Influence of 5.12 Wenchuan earthquake on the security function of Yele dam

Yangu Wu    Huidong Cui    Zhichu Teng
Yunnan Lubuge Consulting Co., Ltd., Kunming Yunnan 650051

Abstract: When 5.12 Wenchuan earthquakes happen, in spite of Yele dam is roughly 300Km distance of the epicenter, but it was felt conspicuously in Yele dam, and the duration is very long. After analyzed and collated the monitoring data about dam deformation, seepage and osmotic pressure, stress and strain. The first, about the dam deformation, the earthquake have considerable influence on external deformation, this was profoundly manifested in the following ways: sedimentation rate is faster than before. After one month later, the rate returned to the normal level. The earthquake had very little effect on internal displacement, and keeps original state. Accordingly, we concluded that the earthquake had very little effect on deformation. The second, about the seepage and osmotic pressure, individual osmometers and groundwater level observation holes were influenced by earthquake, the phenomenon was that water level raised in varying degrees after the earthquake, though a period of time, these survey points’ water level returned to normal gradually. The third, about the stress and strain, the earthquake had considerable influence on strain gauges installed on the core wall, the rest reinforcement stresses, concrete stress and so on were steady. From the above, the dam is normal on the whole and earthquake didn’t pose a threat to the dam security.

Keywords: Wenchuan earthquake, Yele dam, Safety operation, influence

1 Introduction:

At 14:28 on May 12, 2008, Sichuan there was an 8.0 magnitude earthquake happened. Between Yele hydropower station and Wenchuan is nearly 300Km far, here can feel the earthquake obviously, and time of the earthquake is longer than before. But, because the distance is very long, the feeling is not very strong. From the surface of Yele dam, the whole hydropower station and structure around it had no broken mark, no rocks crashed down on to the road below, the surface of the dam had no hollows, embossments, subsidence, fissures. This paper will analyze the influence of the earthquake about Yele dam though the monitoring data after the earthquake.
2 General situation

Yele dam lies in upriver of Nanya River in west of Sichuan province, it is in Shimian County and Mianning County, it is the first hydropower station of Nanya River. The project major tasks are electricity generation, has no tasks of transport, drift wood, flood protection, irrigation and so on. The project area seismic basic intensity is eight degree; the dam was designed according to level 1 structure. The permanent structures of flood discharge, water intake system, underground powerhouse and reservoir emptying were designed according to level 2 structure; the installed capacity was 2×120MW.

Dam site is located at the edge of the Yele basin in the canyon, the location reach is nearly east west, and the terrain in dam area is lower in the east and high in the northwest. Near the dam site position, Left Bank Mountains are solid, the natural slope is up to 460m~510m; Relatively flat terrain on the right bank, Slope height is in between 180m ~ 200m, the terrain of the upriver of Cha He is flat open, valley has a "U" shape valley type, in the Cha He below, the river courses is narrow, and the river valley cut deeply, the upstream and downstream of the right bank were cut by No.7 and No.8 gullies, and form a bar mountain ridge, it is about 600m broad, terrain is relatively thin.

Yele dam is rock fill dam with asphalt concrete core, it has a maximum height of 124.5m, with a dam crest width of 14 m at elevation of 2654.5 m. Dam axis is 411m. The normal water level is 2650.0m, dead water level is 2600.0m, the total reservoir capacity is 298 million cubic meters, regulating capacity is 276 million cubic meters and has many years of regulation. Dam structure is divided into asphalt concrete core wall, the upstream and downstream transition layer, the upper rock fill, the lower rock fill, And in the downstream rock fill zone with the main set of traffic, inspection, observation, reinforcement, such as functions of the monitoring corridor.

