The Assessment of Physical Condition of Delingan Dam in 2019 as an Evaluation on Dam Maintenance

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Abstract. For operating and maintaining dam activities, there is an activity serving the main function, the Assessment of Dam Condition to make it the main building well-monitored and maintained. In addition to having many advantages, dam also hides a big potential hazard. For the dam to function maximally, good maintenance and evaluation are required. Delingan Dam in Karanganyar Regency was constructed by Dutch Government since 1920. This research employed case study approach to evaluate the physical condition of dam for Delingan Dam at 2019. This research aimed to excuse the physical condition of dam, viewed from the component dam body so that component weight is assumed to be 100%. The method employed in this research was descriptive qualitative one. The result of physical assessment of Delingan Dam body obtained score of 91.63%, indicating that the physical condition of Delingan Dam in 2019 is good (condition score ≥ 90% - 100% and damage level < 10%). To maintain physical condition of Delingan dam, it is recommended to operate and to maintain the dam maximally.

1. Introduction

Human beings have developed dam since thousands of years ago to meet the need for water to many interests. Since 50s, dam development initiated by public and private sectors throughout world has grown very rapidly along with population and economic growth. About 45,000 large dams have been constructed for the purposes above. There are about 120 dams in Indonesia, managed by Ministry of Public Work and People Housing, PLN (State Electricity Company) and private in mining sector and in other groups. Viewed from its distribution, most dams are located in Java Island, Bali, Lampung, Sulawesi Selatan (South Sulawesi), Kalimantan Selatan and Timur (South Borneo and East Borneo), Nusa Tenggara Barat (West Nusa Tenggara) and Nusa Tenggara Timur (East Nusa Tenggara). Many dams have been constructed, beneficial to store water, and functioning to control flood. However, the risk of dam failure can also occur, and even the small dam can potentially take property and life toll, when all aspects related to the dam maintenance is considered inadequately. In Dam Operation and Maintenance Activity, there is an activity serving main function, the Assessment of Dam Condition to keep the condition of dam as the main building well-monitored and maintained. In Karanganyar there is a dam constructed by Dutch Government since 1920 and completed in 1923, Tirtormarto Dam or called Delingan Dam. The assessment of dam condition is required to find out the safety level of dam and as the matter of consideration in the dam rehabilitating activity. Considering the problem, an assessment should be conducted on the physical condition of Delingan Dam.
2. Experimental
Some researchers, such as Herlen (2009), explain that the objective of dam management is to prevent the risk of dam damage from occurring [1]. Marzulian Ramli and Bambang E. Yuwono (2015) state “to minimize the failure of dam operation, maximum dam management is required” [2]. Yulius Heryant, et.al. (2014) suggest that in operation and maintenance of dam, an assessment is required as included in the Guideline of Assessment of Dam’s Physical Condition referring to Government Regulation Number 37 of 2010 about dam [3].

2.1. Dam operation
The Guideline of Dam Operation and Maintenance issued by Directorate General of Water Resource in 2003 mentions that before the operation of dam, the water capacity of dam and the chart of the correlation between dam water surface elevation, puddle width, and water volume stored have been calculated and known. However, the correlation is affected by water storage rate and sedimentation rate in the bottom of dam. These factors should be considered in the Guidance of Dam Operation and Maintenance. The elements related to dam operation are:

- Dam’s storage capacity,
- Design flood and Flood Tracking,
- Estimated Water Flow,
- Charging Schedule and Water Releasing Procedure, and
- Operational instruction.

2.2. Dam maintenance
The Guideline of Dam Operation and Maintenance issued by Directorate General of Water Resource in 2003 mentions that Maintenance is any attempt or measure aimed at ensuring the preserved utilization of water resource and dam function, complementary buildings, and other irrigation infrastructure including its environment corresponding to its planned service life [4]. Two basic activities conducted in maintenance are routine maintenance and repairing work. The Guidance of Dam Operation and Maintenance should confirm that the two activities should be planned well including dam maintenance or repairing system, cost need, personnel availability, and equipment need. The result of maintenance implementation should always be evaluated, recorded, and documented chronologically.

2.3. The assessment of dam condition
Regulation of Dam characteristic issued by Government Regulation Number 37 of 2010 about Dam has issued a Guideline of Dam and its Reservoir’s Physical Condition Assessment issued or published by Balai Bendungan in 2010 [5]. The assessment of dam and its reservoir’s physical condition was conducted on some components: 1) Reservoir including: a) sedimentation, b) Reservoir Border Area, c) Green Belt Area, and d) Reservoir Inflow; 2) Dam body including a) downstream slope, b) dam peak, c) upstream slope, d) supporting field, and e) leakage; 3) Complementary buildings including a) intake, b) outlet, and c) spillway. The weighing of each component and subcomponent in the assessment of dam’s physical condition serves as the reference in estimating damage index in each component and subcomponent of dam. Component and scoring in each dam as well as reservoir, according to Standard Guidelines of Dam’s Physical Condition Guidelines in 2010, are as follows.
Figure 1. Scheme of Component and Scoring of Dam and Its Reservoir’s Physical Condition Assessment.

