Static and Dynamic Experimental Analysis of An Immersion Joint

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Summary

As the weakest part of an immersed tunnel, the immersion joint is the key element in research in this field. Relatively large deformations and internal forces may be induced in the immersion joint subjected to various loading types. Based on a real project, the shear mechanical behaviour is investigated by large scale model test. To explore the performance of the immersion joint, compression-shear loads are applied on a tunnel segment in a specific test set-up. For the applied loading schemes, different levels of axial force, corresponding to the water depth of the joint, are considered as well as varying amplitudes of the shear force. Based on these results, both the static and dynamic shear stiffness of an immersion joint were analysed. The results of the test indicate that the static shear stiffness of the joint increases linearly with the axial force and the same trend is found for the dynamic one. Moreover, the dynamic stiffness is larger than the static one.

Keywords: immersed tunnel; immersion joint; shear key; structural experiment; shear stiffness.

1. Introduction

An immersion joint is the connecting part between two adjacent elements of an immersed tunnel. Compared to that of the elements, the stiffness of the immersion joint is relatively small. When it is subjected to shear actions, whether resulting from vertical foundation settlement or horizontal earthquake movements, shear-resistance of the joint is the main concern for a safe and reliable water-proof design. Hence, the immersion joint is always considered as a key part not only for the connection between elements but also the proof for the water tightness.

A flexible immersion joint, which normally includes a rubber seal and the shear keys installed between two adjacent elements, has been a common solution in practice for more than 50 years. The way in which the shear keys and the rubber seal behave in the joint together is of importance to a comprehensive understanding of the shear behavior of the joint. The shear behavior of the joint is mainly characterized by its stiffness. However, only few experimental results on the joint under shear loading are available although they are applied in practice for a long time already. So farre search on the shear performance has mainly been conducted by simulation[1-3]. The use of a linear or bi-linear model to simulate a shear key in a numerical analysis of a joint under lateral shear actions is based on simplified assumptions.

To figure out the shear performance of an immersion joint under transverse shear action, an experimental investigation on the static and dynamic shear stiffness of a model immersion joint is presented in this paper. Compression-shear quasi-static loading is cyclically applied to a specimen, with a geometric scale of 1/10 with respect to a real design. The patterns of compression-shear are set-up according to a certain axial water pressure on a joint, to which it would be subjected during its service life at typical buried depths, and to transverse shear movement due to seismic actions. The lateral forces are applied cyclically at increasing amplitude in the horizontal plane. Through observed load-deformation curves, both the static and dynamic shear stiffness of the scaled joint are obtained and analysed.

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