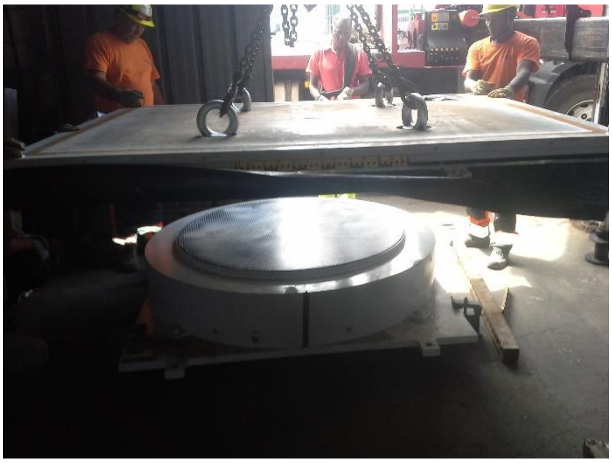

Figure 14. Placing of large sliding plate (with stainless steel sheet on lower surface) on top surface of the piston, following placing and greasing of sliding material on top of piston

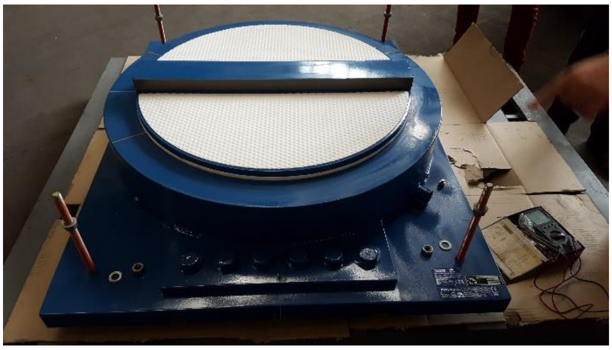

Figure 15. The piston of this guided-sliding pot bearing has a guide bar along the longitudinal axis for resisting transverse movements

Figure 16. Guided-sliding pot bearing following placing of sliding plate on top of piston, with recess in sliding plate for the piston's guide bar

Figure 17. This guided-sliding bearing, shown here with protective dust skirt around edge and transportation fixings, was designed for a vertical load of 98,000 kN (approx. the weight of the Eiffel Tower) while accommodating longitudinal sliding movements of +/- 250 mm

Figure 18. This free-sliding bearing was designed for a vertical load of 119,000 kN and to accommodate sliding movements of +/- 250 mm (longitudinal) and +/- 30 mm (transverse)

Extracts from the design drawing of one bearing are shown in Figures 19 and 20. These show details of the bearing at the land side of Pier 32, which was designed for a maximum vertical load of 123,000 kN. This bearing is of the guided-sliding type, allowing transverse sliding movements of +/- 30 mm while resisting longitudinal forces of 8800 kN.

The drawings show how the large horizontal forces arising at this bearing are transferred between the bearing's anchor plates and the concrete structures above and below – by means of the profiling of the anchor plates when set in fresh concrete or grout during installation.

