Numerical Study on the Structural Safety of the Slideway Project in a Mountainous Tourist Attraction

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Abstract. In order to study the safety of the slide way in a mountain eco-tourism scenic spot, based on the actual design parameters of the slide, a three-dimensional mechanical simulation model was established by numerical simulation method, and the stress and displacement distribution of the slide after its completion were calculated under the condition of self weight and load. The results show that after the construction of the slide way, the maximum principal stress of the slide is mainly compressive stress, which is beneficial to the performance of the main steel structure. The displacement in three directions is small, and the reliability of each component meets the requirements. After the slide is put into use, the maximum principal stress increases with the consideration of human load, which does not exceed the allowable stress value of the structure. The displacement of the slide in three directions is small, which shows that the reliability of each component is good under the condition of human load in the service stage, and basically meets the requirements of use. The research results have important reference value for the safe operation of the slide.

1. Introduction
In recent years, with the improvement of people's material living standards, more and more people begin to pursue a higher quality of spiritual life [1-2]. Tourist attractions have become an important place for people to pursue spiritual life [3]. In order to meet the needs of people's happy mood, many scenic spots have added a large number of exciting projects, among which the slide project is one of them [4-5]. However, due to construction quality or management problems, slide accidents also occur from time to time. Therefore, before the slide project is put into operation, it is of great significance to analyze the structural safety and reliability for the normal and safe operation of the slide.

2. Design parameters and calculation model of slideway project and
The slide way of a scenic spot is located in the northwest of the current distribution square, with a length of 90m and a drop of 50m. According to the design drawings and engineering experience, the 3D model is established in the form of glass slide. In the actual modeling process, due to the
complexity of the model and the limitations of the numerical simulation software, the mechanical
model will be appropriately simplified. In this numerical simulation calculation model, the front height
of the rock mass is 10m, the rear height is 14.3m, the transverse length is 26.4m, and the longitudinal
length is 12m. The modeling dimensions of the superstructure are all design dimensions. The overall
model includes upper structure and rock mass. The mesh of the model adopts mixed grid. The total
number of elements and nodes is 20108 and 8213 respectively. The overall calculation model is shown
in Fig.1, and the schematic diagram of foundation, steel column and steel beam is shown in Fig.2. The
displacement in X direction is constrained on the left and right sides of the model, and the
displacement in Y direction is constrained before and after the model. For the displacement in X, Y
and Z directions at the bottom of the model, the upper structure does not constrain any degree of
freedom. The rock mass and superstructure are all solid elements. In the high-altitude surfing
operation stage, the human load is uniformly distributed on the bottom plate, and the value is
2.0KN/m².

![Figure 1. Calculation model diagram](image)

![Figure 2. Schematic diagram of foundation, steel column and steel beam](image)

### 3. Calculation parameters
The calculation parameters of foundation and materials are shown in Table 1.

| Material parameters | Elastic modulus (MPa) | Poisson's ratio | Bulk density (KN/m³) | Cohesion (MPa) | Internal friction angle (°) |
|---------------------|----------------------|----------------|----------------------|--------------|--------------------------|
| Limestone           | 2.26×10⁴             | 0.2            | 25                   | 0.5          | 38                       |
| C30 concrete        | 3.15×10⁴             | 0.3            | 25                   | --           | --                       |
| Q345 steel          | 2.1×10⁵              | 0.3            | 78.5                 | --           | --                       |
| Tempered glass      | 7.2×10⁴              | 0.2            | 25.6                 | --           | --                       |
4. Reliability analysis of slideway after completion

4.1. Stress analysis of slideway after completion
Structural stress analysis is one of the important contents of the safety assessment of the slide structure itself. The maximum principal stress and the minimum principal stress are used to describe the actual stress situation of the structure. Their size determines whether the structure has cracks and shear failure. Figure 2 show the maximum principal stress distribution of the structure after the construction of slide way. It can be seen from the figure that the maximum principal stress of the slide is mainly compressive stress, which is beneficial to the performance of the main steel structure. The maximum compressive stress value is 1.72MPa. Similarly, it can be seen from the distribution diagram of the minimum principal stress that the extreme value of the minimum principal stress is tensile stress, and the maximum tensile stress is 63.4kpa, which does not exceed the standard value of tensile stress strength of steel structure materials.