The dam upstream ratio of slope is 1:2.0(Located a 4m wide horse road in the middle of the upstream dam), the downstream ratio of slope is 1:2.2(Located three 4m wide horse roads in the middle of the downstream dam), In the downstream dam toe, added an average thickness of 22m, about 215m long pressure zone, at the bottom of all filling materials of the downstream dam, took measures to filter and drainage. Use of dam site "Z" character of the river and the layout conditions of diversion building , combine the upstream cofferdam with rock fill, the widest part of dam foundation along the stream direction is 900m wide, Asphalt concrete core wall is trapezoidal frame, top width is 0.6m, the width is thickening from top to bottom, the widest part is the bottom of the wall, it is 1.2m wide, At the bottom of
the core wall connected to the reinforced concrete pedestal at the top of cut-off wall (thickness is 1.0m), within 30m limits of the dam top, we arranged flexible seismic network grille.

Platform on the right bank of the dam, the length of auxiliary dam is 300m, dam foundation adopt the measure of combining vertical anti-seepage with curtain grouting, total depth of its foundation cutoff is more than 200 meters, and the concrete cutoff wall is 140 meters deep. Its construction was divided into two parts; the two parts were connected by a reinforced concrete corridor. According to the order of their construction, first construct cutoff wall and then corridor, the upper wall and the top of the corridor connecting pattern were embedded or contact connection, grout curtain connecting pattern was first construct corridor and then cutoff wall. Designer set up the curtain grouting on the left bank abutment and slope, dam abutment curtain grouting extended into the slightly weathering zone of bedrock 2m ~ 30m, the left bank bedrock cut-off wall (the thickness is 1.0m) embedded in the bedrock 1.0 ~ 2.0m. Overall length of the dam axis is 860m.

At 14:28 on May 12, 2008, in Sichuan, China 8 earthquake, Yele dam located nearly 300km away from epicenter, the earthquake was felt in Yele. This is the strongest quake since Yele hydropower station began to be constructed; therefore, dam safety evaluation is that we must pay attention to.

When the earthquake happened, dam water level is 2599.48m, the water level was lower, and it was lower than dead water level.

3 Seismic effect analysis

By means of analyzing the dam safety monitoring data after earthquake, Preliminary judge the dam was normal. No abnormal conditions such as water seepage and concave dents were observed by perambulation and inspection. But, according to data of internal monitoring observation, a small number of measuring points were abnormal; they were slightly affected by the earthquake. The abnormal points are listed and discussed as follows.

3.1 The part of deformation

Normally, the deformation of the dam mainly related to water level, time effect and dead weight of dam. For example, when water level rising, the horizontal displacement direction of the dam tend to the downstream, on the contrary, tend to the upstream; Vertical displacement was affect by the water level less, its mainly time effect deformation, In other words, settlement would increase slowly with time passing.

After 5.12 Wenchuan earthquake, surface – displacement change velocity come forth fluctuations abnormally: there were part of survey point change velocity
was larger than the normal situation, at the same time, there were part of survey point change velocity was smaller than the normal situation, this phenomenon showed that dam was affected slightly by the earthquake. However, after the earthquake, the anomalies restored to pre-earthquake level in about 30 days, dam was back to the better performance.

Except the surface displacement, internal deformation of dam also was affected by the earthquake. For example, one measuring point of the multi points displacement apparatus of planted in the slope above the base of the left bank (M6-6) (at the juncture of slope segment and horizontal segment on left bank) was pressurized, the value was -0.09mm, and one measuring point of the multi points displacement apparatus of planted in horizontal segment above the base of the left bank (M3-3) was tensioned, the value was 0.13mm. Conform to stress regularity.

3.2 Seepage and osmotic pressure

Earth-rock dam seepage and osmotic pressure were the focus of monitoring, the same was true of Yele Dam, through seepage and osmotic pressure monitoring, can understand the operation of the dam.

Particularly in the earthquake, it became more important, therefore, after the earthquake, seepage and seepage pressure of dam was given special attention, through continuous monitoring, the main ideas on seepage and osmotic pressure as below.

Under normal circumstances, seepage of dam, osmotic water pressure, and osmotic pressure water level was relevant to change of water level. Measured value changed with change of water level. Seepage pressure was mainly affected by seepage around the dam, it was mainly affected by water level too, but it’s amplitude of variation was smaller than water level, after the earthquake, Individual measuring points of seepage pressure variation scope is greater than water level variation scope.

