Study on the Movement Characteristics of Loess Landslide on the South Bank of Jing River

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Abstract. Through field work and data, the typical profile and internal structure of loess landslide in the south bank of Jing river are analyzed. Through the physical model experiment, the deformation and failure process of terrace formation can be drawn, and a similar terrace model is analyzed under different conditions. This reflects the internal structure of the movement process when the loess landslide movement push terraces, and analysis the influence of the main factors affecting this process.

1. Introduction
In recent years, with the increasing scope and scale of human engineering activities, the problem of slope failure is becoming more and more frequent. The landslide disaster has become the second largest geological disaster [1-4] after the earthquake. The domestic and foreign scholars mainly study the movement speed and distance of the landslide. Sassa[5-6] has studied the landslide movement earlier. The landslide is considered as a fluid, and the differential equation of the landslide movement is derived, and the slip distance is realized. The sled model proposed by Heim[7] and the friction model proposed by Scheidegger[8] are mainly based on the kinetic principle of the particle. However, previous studies have done little research on the deformation and failure of landslides, especially in the loess area. Based on the model experiments, this paper studies the internal deformation and failure of the terrace strata, especially the internal relationship between the development process of landslide shear failure zone in the terrace and the external performance of landslide.

2. typical sections of loess landslides on the South Bank of the Jing River
The Weihe basin, which is located in the study area, is one of the regions with strong modern tectonic activities in China[9]. Under the action of continuous erosion of Jing River, the plateau on the south of Jing river formed a great height difference. With the influence of human production activities, the Loess Landslide is extremely developed. Irrigation is one of the important factors to promote the development of loess landslides[10][11].

Fig.2 is the Profile of Zhaitou Landslide. The trailing edge of the landslide is in a round chair shape. The upper edge of the rear wall of the landslide is approximately 90. The landslide is 278m long, and the material part of the front terrace is about 77m. This shows that, on the whole, the landslide has moved 190m, but the part of the terrace that was pushed up is about 77m. By pushing the uplift terrace, the damage range of the landslide is greatly increased, which gives an illusion of a very far distance of the landslide movement, while the absolute distance of the slide is far less than the slip distance.
The profile position of the landslide exploration slot in the Zhaitou Landslide has been marked in Fig1. From the section of the slots, it is found that the terrace part is bulged, and the original formation of the alluvial deposits in the near horizontal level is opposite to the direction of the landslide movement, and there is an approximate occurrence of the plant layer.

This structure, which is similar to thrust nappe structure, shows that the loess landslide movement in the study area is a whole movement, and the internal fracture occurs regularly, forming a movement similar to the thrust nappe structure. The terrace strata deformed along the internal shear plane, causing complex distortions and deformation, and some strata showed wavy surface micro landforms.

3. model test research
In order to more effectively study the basic laws of the development and change of loess landslide on the South Bank of Jing River, a physical model is established. Because of the huge size of the site, it is difficult to adopt the theory of similarity.

3.1 model test scheme
The physical model is set to two layers. The upper part of the model is a loess shaped soil, which is marked with dark color. Its bottom is sand layer, and it is periodically arranged from fine to coarse.

The physical model is shown as Fig. 3. The thickness of the upper layer is am and the thickness of the lower layer is bm. The use of existing 0.5m*3m*1.2m steel structural glass grooves and their
ancillary facilities is shown in Fig. 4. The hydraulic jack on the left is used to push the steel plate to move to the right side to simulate the pushing effect of the loess landslide on the terrace.

![Fig. 4 physical model test slot](image)

In order to analyze the influence of sliding surface depth on the deformation and failure of terraces, a physical model similar to the prototype is established. Three independent tests are designed, and the test parameters are shown in Table 1

| number | a(cm) | b(cm) | water content of loessiform soil(%) | water content of silt(%) |
|--------|-------|-------|------------------------------------|------------------------|
| 1      | 10    | 10    | 17.6                               | 13                     |
| 2      | 10    | 20    | 17.6                               | 13                     |
| 3      | 10    | 30    | 17.6                               | 13                     |

3.2 model test process

For test 1, the left part of the hydraulic jack was obviously raised before the moving distance is 6cm, but no obvious rupture was found inside the hydraulic jack. When moving to 9cm, the surface of the model is cracked from about 58cm of the starting position of the hydraulic plate. The internal strength of the model reaches the limit of shear strength and local fracture occurs. With the further movement of the hydraulic plate, there are many small shear cracks in the model, forming irregular pinnate arrangements and forming the trend of through shear bands. When the hydraulic pressure plate moves to 18cm, the through shear band basically forms and extends to the bottom of the hydraulic plate. When the liquid pressure plate moves to 27cm, a perforated slip belt from the bottom of the hydraulic plate to the upper surface of the model is completely formed, and the position of the surface of the model appears at the 58cm.

