Study on the formation mechanism of the landslide in the old cellar in Wanzhou

Ting Hu¹, Jinhao Zhang²

¹ Department of Civil Engineering, Chongqing Real Estate College, Chongqing, 400074, China
² Institute of Geotechnical Engineering, Chongqing Jiaotong University, Chongqing, 400074, China

*Corresponding author’s e-mail: yunandhao@163.com

Abstract. The natural geological conditions in the Three Gorges Reservoir Area are complex, which are the frequent and severe geological hazards in China. With the operation of reservoirs, the occurrence of geological hazards is aggravated. This not only causes great loss of life and property, but also destroys the geological environment and hinders the sustainable development of regional economy [1-3]. Since the formation of Laojiao Forest Landslide in Wanzhou District, there have been many landslides and deformations, and the landslide body is densely populated and houses are dense. Deformation bodies often cause cracks and dislocations of main road facilities and residential buildings, triggered by extreme rainstorms, floods and other factors, which can cause sustained and rapid deformations, which will directly promote the inclination of residential buildings. The collapse has resulted in major disasters and accidents, which have posed a serious threat to the lives and property safety of the people in the region. It is of great practical significance to study the formation mechanism of landslides.

1. Introduction
The natural geological conditions in the Three Gorges Reservoir area are complicated, which is the frequent area and severe disaster area of geological disasters in China. This not only caused great loss of life and property, but also damaged the geological environment and hindered the sustainable development of regional economy [1-3]. Since the formation of Laojiao Forest Landslide in Wanzhou District, there have been a lot of landslides and deformation, and the population on the landslide mass is concentrated, the houses are dense, and the deformation body often causes the main road facilities and civil buildings to crack and dislocation, extreme rainstorm, flood and other factors trigger, which will directly cause the residential house to tilt, collapse, and cause major disaster. Therefore, the security of life and property of the people in the region pose a serious threat. It is of great practical significance to study the formation mechanism of the landslide mass.

2. Overview of landslide
Laojiao Forest landslide is located in Xiangping community in the west of Wuqiao Tailong Town, Wanzhou District. On the right bank slope of the Yangtze River, it is 27km from Wanzhou City and 8km from Tailong Town. The lateral width of the landslide is about 1.3km, the longitudinal length is about 240x300m, the area is about 33.8x104m², and the height difference between the front and rear edge is about 95m. The landslide is a collapse accumulation body with a total volume of about
The landslide is composed of a collapse accumulation body with a total volume of about 900×10^4 m^3. The landslide is located on the right bank slope of the Yangtze River and is located at the right bank of the Yangtze River. The front edge of the slope is strongly deformed by I and II, which is in the state of torrential rain and creep deformation, and the sliding bank collapse area in the landslide area is in a stable state at the present stage; after the three Gorges Reservoir area is impoundment, all of them are in the stable state at this stage; after the three Gorges Reservoir area is impoundment, all of them are in a stable state. There may be slip instability. I, II strong deformation and sliding bank collapse area and its trailing edge endanger the safety of hundreds of residents, tens of thousands of fruit trees and other lives and property.

2.1. Topography, geomorphology and material composition

Lao Jiao Lin is located in the geomorphic area of low mountain valley, and the rock cliff above 220 elevation is distributed along the back edge of landslide. The micro geomorphology in the area is mainly steep and gentle slope, and there are four large surface water trenches with intermountain trenches, which cut deeply. The strata in the landslide area are flat, the occurrence is 120°≤ 8°, and the faults are not developed. The geotectonic movement in the area has shaped the four-stage planation plane and multi-stage terraces, and produced a large number of collapse deposits, which cover the platform of the pedestal terraces. The slide body is mainly composed of block rock soil and silty clay. The block rock soil is distributed in most areas of the whole collapse accumulation body, and the layer thickness decreases and thins from the trailing edge to the leading edge. Silty clay is mainly distributed on both wings of the accumulation body, and the thickness of the layer is uneven. There is no unified sliding surface and sliding zone in the landslide area, and the sliding surface at the leading edge of the landslide is soil-rock contact surface, which belongs to the sliding surface type sliding zone, and the sliding zone soil is composed of clay and sandy silty clay. The rainfall in Wanzhou District is mainly concentrated from May to September, and torrential rain and heavy rain are the most common in summer. The three Gorges Reservoir experiences the variation characteristics of the water level from 175m to 145m and the rising water level from 145m to 175m every year.

