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Proceedings of the 9th Australian Small Bridges Conference 2019

First published 2021

Published by Leading Infrastructure Pty Ltd

PO Box 616, Ashburton Victoria Australia, 3147

Email: support@leadinginfrastructure.com

URL: www.leadinginfrastructure.com

Printed by Leading Infrastructure Pty Ltd 2021

Proceedings of the 9th Australian Small Bridges Conference 2019

Leading Infrastructure Pty Ltd ABN 42 604 899 578

ISBN 978-0-6451268-1-5

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Seismic Design of a Railway Viaduct in High Seismic Zone

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ABSTRACT

The design and detailing of rail viaducts for high seismic loads presents several unique challenges that are often not covered adequately by codes of practice. For instance, designers must consider the impact of the natural frequency of the structure on the safety of the train itself.

The following paper outlines a practical design approach for designing typical long, multiple span, simply supported concrete viaducts for seismic events. It considers a staged design approach where the safety of the train can be guaranteed under a so-called Level 1 earthquake and the safety of the viaduct structure is checked under a higher Level 2 earthquake. The paper provides a detailed insight into the benefits of using a push over method that accounts for the ductility of the viaduct piers over a more standard force-based approach.

1 INTRODUCTION

The project will provide a high standard suburban commuter rail in the island of Luzon Philippines. The project comprises the following components:

- Viaduct/ bridges over 35 km;
- Elevated embankment over 2 km;
- 9 bridges at river crossings and 3 highway/road bridge crossing;
- Depot, workshops and Operations Control Center (OCC); and
- 10 Stations.

The elevation along the alignment ranges from RL. 3.0 m to RL. 15.0 m above mean sea level (AMSL). In general, the alignment is characterized by relatively flat terrain with an elevation difference of less than 12.0m, and consists mostly of swampy areas and cultivated land.

SMEC International are the design sub-consultants and are responsible to carry out the Architectural, Civil and Structural aspects of the project, for the Main Consultants, a joint venture of Japanese Consultants.

The design and detailing of railway viaducts for high seismic loads presents several unique challenges that are often not covered adequately by AASHTO, AustRoads or the Eurocode. For instance, designers must consider the impact of the natural frequency of the structure on the safety of the train itself under seismic conditions.

The following paper outlines a practical design approach for designing typical long, multiple span, simply supported concrete viaducts for seismic events. It considers a staged design approach where the safety of the train can be guaranteed under a so-called Level 1 earthquake and the safety of the viaduct structure is checked under a higher Level 2 earthquake.

The paper provides a detailed insight into the benefits of using a push over method that accounts for the ductility of the viaduct piers over a more standard force-based approach.

2 DESCRIPTION OF THE VIADUCTS

The viaducts are designed to be constructed as match cast precast segmental post-tensioned concrete box girders. The simply supported spans are to be built span by span using over-slung gantries due to:

- the length of the viaduct being sufficiently long enough to justify the capital and operating costs of the casting yard, molds equipment and gantries;
- the difficulty of access to transport segments along the crowded streets of Manila; and
- the speed of construction required to meet the construction timeframe.

The typical span was determined to be 40 m based on:

- minimizing the construction depth of the box;
- carrying out an economic analysis of spans versus foundation costs; and
- the size of launching girders available in Asia.

The superstructure comprises a precast segmental box girder. The typical section of the box girder is shown below in Figure 1.

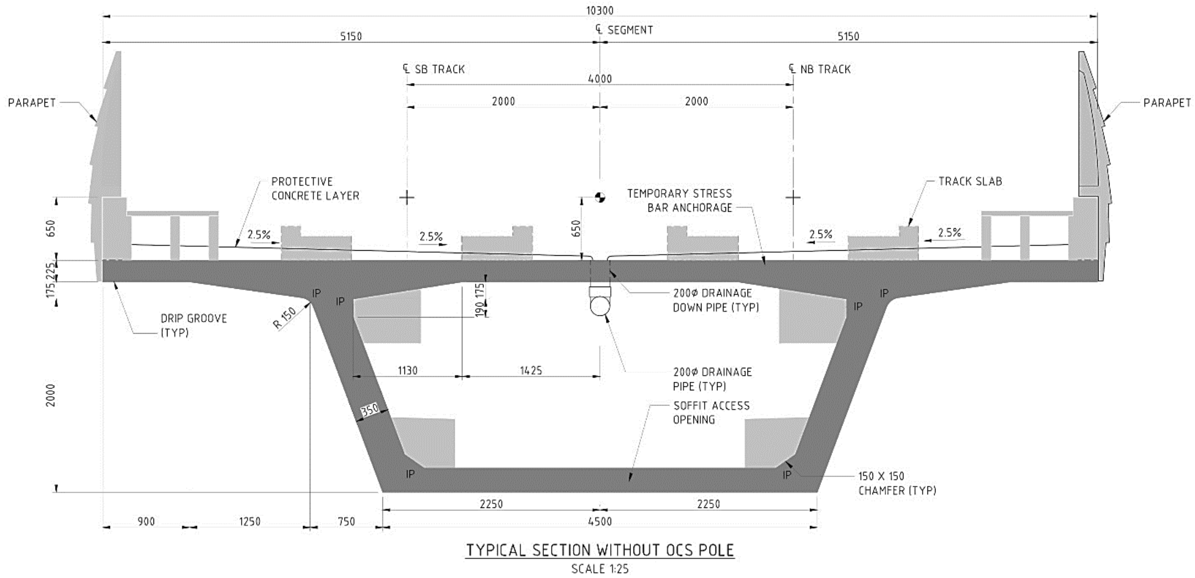

Figure 1 Cross Section of Precast Segmental Box Girder Deck.

The section overall depth was determined to be 2.4m deep and an overall width of 10.3m to provide for:

- Two standard gauge tracks (1435 mm) at 4m centers; and
- 950 mm wide maintenance walkways with service troughs below each side.

Sloping webs were provided to improve the aesthetics of the viaduct.

The width of the base slab was determined from the following considerations:

- Sufficient distance between bearings to prevent uplift under torsional live load;
- Sufficient distance between bearings to prevent uplift under seismic loads; and
- Sufficient distance to provide for the post tensioning tendons in the base slab.

Each typical simply supported span consists of an abutment segment at each end and 12 typical segments. Simply supported spans are typically 40 m long (centerline to centerline of piers) but may vary in length between 24 m and 39 m to fit around existing constraints on the alignment. Constant width webs are proposed to ease constructability and to maintain the number of typical segments.

The box was provided with internally post tensioned tendons. The tendons are galvanised steel duct encased and are best suited for this form of construction as they have the largest eccentricity for prestressing moments and hence, minimize the quantity of prestressing required. The tendons are