Static and seismic performance of Mae Suai dam and its remedial works

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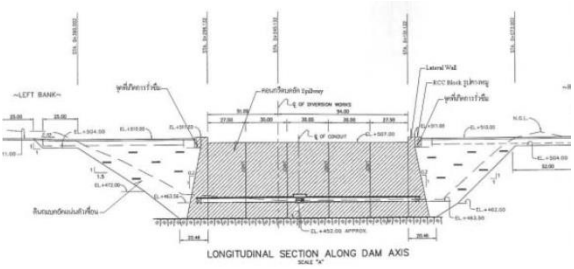
1. Introduction

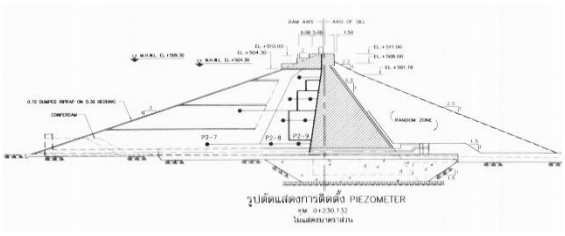
Mae Suai dam is the earth zone dam with the RCC section in the center of downstream slope. The RCC section is used as an overflow spillway. The RCC material type is a low phase RCC and covered its surface with the conventional concrete (CVC). The dam is 59 m high with 400 m crest length. The storage capacity is 73 Million cubic meter. The spillway was designed for 500 years return period of flood. The dam located in Mea Sua district, Chiang Rai province and has been in service since 2003.

Fig 1 shows the plan and section of the dam. The foundation of the RCC was excavated to the sound rock. Grouting has been done as necessary. The RCC section consists of the main part uses as an overflow spillway and the gravity retaining walls at both sides to create the flow channel (Fig 2). The RCC section is surrounded with the earth dam. Upstream part next to the RCC center section is the impervious core with embedded internal filter to reduce the water pressure and discharge into the RCC gallery. Shell section is the coarse grain earth filled with horizontal drain to drain the water during the reservoir drawdown period in order to maintain the slope stability of the shell zone. The earth zone extends to both sides of the abutment. Core trench has been excavated in the foundation and to the abutments.

To prevent the erosion to the earth filled part when the spillway is overtopped, the RCC block has been constructed as a water guide wall as shown in Fig 3. Theses blocks is placed directly over the earth filled material.



(a) Plan



(b) Typical section

Figure 1 Plan and section of the dam [1]

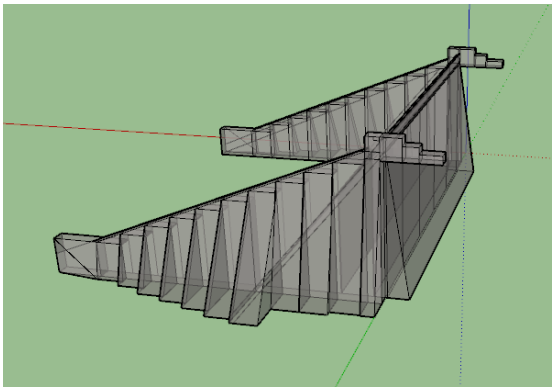


Figure 2 RCC spillway

Figure 3 Guide wall

2. Leakage problem

In 2004, after opening for service in 1 years and the water overtopped the spillway, the leakage has been observed at the downstream crest near the contact area between the earth zone part and the RCC part. The water flows out behind the RCC block and appeared to be clear. The leakage could be observed if the reservoir elevation reaches a certain elevation near the crest of the dam. The maximum flow rate was 1.5 cubic meters per minute with the approximated head water of 1.2 m. Fig 4 shows the photos of the leakage.

Figure 5 The photos of the leakage

Visually, it can be seen that there is a differential settlement between earth filled section and the RCC section. The settlement of the RCC section is approximately 0.18% of its height and the earth filled section is nearly 1% (Fig 5). Even though the differential settlement has been expected but the leakage is unplanned. The investigation done by RID found the crack in the RCC block and opening of RCC lift joints. Theses may contribute to the leakage (Fig 6). Another possibility is the seepage of the water under the RCC block. The repair work has been done by installing the impervious membrane over the surface of RCC blocks as shown in Fig 7. The repair work seems to be effective in reduction the rate of leakage flow but some leakage still persisted. The water filtering and collecting system then installed at the leakage area to prevent the unnecessary seepage erosion that might form piping failure (Fig 8). However, it is found that, at the same water elevation, the rate of leakage is increasing every year which indicated suffused flow (Fig 9).

Figure 5 The settlement of the RCC section and earth fill

Figure 6 The crack in the RCC block and opening of RCC lift joints

Figure 7 The repair work by installing the impervious membrane over the surface of RCC blocks

