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Analysis of aerodynamic loading properties on hood of high-speed railway tunnel☆

Yingxue Wang*, Wenqiang Ren, Jun He, Chang Ye, Qiaolei Chang

MOE Key Laboratory of Transportation Tunnel Engineering, Southwest Jiaotong University, Chengdu 610031, China

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Summary When high-speed train passing through tunnel, aerodynamic effect will be created, which may arise micro-pressure wave at tunnel exit and affect the surrounding environment around tunnel. Setting hood at tunnel entrance is effective and economical method. Using numeral simulation method, two kinds of hood mechanics character under deadweight and aerodynamic load were analysed. The stress concentration field on the hood and the magnitude of the stress caused by aerodynamic loading was defined. By comparing the aerodynamic loading method of pseudo-static and dynamic real-time, the necessity for doing real-time dynamic analysis is shown. The recommended kind of hood also was point out.

Introduction

When high-speed train passes through tunnel, a series of aerodynamic problems will be created. The effect of aerodynamic load on tunnel hood is one of these problems. The process of high-speed train entering the tunnel can be described as a piston movement in a pipe. When the high-speed train entering limited tunnel space from a three-dimensional semi-infinite space, compression wave and expansion wave will be induced and transmit in tunnel from one side to the other side at sound speed. Under the long-term tension and compression stress, tunnel structure is prone to fatigue damage. In order to relieve micro-pressure wave, the hood structure has a plurality of openings, thus reducing the structure's strength. On the other hand, the hood structure has more negative stress state than tunnel trunk because its structure is mostly open cut tunnel.

So, research of aerodynamic loading properties on hood structure is the key to tunnel structure safety analysis.

This paper will analyse the aerodynamic properties of several kinds of hood structures, evaluate the weak points and determine the recommended hood structure's form.

To this problem, some scholars have conducted some research about the peak of the tunnel's aerodynamic pressure and tunnel structural safety.

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* Corresponding authors.
E-mail addresses: wangyingxue@swjtu.edu.cn (Y. Wang), 1026978930@qq.com (W. Ren).

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Doctor Zhao Jing and Feng Zhipeng (Zhao, 2010; Feng et al., 2010), using numerical method, simulated the flow field of a single high-speed train passing and two high-speed trains meeting in tunnel. They analysed the variation characteristics of pressure wave in tunnel and the stress state on tunnel structure and carriages' window when high-speed trains meeting in tunnel.

Dr. Ma Weibin (Ma et al., 2012), from China Academy of Railway Sciences, discussed the research progress of high-speed railway tunnel aerodynamic effect, analysed the pressure fluctuation on subsidiary facilities when single train running or rendezvousing in tunnel, which can provide some reference for these facilities design.

Professor Ma Yundong (Ma et al., 2011), Dr. Fan Bin (Fan, 2010), based on meso-mechanics theory, the mechanical properties of tunnel lining vault's concrete under high-speed train passing through, was simulated. The concrete's stress state at different time was obtained, which could provide an important reference for the analysis of tunnel durability on consideration of aerodynamic load.

From the above research and analysis, it can be seen that the influence of aerodynamic loading on tunnel structure has attracted many scholars' attention, but pointing

