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Comparative Study of Rail Transit's Platform Screen Door System Simulation and Test Based on the Finite Element Method

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Abstract

In order to test the reliability of the rail transit's platform screen door system structure, this paper focuses on studying the rail transit's platform screen door system. Through modular design of the rail transit's platform screen door system mechanical structure, analysis and comparative study of the mechanical structure based on the finite element method. Finally, the finite element simulation is verified by the experiment, The test results show that the finite analysis method is reliable. This paper attempts to provide theoretical references for optimization of the rail transit's platform screen door system structure.

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Keywords: finite element method; platform screen door system; modeling and simulating; test

1. Introduction

Platform screen door system is one of the important devices to guarantee the safety of China's rail transit system. Recent years have witnessed a series of platform screen door accidents, which are mainly caused by the unreliability of the platform screen door system structure. Therefore, mechanical structure strength is a necessary condition to guarantee device safety.

This paper first conducts structure modeling and simulation of the structure design plan based on the finite element method. Then, the structural characteristics of the platform screen door mechanical structure are tested through the simulation of the wind pressure load and the passenger squeezing load. At last, through test data comparative study, it is found out that the maximum deformation of the platform screen door structure can meet relevant requirements in CJ/T 236-200 6 Platform screen door for Urban Rail Transit, which provides reliable data references for further structure optimization.

2. Finite element theory

The basic principle of the finite element theory is to replace complex problems with simple ones to get solutions. The solutions thus obtained are regarded as a small interconnected subfield of finite elements. Every element is assumed to have a relatively simple approximate solution. Then, the general conditions (such as the structural equilibrium conditions) to satisfy the field is solved through derivation. Then, solutions can be obtained. Finite element method is realized by solving the joint displacement through the node equilibrium equation, and by inferring the internal force of various elements through displacement. The node displacement can be expressed by the matrix.

$$\{\delta\}^e = [\mu_1, \nu_1, \mu_2, \nu_2 ... \mu_n, \nu_n]^{\mathrm{T}} \tag{1}$$

Below are basic steps:

1) Adopt the node displacement, $\{\delta\}^e$ of every element as the basic unknown. Build the displacement mode within the element, namely:

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$$\{f\} = \begin{Bmatrix} \mu \\ \nu \end{Bmatrix} = [N]\{\delta\}^e \quad (2)$$

Where, $[N]$ is the shape functional matrix.

2) The strain matrix within the element is built according to the strain matrix, namely:

$$\{\varepsilon\} = [B]\{\delta\}^e \quad (3)$$

Where, $[B]$ is the strain matrix.

3) The stress matrix within the element is built according to the physical function, namely:

$$\{\sigma\} = [D]\{\varepsilon\} = [D][B]\{\delta\}^e = [S]\{\delta\}^e \quad (4)$$

Where, $[D]$ is the elastic matrix, which is decided by the elastic constants, E and μ; $[S]$ is the stress matrix.

4) The node force within the element can be solved according to the virtual work principle.

$$\{F\}^e = [k]\{\delta\}^e \quad (5)$$

Where, $[k]$ is the element stiffness matrix.

5) There are two kinds of loads which can function on the structure, which are concentrated load and distributed load. During the process of finite element division, the two loads should be equivalent to the node load, $\{P\}^e$.

6) Build the equilibrium function of every node:

$$\sum_e \{F_i\} = \{P_i\} \quad (6)$$

Put $\{F\}^e = [k]\{\sigma\}^e$ into the above equation, and obtain:

$$\{P\} = [K]\{\delta\} \quad (7)$$

Where, $[K]$ is the global stiffness matrix; $\{\delta\}$ is the node displacement matrix of the whole structure; $\{P\}$ is the node load matrix of the whole structure.

3. Modeling and simulation of the platform screen door system

3.1 Platform screen door finite element model

Finite element simulation software can realize simulated analytical calculation in machinery, hydraulic pressure, pneumatic and electromagnetism field. In order to accurately work out the structural characteristics of the platform screen door for rail transit, this paper conducts analytical calculation of the standard element of the rail transit's platform screen door. A standard element mainly includes the stand column, the fixed gate, the left box, the left sliding door, the right sliding door, the right box, the platform screen door, etc. The calculation accuracy of the rail transit's platform screen door model depends on the grid density. Therefore, the grid division adopts Category 3 Grid. The shell components and the glass adopt the quadrangle shell elements and face elements; the door frame and the stand column adopt the hexahedron entity element; the connection structure adopt the simplified connected relationship. The platform screen door finite element model is shown in Fig. 1.

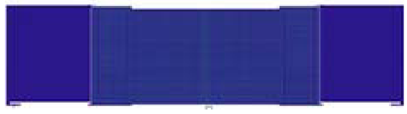

Fig. 1 Platform screen door finite element model

3.2 Finite simulation operating conditions

According to the finite modeling method, the simulation model of major platform screen doors, including the side box, the fixed door, the left box, the left sliding door, the right sliding door and the escape door is built to finish the simulated modeling of platform screen door. The shielded door model thus built up have the following three operating conditions: 1) wind load (the wind load value in the platform screen door general instructions, namely 600Pa); 2) squeezing load (the squeezing load of the crowd against the exit is 1,500N/m, which functions on the part 1.1m above the platform and is vertical to the exit plane); 3) resultant force of wind load and squeezing load.

In view of the above three operating conditions, the value setting should be based on the force bearing point of various components of the platform screen door in the practical project. The value setting point for the force bearing point of the fixed door is the center of the glass, the upper door frame and the frame. The value setting point for the force bearing point of the sliding door is the center of the glass, the upper door frame and the frame. The value setting point of the escape door is the center of the glass, the upper right corner of the escape frame, the center of the frame, the upper left and right corner of the side box. See Fig. 2 for details.

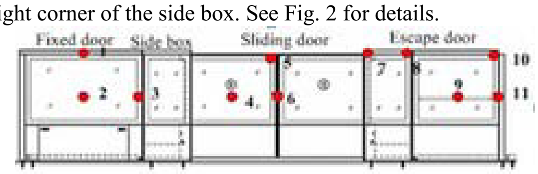

Fig. 2 Value setting points distribution schematic diagram

According to the model, load and constraint thus defined, the solver provided by the finite element analysis software is employed to conduct structural analysis of three operating conditions. The displacement of various nodes is worked out. Based on the node displacement, the stress of various nodes can be worked out.

3.3Finite element analytical calculation of the platform screen door

According to the finite modeling method, the simulation model of major platform screen door, including the side box, the fixed door, the left box, the left sliding door, the right sliding door and the escape door is built to finish the simulated modeling of platform screen door. Below are deformation cloud pictures of the platform screen door under three working conditions. (See Fig. 3~Fig. 5).