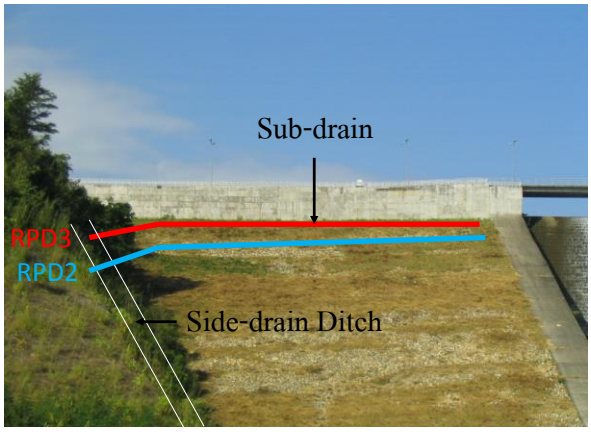


Figure 8 The water filtering and collecting system

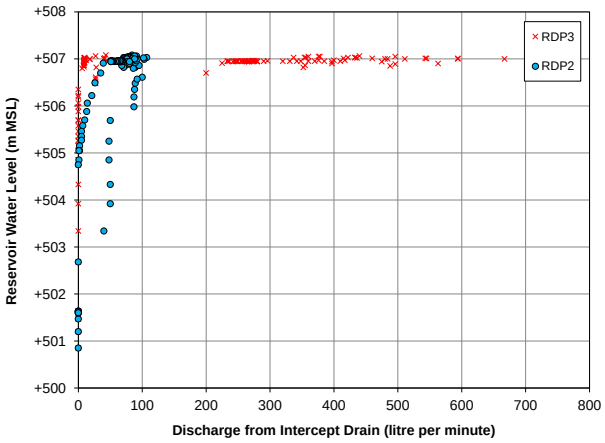


Figure 9 The **discharge from intercept drain**

On the 5th of May 2014, the 6.3 magnitude earthquake occurred in Chiang Rai province. The epicenter to the dam site is 18 km. However, the epicenter of the aftershock is closer to the dam site. The dam experienced the strong ground motion and the accelerometer at the right abutment recorded the maximum PGA of 0.33g (Fig 10). The dam performed well. There is some crack observed in the concrete cover of the RCC block on the crest of the dam. The crack is much above the maximum water elevation, therefore the safety is not to be concerned. Especially, the RCC block that seen some cracks is the part that not related with the stability of the dam.

The piezometric values in the impervious core and the foundation increased at the time of the main shock and responded most of the time to the strong aftershock. However, the piezometric values are still under the safety limit (Fig 11).

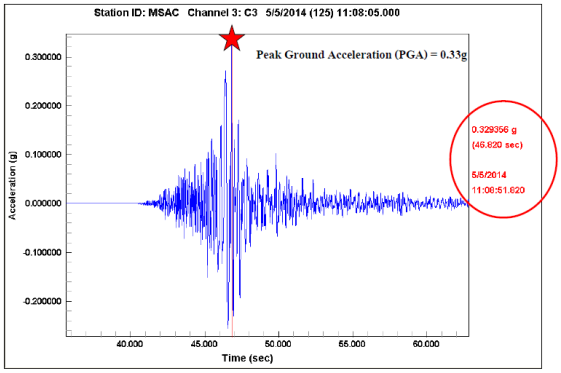


Figure 10 The measured peak ground acceleration at right abutment [2]

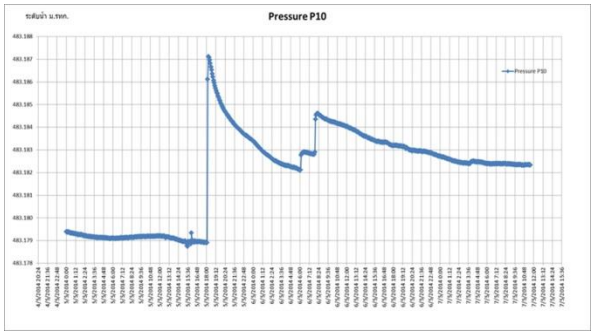


Figure 11 The piezometric values in the impervious core at the time of the main shock and strong aftershock

3. Community response

Even though the dam is performed well according to the engineering evaluation, however the people who lives downstream of the dam are very concerned about the safety of the dam. This is because they thought that the cracks of the concrete covered of the RCC block may lead to the leakage just like what they had experienced before. The concerns became a panic and serious since the community required that the dam shall be removed. Several meetings were set up to discuss about the practical solution and the consensus are to

keep the water storage to be lower than 60% until the dam has been fully repaired.

4. Tentative plan of improvement

The dam improvement will be done in three parts. First, the RCC blocks in the earth dam crest will be removed and replaced by the more flexible and vibration resistance structure. The GRS wall with the cut off sheet pile as shown in Fig 12 will be used. The 3m diameter tunnel will be constructed in the left abutment and at the lowest water elevation. The tunnel will be used whenever the dam is damaged and need immediate reduction of the water. The water will be released with care of sudden drawdown failure of the upstream slopes and the flooding of the people who lives downstream.

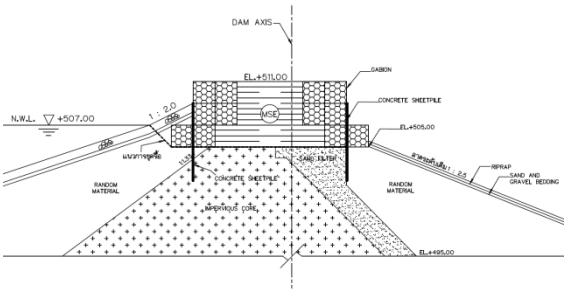


Figure 12 Tentative plan of improvement

5. Conclusion

5.1 Different settlement causes the lift joints open and crack to the RCC block may lead to the concentrated leak of the dam.

5.2 To avoid the future crack and post the concern to the community, the flexible material need to be used rather than the brittle material, especially near the crest of the dam.

6. Acknowledge

The author would like to thank Royal Irrigation department.

7. References

[1] Royal Irrigation Department., “Final design report”

[2] Khamkom W., “Peak ground acceleration, Peak ground velocity, Duration of motion, frequency content of Main shock M6.3 at Phan district, Chiangrai provinces and aftershock M5-6 and M4-5” การประชุมสัมมนาเรื่อง “บทเรียนแผ่นดินไหวแม่ลาว เชียงราย ภัยพิบัติใกล้ตัว 20 พฤศจิกายน 2557. pp.89-98.