| Working condition | Native state | Rainstorm state | Submerged condition |
|-------------------|--------------|-----------------|---------------------|
| Type              | Sliding weight /KN/m^3 | Sliding soil C /kPa | Sliding weight /KN/m^3 | Sliding soil C /kPa | Sliding weight /KN/m^3 | Sliding soil C /kPa |
| Physical parameters | Silty clay | Block stone | 25.8 | 15.9 | 22.0 | 16.9 | 19.0 | 21.8 |
| Strong deformation | Block stone | 20.3 | 14.8 | 20.3 | 13.0 | 28.8 | 11.0 |
| Landslide whole   | Silty clay | 22.3 | 13.4 | 22.3 | 12.0 | 31.6 | 15.2 |
|                   | Block stone | 11.0 | 14.1 | 10.0 | 10.0 | 14.1 | 10.0 |

2.2. Surface deformation and deep deformation

The houses and the surface of Laojiao Forest landslide are cracked and deformed. Most of these deformations and cracks are caused by landslide deformation. Tensile cracks are found at the rear edge of the strong deformation zones I and II, and feathering cracks are found on both sides, as shown in figure.1. The front shear outlet is provided with extrusion cracks, deformation of external protrusions and dislocation and shearing of retaining wall.
3. Landslide formation factor

3.1. Internal causes

Effective material structure. The slide body of old cellar forest is a accumulation body formed by collapse, which is mainly composed of block rock soil and silty clay, the bond force between block soil and silty clay is relatively small, and the front edge of slide body is thin and the back edge is thick and the stability is poor, the slip surface of landslide front edge is soil-rock contact surface, and the sliding zone soil is composed of clay, sand-containing silty clay, which is easy to slide in the event of water. The silty clay has many hydrophilic minerals and is easy to soften in case of water, and silty clay is mostly distributed in the leading edge of landslide, which is located below 175 water level line of three Gorges Reservoir.

Easy-to-slip terrain. The micro-landform in the area is a steep and gentle slope, and the four large gullies developed in the area are deep to form a clear boundary condition of the landslide; the slope of the gullies is larger than that of the large, and the falling water is often formed, and the impact of the water flow can cause the stability to be reduced; in addition, the local section of the rear groove is laid with a strip stone, No protective measures are taken for the rest of the section. As shown in figure 2, the gully landform is shown in figure 2, and the gully will divide the boundary of the landslide to form a powerful sliding condition. The leading edge of the landslide is a steep slope, and the local area is in a steep canto form an effective air-to-air surface.
Figure 2. Geomorphology of the groove after the landslide.

Tectonic conditions. The landslide is located on the north-west wing of the synclinal structure and on the right bank of the Yangtze River. The bedrock outside the rock strata is unloaded and expanded in the steep slope (cliff) area of Linjiang River, and the cracks are easy to cut the boundary such as the back edge and side edge of the landslide, and provide the prerequisite for the slip zone of the slope body to pass through. Under the action of weathering force, sliding extrusion and so on, the broken zone with thickness of about 1cm in the soil layer of the sliding zone is clamped, and during the sliding process, extrusion, kneading and shearing are produced at the same time, resulting in an approximate shear surface, as shown in figure 3.

Figure 3. Deformation cracks in the probe well.
3.2. External causes

Continuous heavy rainfall. In the strongly deformed area, the house and surface cracks are constantly deformed, and the phenomenon and trend of increasing year by year. After long-term heavy rainfall in the rainy season, the clay of the landslide is saturated with water absorption, the strength is reduced, and the surface ponding is serious.

The Three Gorges reservoir is impounding. After the water storage operation of the Three Gorges reservoir, the water level of the reservoir rises, the infiltration line of the groundwater in the slope rises, and the mechanical strength of the soil will be reduced. At the same time, the water level of the reservoir will change periodically between 145 and 175m, and under the influence of the water fluctuation of the reservoir, it can bear the long-term wave erosion effect, especially the surge wave generated during the navigation of the ship is more destructive.

Human activities. The water for living and production of the residents on the landslide is directly led by the households themselves from the water pipes on the back of the mountain. They are not controlled and managed, so they are allowed to flow freely. Therefore, the places where the residents live in are filled with water throughout the year.

4. Analysis of failure mechanism of landslide

4.1. Analysis of the causes of deformation

As shown in figure 4, the first and second strong deformation areas in the landslide area are located in the near-river section of the leading edge of the slope, and the content of the cohesive soil at the leading edge is high, and the clay mineral content of the soil body is high, and the strength is affected by the water, so long as the stress condition is slightly changed (such as three-dimensional change to two-dimensional), its strength will quickly become low, forcing it to create a slip-and-deformation failure in the air-to-air direction[5-8]. The water permeability of the overlying cohesive soil in the landslide is weak, and the water permeability of the lower part of the rock layer is strong. Because of the high water level and natural conditions, they are mostly in the water-saturated state. When the lower water body causes the lower water to be drained quickly, the overlying clay will cause the consolidation settlement deformation due to the slow water loss.