![Figure 3. Cloud chart of the maximum principal stress after the completion of slide way](image)

4.2. Displacement analysis of slideway after completion
Through the simulation calculation, the displacement distribution map after the construction of the sliding way is obtained (Fig.4, Fig.5). It can be seen from the x-direction displacement diagram that the maximum displacement of the slide in X-direction occurs in the rock mass below the highest four steel columns, and the maximum displacement in the x-direction is 1 mm. The maximum displacement of y-direction displacement is located on the top of the highest side guardrail, and the maximum displacement in Y direction is small. It can be seen from the vertical displacement distribution diagram that the maximum vertical displacement of all components of the slide is less than 1 mm. Based on the above analysis, the reliability of each component is good after the construction of slide way.

![Figure 4. X-direction displacement nephogram of slide after completion](image)
5. Reliability displacement analysis of slide way considering load

5.1. Stress analysis of considering load after completion

During the operation of slide way, the floor will be affected by self weight and human load, which exists in the action of dead load and live load. Therefore, it is necessary to analyze the stress of high-altitude surfing. In order to analyze the above load, the dead weight is considered according to the actual weight of the material, and the human load is converted into uniformly distributed load and applied on the bottom plate, with the value of 2.0kn/m².

Figure 6 shows the maximum principal stress distribution of the slide under the condition of considering the load. It can be seen from the figure that the maximum principal compressive stress of the overall structure of the slide increases from 1.72 MPa to 3.52 MPa due to the human load and the self weight of the slide way, and there is no obvious concentration of compressive stress. The minimum principal stress under load is tensile stress, and its maximum value is 2.62mpa, which does not exceed the allowable stress of the structure.

5.2. Displacement analysis of considering load after completion

Considering the load, the displacement in X-direction is shown in Fig.7, the displacement in Z direction is shown in Fig.8. The overall displacement of the slide increases with the increase of slope height, and the rock mass displacement is small. It can be seen from the x-direction displacement diagram that the maximum displacement in X-direction of the slide still appears in the upper half of the ramp and the steel column contacting with the ramp, and the maximum displacement in the X direction is still less than 1 mm. It can be seen from the Y-direction displacement diagram that the maximum displacement in Y direction occurs at the upper part of the guardrail on the higher side of
the slide, but the displacement is small. It can be seen from the vertical displacement distribution diagram that the vertical displacement of the upper part of the steel column on the higher side of the slide way and the guardrail of the slide way is the largest, and the maximum vertical displacement value is small. Based on the above analysis, the reliability of each component is better under the condition of considering the load after the construction and operation of the slide way.

Figure 7. X-direction displacement nephogram considering load

Figure 8. Vertical displacement nephogram considering load

6. Conclusions
After the construction of slide way is completed, the maximum principal stress of slide is mainly compressive stress, which is beneficial to the performance of main steel structure. The maximum value of tensile stress is 63.4kpa, which does not exceed the standard value of tensile stress strength of steel structure materials. After the construction of slide way is completed, the maximum displacement in X direction appears in the rock mass below the highest 4 steel columns, the maximum displacement in Y direction is small, and the maximum vertical displacement of all components of the slide is less than 1 mm. Based on the above analysis, the reliability of each component can meet the requirements after the construction of slide way. After the slide is put into use, considering the human load, the maximum principal compressive stress is compressive stress. The tensile stress concentration occurred in the middle of the fourth section of the steel column near the slide way, with the maximum value of 1.85 MPa, which did not exceed the allowable stress value of the structure. After the sliding way is built, the displacements in X direction, Y direction and Z direction are small, and the maximum displacement in X direction appears in the upper part of slide way and steel column, and the maximum displacement is less than 1 mm. The maximum vertical displacement of each member is less than 1
mm. Due to the influence of the spacing of the foundation columns at the bottom of the platform, the upper displacement of the steel column is larger, and the maximum vertical displacement is smaller. Based on the above analysis, the reliability of each component can basically meet the requirements under the condition of considering the load after the construction and operation of the slide way.

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