A Comprehensive Review of Rainfall-induced Situ Gintung Dam Failure in Indonesia

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Introduction

Situ Gintung was an artificial lake with earth dam structure located at Cireundeu, South Tangerang, near Jakarta. The earth fill embankment was built at the tributary area of Pesanggerahan River by Dutch colonial authorities in 1932-1933 with the height of 10 meters and the length of 180 meters. By the time, the cultivated land turned into high density residential areas. Since then, the main purpose of this reservoir has been utilized for flood control, water conservation, domestic water supply, and recreational areas.

Harsoyo (2010) analyze the spatial condition in Situ Gintung areas. The southern area of this reservoir has the highest elevation (49.8-52.9 meters) and get lower to the northern area. The catchment area of Situ Gintung is around 112.5 ha. Distributed land use of the Situ Gintung catchment area consists of residential houses (45.6%), moor (16.0%), plantation (17.8%), water body (16.9%), grass (3.4%), and building (0.2%). Inundated areas of the Situ Gintung are 22.79 ha with a storage capacity for the water level at the spillway crest of +98.00 m is 0.862 x 10^6 m^3, whereas at the embankment crest, at +100 m, the storage is 1.38 x 10^6 m^3.

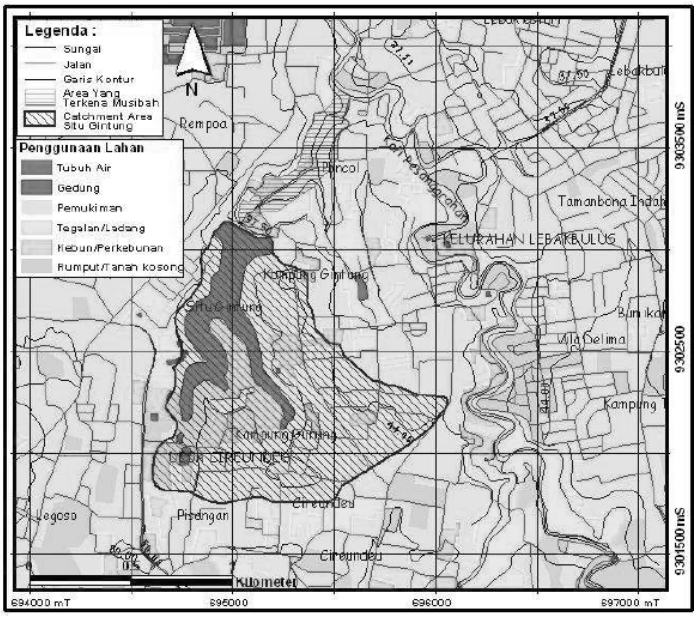

Figure 1 Land use map of Situ Gintung areas (Harsoyo, 2010)

Friday morning at 04.00 AM on March 27, 2009, Situ Gintung dam failed and flooded the surrounding areas. More than a hundred people were died including a number of people were missing due to this catastrophic disaster. Moreover, a number of people were injured and more than 260 resident houses were damaged. The night before, Situ Gintung Dam was suffered by high intensity rainfall causing volume of water in the dam was increased.

BMKG (Agency of Meteorology and Geophysics) observatory station at Pondok Bentung, Tangerang reported some observation data of daily point rainfall (mm) recorded at March 26 and 27, 2009 from 6 stations– Pondok Betung, Ciputat (Balai II), Lebak Bulus, Krukut Hulu, Pasar Minggu, Pakubuwono. The result showed that rainfall depth recorded from 07:00 at March 26, 2009 until 07:00 at March 27, 2009 has the highest depth as 111.3 mm at Ciputat (Balai II) station. In addition, Ciputat (Balai II) observatory station recorded the rainfall which occurred at 16:00 until 19:00 has the maximum intensity as 70 mm/hours. This rainfall was categorized as relatively heavy rainfall.

Analysis of Situ Gintung Dam Failure

Tulla et al. (2013) listed several causes for dam failures or malfunction– design errors, construction deficiencies, operation and maintenance errors, hydrological deficiency (e.g., overtopping, seepage, and piping), insufficient level of safety against slope instability, insufficient resistance of earthquake forces, structural deficiency, surface erosion, insufficient foundation resistance against translation or rotation, and subsidence or settlement.

Sujono (2012) analyzed the hydrological aspects of this failure by using HEC-HMS version 3.5. The result showed that the Situ Gintung dam should be safe in March 26, 2009 flood as the result of rainfall intensity occurrence. The maximum water depth on the spillway crest was only 63 cm (+98.63 m) while the dam crest level was +100 m. This means that there is no overtopping through the embankment. Furthermore, reservoir routing based on a 100 year flood return period yielded maximum water storage elevation at +98.95 m which means that the dam should be stand still up to a 100 year design flood.

The spillway structure at Situ Gintung dam is an Ogyee type where the width of crest is 11.0 meters and the height is around 10 meters. The chute spillway width is around 2.0 meters indicates that this spillway is very narrow. In fact, the condition was poorly maintained and the stilling basin was not clear enough. This indicate that there was no spill activities for a long time. Dam breach also has been analyzed by using HEC-HMS. The peak discharge resulted was 427 m^3/s implies that there was a big outflow discharge beyond channel capacity. The spills process predictably began at around 17:00 and continuously occurred up to 3:00. The breach and erosion process was probably occurred as long as the time for more than 10 hours. As the result, a big pond emerged and created instability of the spillway structure.

Fathani (2012) analyzed the instability process and failure mechanism of Situ Gintung. According to the analysis, this failure was caused by left embankment structural instability and breaching mechanism. The instability occurred due to cutting slope and additional external load reaching the embankment crest as the residential house built over the dam body, which will reduce the safety factor of the embankment. Breaching mechanism occurred as the hydraulic gradient increases, accompanied with seepage and piping. This mechanism will significantly reduce the soil shear strength in the saturated condition. Actually, the earth fill material and the existing embankment foundation have a good stability against erosion as long as there is no defect in the embankment structure.

Conclusion

Incident of Situ Gintung reflects important relation between human activities and nature responses. Some rules should be developed to recognize the hazardous zones in the surrounding areas of essential building. In the other side, research on breaching mechanism is also necessary focusing on the correlation between water discharge rise and the velocity of erosion in the spillway part of the dam by the time. As the result, some techniques should be developed to overcome the erosion on the spillway part. In addition, some instrument to detect the erosion and crack condition in spillway dam are also needed.

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