How can classical structural analysis of a displacement-monitored segmented tunnel increase our insight into the structural performance?

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ABSTRACT

In order to study the structural performance of segmented tunnels, a real-scale structure was tested at Tongji University [1,2]. The tunnel exhibits a diameter of 6.2 m, the thickness of shell segments amounts to 35 cm, and their axial length is equal to 1.2 m (Fig. 1(a)). The ring structure consists of six reinforced concrete segments, connected with steel bolts. Compressive radial loading was imposed by means of 24 hydraulic jacks, equally distributed around the perimeter of the tunnel ring. The structure was subject to anisotropic compressive loading (Fig. 1(b)) which is representative for real-life applications. Selected displacements and deformations of the tunnel ring were carefully monitored with a comprehensive set of displacement sensors and strain gauges.

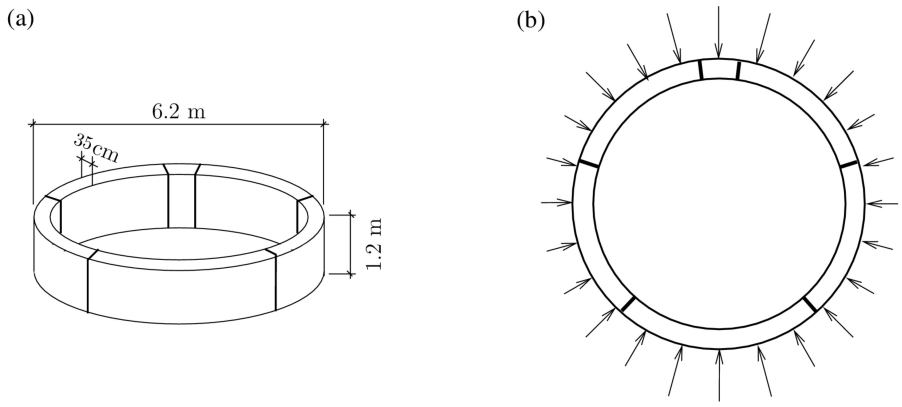

Figure 1: Sketch of the real-size segmented tunnel ring which was tested at Tongji University [1,2]: (a) a tunnel ring; (b) distribution of loading

Herein, we combine multiscale material models for concrete with classical methods of structural analysis in order to re-analyze the behavior of the segmented tunnel. To this end, we combine geometric relations, constitutive equations, and equilibrium conditions of circular arch elements, in order to derive so-called transfer relations for state variables including radial and tangential displacements, cross-sectional rotations, bending moments, as well as normal and shear forces. This method allows for a straightforward consideration of external point loads and of displacement jumps observed across joints connecting neighboring tunnel segments. This way, interesting insight into the structural behavior of the segmented tunnel ring is obtained, and this turns out to be valuable for complementary Finite Element analyses of the structure [1,2].

REFERENCES

[1] H.L. Zhang, X. Liu, and Y. Yuan, “Non-linear mechanical analysis of shield tunnel structure at ultimate loading”. *Proceedings of the EURO-C 2014 Conference on Computational Modelling of Concrete Structures*, St. Anton am Arlberg, Austria, March 24-27, 2014, Eds. N. Bićanić, H. A. Mang, and R. de Borst, Taylor & Francis Group, Leiden, p. 893-898 (2014).

[2] T. Tang, X. Liu, and Y. Yuan, “Non-linear analysis of mechanical behaviors of shield tunnel segments reinforced by steel plate”. *Proceedings of the EURO-C 2014 Conference on Computational Modelling of Concrete Structures*, St. Anton am Arlberg, Austria, March 24-27, 2014, Eds. N. Bićanić, H. A. Mang, and R. de Borst, Taylor & Francis Group, Leiden, p. 899-904 (2014).