

# Optimization Design of Treating Slope Dangerous Rock Mass in Penglai Pavilion

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**Abstract.** Slope dangerous rock mass is a common geological hazard in mountain. This paper take the dangerous rock mass of Penglai Pavilion slope as an example that puts forward the design concept of cleaning up dangerous rock mass on the principle of "first easy, difficult afterwards, first on and below, first pry, then top, first push, then push". We put forward the protective measures using SNS active protective net in view of the dangerous rock mass on the slope of Penglai Pavilion. In addition, we also put forward a water cut wall which is made of reinforced concrete structure and arranged three plain concrete structures on the slope. At the same time, we also used to slope masonry retaining wall do to do comprehensive governance. The design has been successfully carried out in Penglai Pavilion and has reference and reference for similar projects.

## 1. Introduction

Slope dangerous rock mass is an important type of natural disasters. It is not only a natural phenomenon, but also a social economic phenomenon. The increasingly unstable slope is caused by the influence of natural conditions and the destruction of geological environment [1]-[2]. According to statistics, China is one of the countries with the most serious geological disasters in the world. The occurrence of geological disasters has the regularity in regional space and the sudden characteristics in time. In the past 20 years, more than 100 deaths have been caused by major geological disasters in our country almost every. year[3]-[4].

The developed countries, such as the United States, Britain and Japan, have realized the danger of geological disasters to the country and the people earlier. Since the 60s of last century, they have begun the investigation and evaluation of disaster geology. They mainly investigate and analyze the conditions and activities of disaster formation. They mainly focus on the emergency response of single disaster types and the dangerous zoning in small areas[5]- [6]. At present, the prevention and control of geological hazards in China is mainly based on prevention, and the necessary measures should be taken to deal with them. The main measures are weight reduction, back pressure, retaining and retaining works, drainage works, as well as the change of rock and soil characteristics of slide zone. Among that, the weight loss back pressure is the most economical and effective means. Secondly, drainage engineering is a particularly effective method for landslide control. It is necessary to carry out the support for the landslide with large glide force. Method for the improvement of governance of the sliding zone soil due to construction is difficult and expensive, so this method has not been widely used. In a word, the purpose of preventing and controlling the slope geological hazard is to prevent the movement of landslide or change the direction of its movement, so that the loss will be minimized[7]-[8]. Regional human engineering activities in Penglai Pavilion are frequent, and as economic activities increasingly affect the safety of buildings from up to down. Taking the dangerous rock mass in Penglai Pavilion area as an example, the control scheme of dangerous rock body in this area is studied.

## 2. Engineering Situation

The proposed project site is located in Penglai Pavilion scenic spot, Penglai, Shandong Province. Penglai Pavilion scenic area is located in Shandong, Penglai province about 1.1 kilometers northwest of Bohai coas. The peaks are lined with trees, with dense ancient buildings and beautiful scenery. It is a world-famous tourist attraction. Danya Mountain is mainly composed of quartzite and phyllite. There are many stratas from east to west in Danya mountain such as thick layer of quartzite, purple thin layer of siliceous mantle, green thick layer of phyllite and purple red layer of quartzite. The formation of the formation is affected by the structure, the change is larger and the rock tendency is generally  $130 \sim 150^\circ \angle 26 \sim 40^\circ$ .



Fig. 1 Sketch map of location



Fig. 2 Plane sketch map

## 3. Treat slope dangerous rock mass in Penglai Pavilion

### 3.1 Present situation of slope dangerous rock mass.

The east of Penglai Pavilion rises from the northwest gate, from the west to the ice and snow world. As show in Fig. 3, the rock slope is exposed between the northwest gate of Penglai Pavilion and cableway South Station. Rock affected by wind, sea, rock surface weathering serious geological disasters, and has appeared the phenomenon of collapse and rockfall. As show in Fig. 4, the old

wall piled walls on the top of the slope have been inclined obviously and may collapse at any time. The height of the slope is relatively large, and it is closer to the coast, which poses a serious threat to the safety of tourists at the seaside.



Fig.3 Slope rock



Fig.4 Wall stacks of old city

### 3.2 Treatment schemes.

#### (1) Clean up dangerous rock body

According to the site reconnaissance, there are pumice and dangerous rock in the regional rock slope, which needs to be cleaned up. Clean up the dangerous stone should follow this principle which is "first easy, difficult afterwards, first on and below, first pry, then top, first push, then push". Clear slope staff should ensure that the level of contours at the same time down, not up and down cross operations. The location of the specific dangerous rock body see Figure 5 and Figure 6.