It is as follows:

Before and after the earthquake, dam seepage no significant increase or decrease, seepage quantity changed steadily, it was mainly affected by weather conditions and water level.

In this respect, osmometer PB02 of embedded on the upstream side of the cut-off wall observation showed that had abnormal conditions, in case of water level had a slight fall, infiltration pressure in the earthquake had a certain degree of increase, the pressure after the earthquake(May 12, 2008) contrast with before the earthquake (May 8 in the same year), osmotic pressure water level went up2.19 meters, water level was lowered 0.7m, the situation was slightly abnormal. analyzed the main reasons were that it was affected by the earthquake, its surrounding soil was changed, and came about some new cracks, lead to some new
channels appeared.

However, the rising speed of the seepage pressure reduce after the earthquake, the reason is the osmometer laid on the upstream side of cut-off wall. In other words, it is connected with the reservoir water. From May 13, at this time with the water level rising, that is caused the seepage pressure water level rise.

Since the May 12th, about 30 days, the values of PB02 osmometer gradually returned to normal, so far (the Contribution Day of this article) as well.

Long-term ground water level observation hole in the earthquake, the water level’s rising range of the pipe GC14 which located on the third rock cover group Q32-1 (III) of the right bank was greater.

We preliminary judge that the reason of water level of GC14 changed greatly was affected by the earthquake, lead to the cracks of around the GC14 became compacting, and the water can’t be discharged quickly. We found from the geological profile and drainage corridor profile, the below of the pipe lied in the third rock cover group Q32-1 (III), the rock cover group was silty loam alternating layers of weak permeable gravel layer and a very weak inter-permeable layer, the characteristics of distribution was that equated and impermeable layer alternative distribution. Accordingly further that ground water pressure of the pipe was bigger, Hydraulic contact with the lower reaches was non-close, has the characteristics of confined water, the water level continued to rise higher and the water level was caused by poor drainage.

Over time, the impact of the earthquake was gradually weakened, anomalies above were slowly recovered, to the end of May 2008, the anomalies had been restored to pre-earthquake level, the earthquake does not significant and adversely affect to the dam.

3.3 Stress-strain

Under normal circumstances, stress and strain of dam is relevant to water level and temperature.

Earthquake in Wenchuan, stress and strain (including the steel stress, concrete stress-strain, etc) of the whole dam was normal, before and after earthquake, measuring value was stable, no obvious abnormalities appeared. Only the individual strain gauges planted in the asphalt concrete core wall at before and after the earthquake had a larger range of change, as follows:

SX19 witch planted in the upstream side of asphalt concrete core wall was changed larger than others; its value raised -274με since 8th May, 2008 to May 29th, 2008.

SX29 that on the right bank of the dam, the section of 0+320.00, the elevation of 2600m changed larger, its value raised -210με since 8th May, 2008 to May 12th, 2008.
Except the two strain gauges changed larger, may be relevant to the earthquake, stress and strain of the whole dam were normal, the change regularity was normal, it was not affected by the earthquake.

4 Conclusion

The safety monitoring data after earthquake shows, the dam runned stably. There were a small number of measuring points values were abnormal, but so far they had been restored to pre-earthquake level. So, the situation was normal, had no abnormal things happened.

The reasons that the effects of the earthquake were slightly were the water level was slow, and the dam was far from the epicenter. Yele dam seismic intensity was 6°below, and the dam design fortification intensity is was 9°, it was in the range of safety.

Therefore, we thanked that the dam was affected by the earthquake slightly, and there were no dangers on dam running normally; though this earthquake, showed that the dam had capacity to remain stably when earthquake happening.

Of course, administer and other units should realize that when a big earthquake or flood or some sudden things happened, what things we should do, what methods we should adopt to make people’s lives promised.

References

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Author Introduction:

1. Yangu Wu, (1980-), Female, Yiliang country in Yunnan Province, bachelor, engaged in study of hydropower safety monitoring analysis and earthquake resistance engineering

2. Huidong Cui,(1978-), Male, Shulan country in Jilin Province, bachelor, supervision engineers, engaged in construction technology and management of hydropower