11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Numerical Analysis of Mechanical Behaviours of Immersion Joint

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Key Words: *Numerical analysis, Immersion joint, Mechanical behaviours, Model test.*

The immersed tunnelling technique[1] is commonly used for river or sea crossings worldwidely. Seismic safety criterions[2] of immersed tunnels involve the shear stiffness, axial stiffness, flexural stiffness, and opening deformations of the immersion joints. Therefore, it is necessary to conduct mechanical analysis of joint between immersed tunnel elements.

Researches about mechanical study of immersion joints mainly focus on[3] full-scale test, model test and numerical simulation. A full-scale test can reflect the real situation, however it is difficult to be carried out. Small scale model is reasonable to cope with this problem. Nevertheless, there still exists a great challenge to conduct various cases through model test. Inversely, numerical modelling for large-scale structures is an alternative way to diversify the geometric dimensions and loading mechanisms[4].

A pseudo-static numerical analysis of an immersion joint is presented in this paper, mainly involving the modelling method, loading mechanism and conclusions. The joint model in this study includes two 38m x 11.5m x 22.5m segments with GINA gasket, horizontal and vertical shear keys between them. The profile of applied immersion joint is shown in Figure 1.

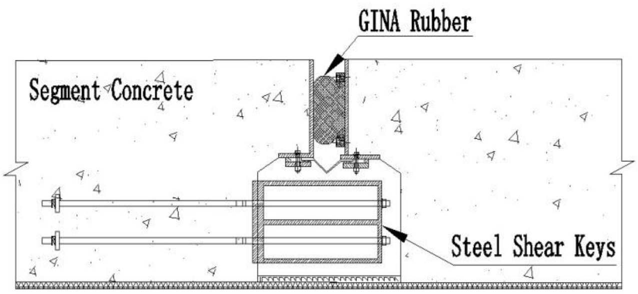

Figure 1: Profile of Applied Immersion Joint

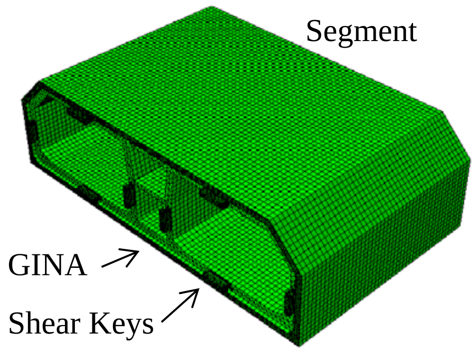

Figure 2: Numerical Model of immersion joint

A flexible joint consists of GINA gasket, shear keys and steel shells. Figure 2 shows the numerical model of an immersion joint. In the model, anchor bolts connecting shear keys and concrete segments are replaced by an assumed equivalent layer and the vibration isolation was simplified as tolerated value of contact. The load-displacement behaviour of the shear keys is shown in Figure 3. Additionally, the nonlinear feature of GINA gasket[2] was also considered in this model. The numerical loading mechanism of the test under horizontal seismic excitation is established according to analysis on single steel shear key.

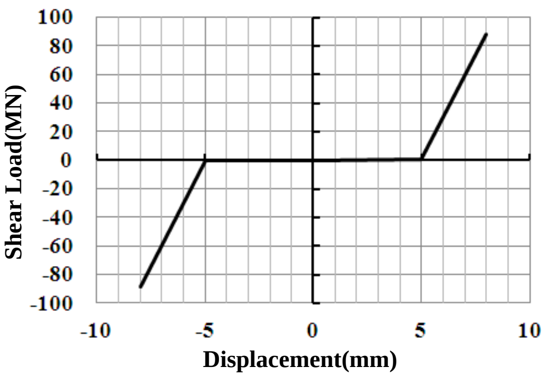

Figure 3: Load-displacement Behaviour of Shear Key

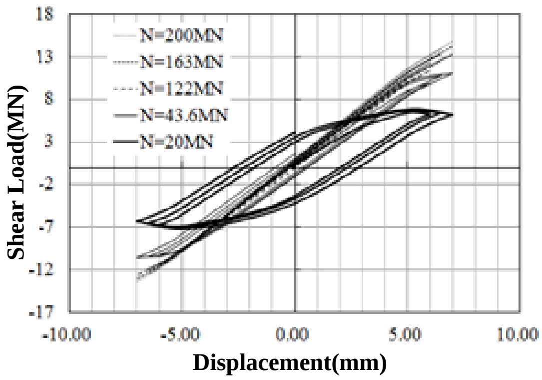

Figure 4: Load-displacement Behaviour of GINA

In addition, different levels of water pressures were considered due to the significant changes of water depth. The displacement of immersion joint under multi-level loads was obtained and analysed in consideration of the hyper-elastic property of GINA rubber which can be seen in Figure 4.

It can be concluded that the mechanical property of GINA rubber is significantly affected by both flexure and axial loadings. In contrast, the loading effects on the behaviours of shear keys can be neglected, which indicates hysteresis characters under cyclic loadings. The numerical results and conclusions are benefit to the further large-scale model tests of immersion joint in progress, and more related further publications are expected in future.

Acknowledgements
This research is supported financially by the National Natural Science Foundation of the People’s Republic of China (Serial Number: 51208296), National Key Technology R&D Program of the People’s Republic of China (Serial Number: 2011BAG07B01), National Key Technology R&D Program of the People’s Republic of China (Serial Number: 2012BAK24B00).

REFERENCES

[1] I. Maekey, J. Baber, W. Janssen, et al.. ITA working group 11 for immersed and floating tunnels[R]. *ITA*., ITA report N^{0}007/OCT, 2011.
[2] I. Anastasopoulos, N. Gerolymos, V. Drosos. Nonlinear response of deep immersed tunnel to strong seismic shaking [J], *Journal of Geotechnical and Geoenvironmental Engineering*, 2007, 133(9): 1067-1090.
[3] O. Kiyomiya. Earthquake-resistant design features of immersed tunnels in Japan[J], *Tunnelling and Underground Space Technology*,1995, 10(4): 463-475.
[4] Y.N.A. Hashash, J.J. Hook, B. Schmidt, et al.. Seismic design and analysis of underground structures [J]. *Tunnelling and Underground Space Technology*, 2001, 16(2): 247-293.