Fig.5 Cleaning area of Slope rock



Fig.6 Tear down Wall stacks

#### (2) Slope protection

Taking into account the impact of the ecological environment on the scenic spots after construction, this design intends to adopt SNS active protective network protection measures. The active protection network is mainly used for the rock slope of the North West gate of Penglaige and the rock slope on the west side of the mountain and the north side of the South Station of ropeway. Rock slope in the rock mass after the completion of the construction of cleaning, before the active protection network construction. Anchor hole diameter is 60mm, the length of the anchor cable is 3.0m, vertical and horizontal spacing was 2.0m, the plum blossoms along the slope surface, and the angle between the horizontal plane and the horizontal plane is 15 degrees.

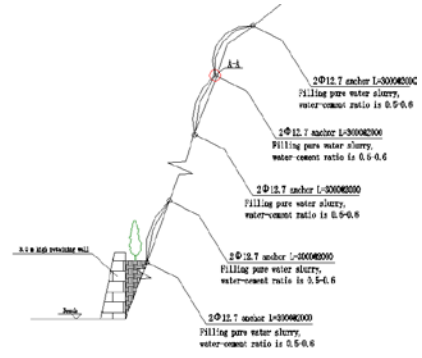
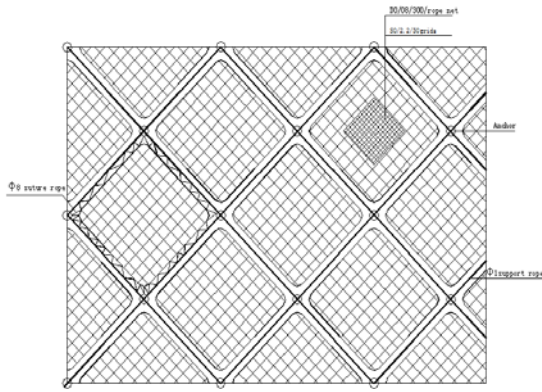


Fig.7 Vertical view of SNS protective net      Fig.8 Profile-paper of SNS flexible steel

### (3) Cutoff wall

No measures of drainage at the slope of the slope between the northwest gate and the west side of Penglai Pavilion. The top of the slope is directly diffused to the slope, and there is a serious erosion phenomenon on the slope slope. Therefore, the wall is cut at the top of the slope to reduce the impact of rain on the erosion of the slope. The cut wall is made of reinforced concrete structure. The cutoff wall from the top edge of the slope 1.5m, wall height of 0.5m, width 0.3m, the wall set up two rows of anchor, drilling diameter of 60mm, anchor length of 2.0m, anchor into the wall length of not less than 0.3m. The anchorage distance of the anchor anchor along the slope is 1.5m, the rod material is 1C22 steel bar, the pure water slurry is filled in the hole, and the water-cement ratio is between 0.5 and 0.6. The main reinforcement in the wall is 6 C 12 reinforced, the stirrup is made of Φ6.5 steel, the stirrup spacing is 200mm, the thickness of the protective layer is 50mm. The cutoff wall concrete strength grade is C25. The cutoff wall shall be constructed according to the site topography and the water outlet shall be reserved on the slope drainage site to avoid the phenomenon of water accumulation at the top of the slope.

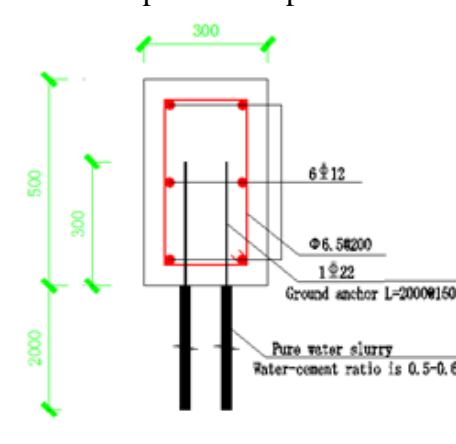


Fig.9 The detail drawing of cutoff wall

### (4) Slope drainage

There are three drains on the slope, and the ditch is located on the slope. The ditch is constructed of concrete in the form of concrete, and the concrete strength grade is C25. The surface of the ditch is laid with cement mortar. Cement mortar specifications are M10. Mortar surface laying pebbles, pebbles diameter 3-5cm, pebbles should be as far as possible local materials, so that coordination with the surrounding environment. The ditch is 1.5m wide, the step height is 15cm and the step width is 35cm. Drainage at the bottom of the laying of concrete cushion, cushion thickness of not less than 10cm, the thickness of the actual situation should accord to the scene to adjust. The cushion concrete strength grade is C25. The reinforced concrete structure is adopted on both sides of the steps, and the channel wall specification is 300\*300mm, and the concrete strength grade is C25. The stirrup is made up of 6.5 steel bars, the spacing between stirrups is 200mm, and the thickness of reinforcement protection layer is 50mm.

