Proposed Seismic Design Methodology for Steel Pier-Pile Integrated Structure Considering Dynamic Soil-Pile Interaction and Ductility Performance of Elongated Members

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Abstract

This paper discusses the seismic design policy and the design results for a novel pier-pile integrated rigid frame bridge, herein, denoted as the Pier-Pile Integrated Structure. The novelty of the structure lies in its foundation as the footing is eliminated leading to reduced substructure size, in turn, leading to reduced cost, construction time, and the need for topographic modification. The traditional design methodology for foundations with the assumption of fixed support or a rigid member at the footing does not hold for these structures. Hence, a novel seismic design methodology is proposed that considers the ambiguity in the failure mechanism and the ductility performance of ERW SKK 490 steel. Additionally, the seismic response and performance objective are set according to related past studies to form a comprehensive seismic design methodology for practical design. The proposed methodology is then applied for design of a road bridge and a comparison to the conventional design philosophy is presented.

Keywords: Pier-Pile Integrated Structure; *M-ϕ* model; Beam on Nonlinear Winkler Foundation; SKK steel; non-linear dynamic analysis; seismic design.

1 Introduction

The multipolar rigid frame bridge (Fig. 1), is a bridge structure with its substructure consisting of pier-pile integrated structure supported directly on soil and superstructure consisting of transverse and longitudinal beams, all connected by rigid joints. Such bridges have been adopted throughout the world as pedestrian bridges, as port facilities consisting of multiple piers, and as multipolar rigid frame structures without footing for emergency roads in mountainous areas. These structures can be designed as economic, easy to construct and easy to maintain structures requiring minimum topographical alterations because of the absence of a footing and shorter construction periods. These features are especially advantageous in narrow mountainous regions along evacuation routes.

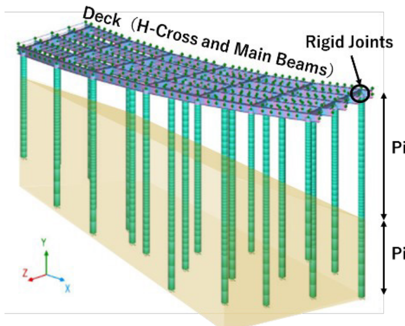

Figure 1. General arrangement of a multipolar pier-pile integrated structure

The traditional design methodology for foundations with the assumption of fixed support or a rigid member at the footing does not hold for the pier-pile integrated structures. Rather, the behaviour of these structures is governed by the effective buckling length of the pier elements, by the relative rigidity of the super- and sub-structure that dictates the failure mechanism. In such a case

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