The classification of condition assessment is determined based on the problem and the damage level of dam and its reservoir. The classification of condition assessment can be seen in Table 1.

| No. | Condition           | Explanation                                                                 |
|-----|---------------------|-----------------------------------------------------------------------------|
| 1   | Good                | The condition score is $>90\%$ and the damage level is $<10\%$ compared with the early condition of building. |
| 2   | Mildly damaged      | The condition score is $80-89\%$ and the damaged level is $10-20\%$ compared with the early condition of building. |
| 3   | Moderately damaged  | The condition score is $60-79\%$ and the damaged level is $21-40\%$ compared with the early condition of building. |
| 4   | Severely damaged    | The condition score is $<60$ and the damaged level is $>40\%$ compared with the early condition of building. |

Source: [1] *Balai Bendungan (Anonymous, 2010)*
3. Result and Discussion

In Karanganyar there is a dam constructed by Dutch Government since 1920 and completed in 1923, Tirtormarto Dam or called Delingan Dam. Geographically, Delingan Dam is located on coordinates 7° 35' 14, 60" SL and 110° 59' 22, 60" EL. Considering the river area system, Delingan Dam belongs to Bengawan Solo River Area, and Bengawan Solo River Flow Area. The management of Delingan Dam is under BBWS Bengawan Solo today. Delingan Dam is an upstream slope homogeneous type-landfill dam with declivity of 1:1.5 with concrete slab layer, and declivity of 1: 2.0 in the downstream slope with thick grass, and fishbone drain, and toe drain on the leg of dam body. This dam is ± 21.00 tall, and ± 885.00 m long, with average peak width of 4.5 m. The assessment of Delingan Dam’s physical condition in 2016 on dam body component is as follows.

3.1. The Assessment of upstream slope condition

Figure 2. Upstream Slope Condition in 2019

Considering the result of survey on body dam in a good condition, slope protection consists of riprap (rock), regular or stable declivity condition. There is no extraordinary condition. This upstream slope condition has score of 90 (good).

3.2. The assessment of dam crest condition

Figure 3. Condition of dam crest in 2019

The condition of crest seems to be good, with no surface crack, no deflection, no decline, and with linearity as planned. There is no extraordinary condition. The crest condition has score of 91 (good).
3.3. The assessment of downstream slope condition

![Figure 4. Downstream Slope Condition in 2019](image)

Generally, the condition of dam is still good, the slope protector consists of riprap (rock), the declivity of slope seems to be organized/stable, with no sign of movement, no erosion plot and ruin, weathering beginning to appear, wild plant consisting of short grasses only, no subsidence, no animal hole/nest, and no leakage and wet area. There is no extraordinary condition. The score of downstream slope condition is 94 (good).

3.4. The appearance of right and left support condition

![Figure 5. Condition of Right and Left Support in 2019](image)

Considering the result of survey or observation, the dam is generally in good condition with no leakage, crack, wild plant, and sign of movement. The score of right and left support condition is 91 (good).

3.5. Seepage condition

![Figure 6. Condition of Seepage and V-notch in 2019](image)
The condition of seepage is good, with clean environment, no perennial plant, the V-notch (seepage measurement tool) still functioning well, and the seepage water is clear. This condition obtains score of 92 (good). These assessments can be seen in table 2 presenting physical condition and weight scores of dam body component.

| No | Name of Building       | Weight Score (%) | Performance Score |
|----|------------------------|------------------|-------------------|
| 1  | Upstream Slope         | 25.00            | 90.00             | 22.50             |
| 2  | Crest                  | 25.00            | 91.00             | 22.75             |
| 3  | Downstream Slope       | 25.00            | 94.00             | 23.50             |
| 4  | Left and Right Support | 12.50            | 91.00             | 11.38             |
| 5  | Seepage                | 12.50            | 92.00             | 11.50             |

|               | Total Score | NKF (%) | NKB (%) |
|---------------|-------------|---------|---------|
| Dam Body      | 100.00      |         |         |

**4. Conclusion**

The conclusion of research was physical condition assessment on Delingan Dam body obtains score of 91.63%, indicating that Delingan Dam physical condition is good in 2019 (condition score >90% - 100% and damage level <10%).

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