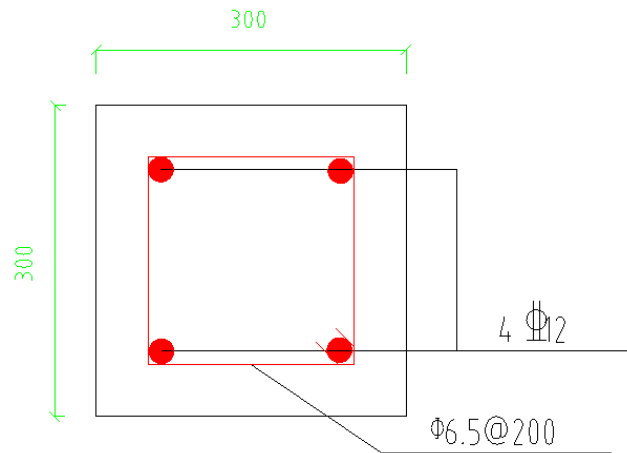


Fig.10 Waterfall gully wall reinforcement.

#### (5) Retaining wall of toe

In order to avoid the backfill toe by seawater to wash, at the foot of the slope masonry retaining wall, retaining wall with stone masonry. The stone is not easy weathering and no serious cracks, stone should try to make the best use of quartzite. The specification of mortar is M10. Cement mortar should be added iron oxide, red pigment and other additives. Retaining wall should be based on the curve of the mountain terrain, the walls should be uneven, the wall body like the shape of the mountain, masonry retaining walls and the surrounding environment in harmony. Retaining wall height is 3.5m, the top of the wall width is 0.5m, the top of the wall is concrete capping, capping thickness is 50mm, concrete strength grade is C25. The foundation over excavation part is filled with slurry block stone to fill the bottom elevation of the foundation, and the technical requirement of the backfilling block stone is the same as that of the retaining wall block stone.

#### (6) Landscape engineering

In order to improve the level of green area, but at the foot of the slope retaining wall side planted *Pinus thunbergii* Parl. Its high is 2.5m. Its crown is 2.0m. Its diameter is 0.12m. Its planting spacing is 2.5m. This region should try to choose a sleek *Pinus thunbergii* Parl planting.

### 3.3 Treatment efficiency.

Through the collapse and rockfall in the area, the old city wall pile on the top of the slope is removed and slope is cut. Through doing the slope protection, setting the wall, doing the slope drainage, slope foot retaining wall, greening and other measures in this area to eliminate the security risks. It protects the personal safety of tourists.



Fig.11 Slope treatment

## 4. Conclusion

The slope of the Penglai Pavilion area is the key to ensure the stability of the slope. Taking Penglai Pavilion Slope dangerous rock body as an example, from cleaning up dangerous rock body,

slope protection, cutoff wall, slope drainage, retaining wall of toe, landscape engineering, get the following conclusions:

(1) Clean up the dangerous stone should follow this principle which is "first easy, difficult afterwards, first on and below, first pry, then top, first push, then push".

(2) This design intends to adopt SNS active protective network protection measures. The active protection network is mainly used for the rock slope of the north west gate of Penglaige and the rock slope on the west side of the mountain and the north side of the South Station of ropeway.

(3) The wall is cut at the top of the slope to reduce the impact of rain on the erosion of the slope. The cut wall is made of reinforced concrete structure. The cutoff wall from the top edge of the slope is 1.5m, wall height is 0.5m, width is 0.3m.

(4) There are three drains on the slope, and the ditch is located on the slope. The ditch is constructed of concrete in the form of concrete, and the concrete strength grade is C25.

(5) In order to avoid the backfill toe by seawater to wash, at the foot of the slope masonry retaining wall, retaining wall with stone masonry.

(6) In order to improve the level of green area, but at the foot of the slope retaining wall side planted *Pinus thunbergii* Parl.

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