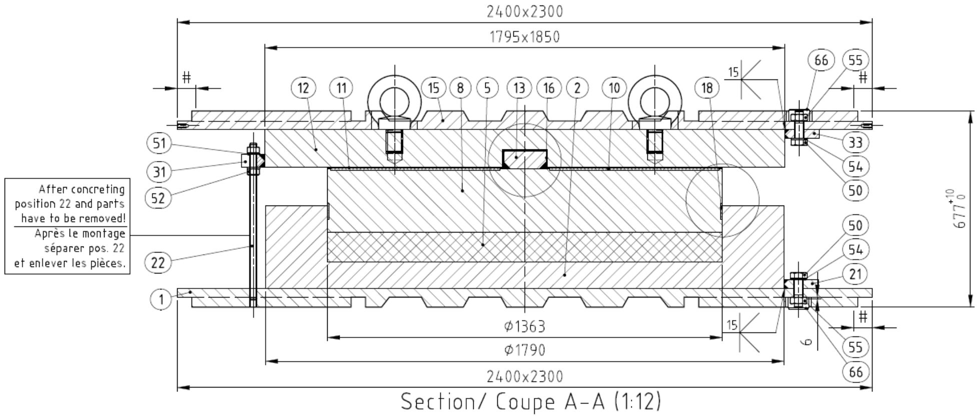

Figure 19. Cross section drawing of guided-sliding bearing at Pier 32

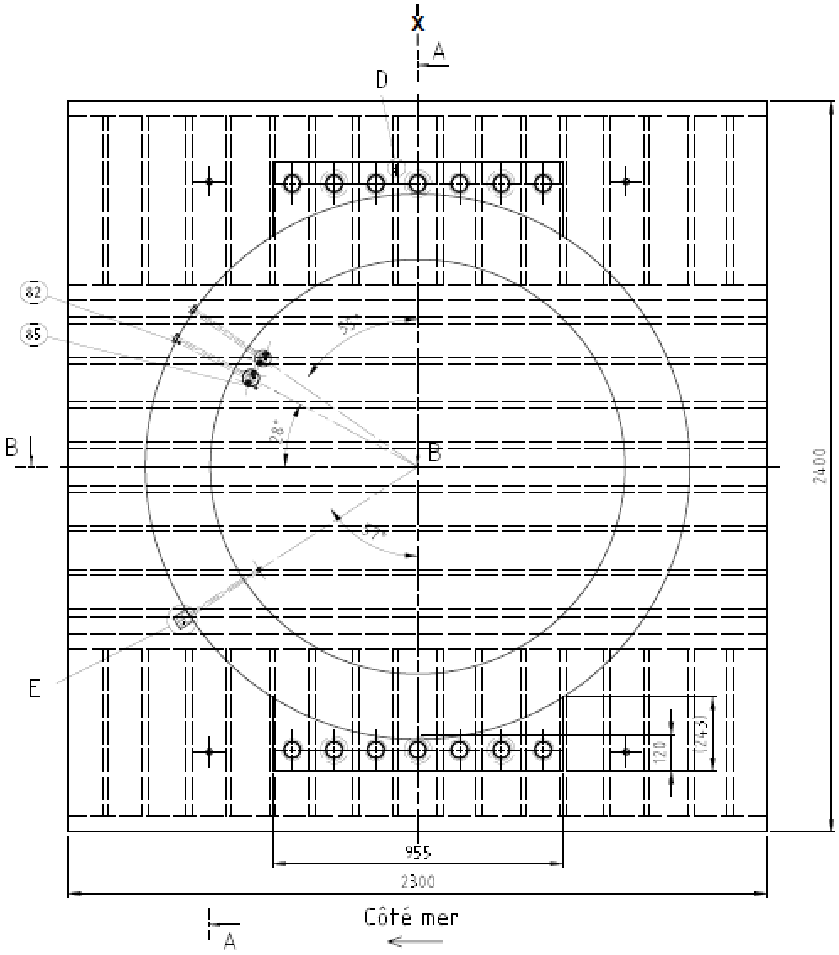

Figure 20. Top view of guided-sliding bearing at Pier 32

Figure 21. The guided-sliding bearing shown in Figures 19 and 20, as fabricated

Following completion and approval of design work – a lengthy process in its own right for the many bearings involved – the project required the delivery of two bearings every two weeks, over a period of two years. The first bearings were installed in 2017, and the last is to be installed in late 2018.

4 Testing, transportation and installation

Following completion of fabrication and all quality checks, the proper functioning of the bearings' pressure sensors was tested using appropriate supplier-developed "RCP" software as shown in Figures 22 and 23. The bearings were then transported to site – where possible in shipping containers for maximum protection (Figure 24).