Due to the difference of hydrogeological structure in the accumulation area, the accumulation body has high osmotic pressure under certain conditions, especially the topographic slope of the landslide accumulation area is smooth, the overall permeable capacity of the slide body is poor, and the soil with high groundwater level makes the soil which is already very weak in saturated state for a long time. At the same time, the rainy season is easy to cause the water head accumulation and increase, thus forcing it to cause deformation and failure in the direction of face to air.
4.2. Mechanism analysis

4.2.1. Front edge instability failure. After the heavy rainfall, under the action of the slow creep of the landslide mass, the surface deformation and the crack of the house at the leading edge of the landslide, the trailing edge of the landslide, the pinnate cracks on both sides of the landslide and the expansion of the leading-edge shear outlet belt and the deformation and the dislocation of the retaining wall are further severely damaged; The deformation is increased, the crack is widened, and the slope is gradually extended to the rear of the mass. Under the erosion of water in the three Gorges Reservoir, the fine soil is taken away by scouring, and the reservoir bank is deformed and destroyed, resulting in bank collapse[9-11]. With the increase of the empty surface of the front edge of the slope, the deformation body is prone to instability, while the shear strength of the soil is greatly reduced and the stability of the soil is reduced when the soil is immersed in the reservoir water cycle. The change of the surface of the slope and the change of the ground surface is made by the transformation of the human body to the slope, and the discharge condition of the surface water is degraded. The soil mass on the slope is in a saturated state and becomes soft and easy to slide.

4.2.2. Back slide in the middle. At the rear edge of the slide body, the terrain slope is gentle, and a large number of Quaternary loose materials are accumulated. The surface water of the slope body is densely distributed, which is conducive to surface water seepage and recharge, and reduces the shear strength and stability of the slope soil. The leading edge of the slope is the slip zone of the soil–rock interface, and the middle and rear part is the slip zone of the clayey soil or the high content area of the local
clayey soil in the block stone soil. When the crack extends backward, a penetrating slip zone can be formed, which is more likely to cause the traction slip of the rear edge in a larger range. There is an empty surface with large height difference in the landslide. After the front soil slides unstably, it pulls the middle and rear soil sliding. In addition, the middle and rear soil has a larger weight, which has a certain driving effect and is easy to cause the overall sliding of the landslide.

4.2.3. Sliding characteristics. Laojiaolin landslide has the mechanical properties and characteristics of tractive sliding. The landform in this area mainly develops steep and gentle inter-facial slopes, and there are multi-stage sliding surfaces, which are important topographic conditions for traction landslides. Four large gullies cut the landslide and form favorable boundary conditions. Deformation instability of landslide first occurs in the front of landslide, and then gradually transfers or expands upward. The leading edge of the slope is mainly composed of silty clay and has an empty surface. With the rise and fall of the water level of the Three Gorges and the surge, it has its own material conditions and external inducing factors. Deformation and bank collapse are inevitable. The traction force of landslide mainly comes from the loss of stability, deformation and expansion of the main sliding section at the lower part of the slope, the penetration of cracks to the back, and the excessive gravity of the middle and rear sliding section, which promotes the front sliding[12].

5. Conclusion
Laojiaolin landslide belongs to an accumulation landslide, which has the characteristics of thin front and thick left and right rear edges. The leading edge is located in the steep slope area, which is below the 175 water level of the Three Gorges Reservoir and mainly consists of silty clay. Four large gullies cut the slope at the edge of the landslide area to form good material, topography and boundary conditions. The physical and mechanical properties of the soil change under the conditions of rainstorm and periodic immersion during the impoundment period of the Three Gorges Reservoir, which makes the soil soft and slippery.

The deformation intensity and stability coefficient of strong deformation bodies and potential sliding bank collapse areas in the landslide area are closely related to the water level of the Yangtze River, erosion and side erosion of the Yangtze River water, and precipitation density. The four gully waters in the area have typical characteristics of inter-mountain gullies, and the discharge increases sharply during the flood period, which is extremely unfavorable to the soil stability in the landslide area.

Distribution and deformation of two strong deformed bodies and bank collapse areas of Laojiaolin landslide reflect its tractive sliding characteristics. Both of them are located in the front of the slope body, which is greatly affected by heavy rain and reservoir water storage. The front loses stability, deformation and expansion, and gradually penetrates into the back, pulling the middle and rear soil sliding.

Acknowledgments
This study in the paper was funded by The Research and Practice on Construction Standards of Assembled Construction Student Practice Base (No.GY173002), and the Scientific Research of Higher Education of Chongqing Higher Education Society (No.CQGJ17050A).

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