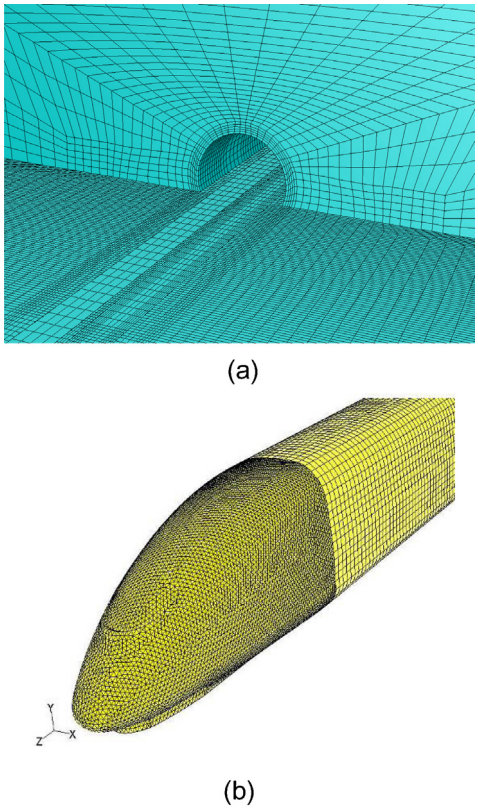

Figure 1 Mesh of the tunnel and train in simulation model.

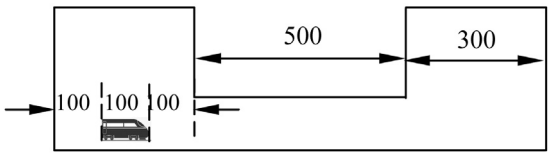

Figure 2 Dimension of numeral simulation model (unit: m).

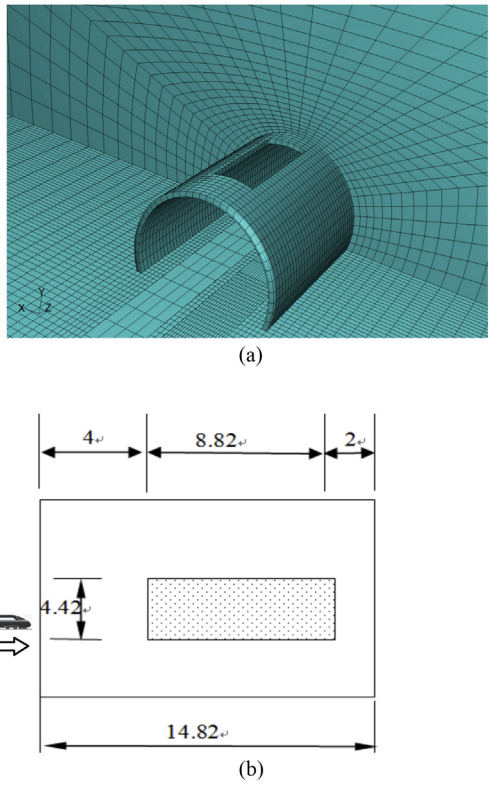

Figure 3 Single-top opening hood mesh and dimension (unit: m).

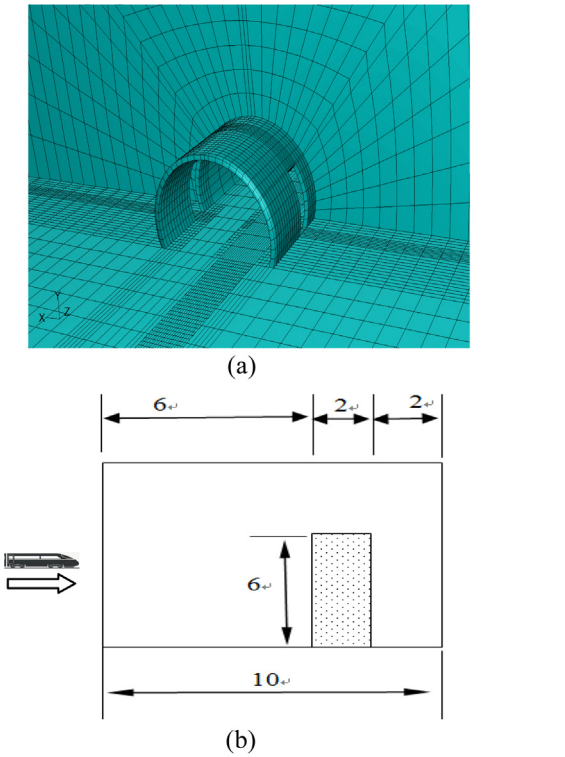

Figure 4 Single-side-strip opening hood mesh and dimension (unit: m).