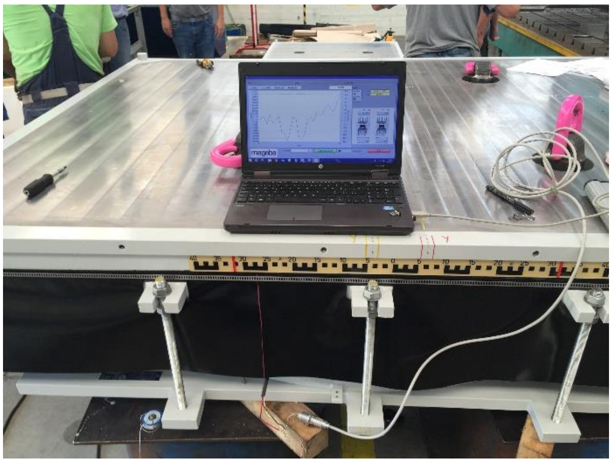

Figure 22. Testing of load-measuring function of a free-sliding bearing – designed for a load of 118,000 kN and movements of +/- 315 mm (longitudinally) and +/- 30 mm (transversely)

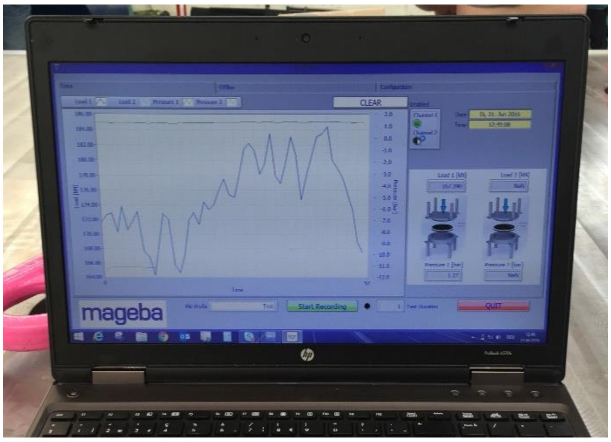

Figure 23. Detail of load-checking application shown in Figure 22

Figure 24. Transportation of bearings to site in shipping containers for maximum protection from damage during transit

The bearings were then installed as shown in Figures 25 and 26, with concrete/grout placed between their anchor plates and the concrete structures, ensuring precise positioning, even load transmission, and that the bearings' upper and lower parts are perfectly parallel – important factors in ensuring good long-term performance.

Figure 25. Installation of a bearing on site, before concreting/grouting of connections to main structures above and below the bearing

Figure 26. A bearing as installed, before final application of dust skirt to protect sliding surfaces

5 Conclusions

The construction of the new Route du Littoral offshore viaduct in La Réunion required very special pot bearings to support its deck. Not only are they very large – with vertical load capacities of up to 125,000 kN and able to accommodate longitudinal movements of up to +/- 400 mm – they are also equipped with load-measuring sensors and designed with the ability to lift the superstructure should the need ever arise. This lifting can be achieved simply by injecting a special silicone rubber into any bearing's pot, beneath its elastomeric pad, thereby increasing the bearing's height and thus lifting the bearing's piston and the supported superstructure. As a result of the use of these bearings, the long-term performance of this major piece of infrastructure can be ensured, in spite of its challenging maritime environment and the volcanic nature of the area in which it is located.

References

[1] European Committee for Standardization. EN 1337 Structural bearings.

[2] Deutsches Institut für Bautechnik. European Technical Approval 08/0115 relating to mageba Reston Spherical and Cylindrical Bearings. 2008.

[3] Österreichisches Institut für Bautechnik. European Technical Approval 11/0453 relating to mageba Reston Pot Lift Control bearings. 2011.

[4] Österreichisches Institut für Bautechnik. European Technical Approval 13/0039 relating to mageba Reston Pot HP bearings. 2013.

[5] European Committee for Standardization. EN 1991 / Eurocode 1 Actions on structures, Part 2 Traffic loads on bridges. 2010.