In test 2, a partial opening fracture occurred at the upper part of the left side of the movement of the hydraulic plate. When the moving distance was 6cm, the local discontinuous fracture appeared first. When moving to 12cm, there are multiple parallel shear cracks in the interior. One of them rises upward to the surface, and the first surface on the model surface is about 78cm from the starting point of the hydraulic plate. With the movement of hydraulic plate, many shear cracks develop continuously. Unlike test 1, test 2 forms multiple shear bands. When the hydraulic plate moves to 18cm, second fractures are formed on the surface and 107cm from the starting point of the hydraulic pressure plate.

With the further movement of the hydraulic plate, the shear band develops further downward. It forms a through shear band and forms a trend of two steps. In test 2, the embedment depth of the shear surface increased, and more complex shear cracks were formed in the model with the pushing of the hydraulic plate. Two cracks are formed on the surface of the model, and two steps are formed on the surface of the model. The first crack is about 78cm at the starting position of the hydraulic plate, and the starting point of the second break distance hydraulic plate is 107cm.

At the initial stage of trial 3, the same as the experimental group 1 and 2, the partial opening fracture occurred in the upper left part of the trial stage. When the hydraulic plate moves to 6cm,
cracks appear on the surface of the model, and the first crack appears at 78cm from the initial position of the hydraulic pressure plate. When the hydraulic plate moves to 12cm, there are many cracks on the surface of the model, and the distance between the crack and the starting position is about 98cm. With the further movement of the hydraulic plate, there are many small cracks in the model, and there are regular patterns of small cracks and downward trend.

In test 3, when the shear surface is buried deeper, the internal cracks develop regularly, and finally form multiple shear bands. Each shear band corresponds to the ladder on the upper surface of the model, and there are 4 steps. The crack at the far end of the model surface from the starting position is 98cm.

4. Analysis of model test results

From the model test, it is known that the process of pushing loess terrace is the process of extruding terraces. The internal shear cracks develop simultaneously with the surface cracks of the model. Finally, one or more main shear bands are formed, and the manifestation on the surface is the wavy landform formed by multiple steps.

The two figures show that the deeper the depth of the shear plane is, the larger the rupture range of the physical model is, and the more obvious the internal wave structure is.

On the basis of field investigation and laboratory tests, the movement process of loess landslide on the south bank of Jing river is divided into three stages. A marker layer is set up to illustrate the process of internal deformation and rupture in the process of landslide movement.

In the first stage, as shown in Fig.10a, the landslide is in a state of sliding and is affected by various factors such as irrigation and long-term strength weakening. Under the action of different mechanism of disaster generation, the sliding surface is formed along the edge of the plateau, and the stability coefficient is slightly larger than 1, and the slope is in a dangerous state.

The second stage, as shown in Fig.10B, is a process of accelerating the decline of loess slope. When the slope starts to slide, the strength of the slip zone decreases to the residual strength. When the potential energy of the slope is converted into kinetic energy, the velocity of the slope increases. At the same time, the sliding surface extends to the interior of the terrace. The local shear deformation of the terrace is developing continuously due to the common development of local rupture and sliding surface.
In the third stage, as shown in Fig.10C, the Loess slide continues to move forward at the moment of inertia. This stage belongs to the deceleration stage of the sliding body, mainly by horizontal movement. The squeezed terrace strata are distorted and the land mass is squeezed, showing a wavy shape.

Fig.10 Loess landslide moving model on the south bank of the Jing River

5. Conclusion

In this paper, the loess landslide on the South Bank of Jing River is taken as the research object, and this phenomenon is analyzed by physical model test. The following conclusions are obtained:

(1) during the movement of loess landslide on the South Bank of Jing River, the process of extrusion terrace material, internal shear fracture and model surface crack develops simultaneously. Finally, there are several main shear bands, and the surface manifestation is the wavy landform formed by multiple steps.

(2) the movement process of loess landslide on the South Bank of Jing River can be divided into three stages, namely, three stages, namely, the sliding state, the accelerated slide, and the extruded terrace. So we have a further understanding of the movement and deformation process of loess landslide in this area.

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