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CURTAIN GROUTING TEST ON VOLCANIC BRECCIA FOUNDATION AS AN EFFORT TO ASSESS THE EFFECTIVENESS OF GROUTING CASE STUDY: CONSTRUCTION OF MINTING DAM

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ABSTRACT

Keywords: grouting; dam; Foundation; breccia.

Meninting Dam is located on the Meninting River, Meninting Watershed WS Lombok. Administratively, the location of this dam is located in Bukit Tinggi Village, Gunungsari District, and Gegerung Village, Lingsar District, West Lombok Regency. It is planned that Meninting Dam has a height of 79 m, the type of Urugan Zonal Random Dam with Upright Core, with a maximum storage capacity of 12.18 million m3 and an average storage capacity of 9.91 million m3. From the results of geological investigations during planning and pre-construction geological investigations, it is known that the body of the Meninting Dam will rest on a foundation in the form of volcanic breccia rock. Given that Meninting Dam has a reasonably high height, the foundation rock's quality is essential in terms of foundation permeability and the ability of the foundation rock to support the dam above it. On the left backrest, there is a volcanic breccia layer with a lousy level of cementation, which affects the high permeability value of the layer. In order to reduce the permeability value, it is necessary to conduct curtain grouting experiments to determine the extent of grouting effectiveness to reduce the permeability value and improve the overall foundation. The results of curtain grouting experiments and cement injection showed that the average incoming cement per meter was 21.43 kg / m or classified as efficient with a mixture change of 1 4. The effectiveness of grouting in poorly cemented volcanic breccia in Check Hole (CH) against Pilot Hole (G1) with an average of = 65% or classified as GOOD (Good) and seen semi-logarithmetically the significant decline of Lugeon towards target < 3 according to technical specifications.

Introduction

In PUPR Minister Regulation number 27 / PRT / M / 2015, article 2 states that dam construction and management are carried out based on the conception of dam safety, which consists of 3 structural security pillars, namely safe against structural failure, safe against hydraulic failure, and safe against seepage failure (Mulyono, 2017). Dam safety arrangements are intended to realize the orderly implementation of dam construction and management so that it is technically feasible in design and construction and safe in management to prevent or at least reduce the risk of dam failure (Ewert & Hungsberg, 2018).

The foundation is the most crucial part of construction planning. The foundation itself is part of an engineering system that continues the load supported by the foundation and its weight into the soil and rocks below (Andriyani, 2019).

In the construction of the Meninting Dam, volcanic breccia is the bedrock found at the dam location and its surroundings (Nurnawaty & Farida, 2015). The distribution is quite wide from the left backrest and river bed to the proper backrest. In weathered conditions, brown to dark brown; in fresh conditions, dark gray (Amani, 2018).

The results of water graduation testing with the falling head method showed the value of the water graduation coefficient (k) ranging from >5x10-3 to <5x10-6 cm/sec. The test results with the packer method showed lugeon values between Lu<5 and Lu>20.

Vital to moderately weathered breccia with poorly cemented sand matrices are found on the left backrest between 15-25 m deep and 25-50 deep. Water passing values <5x10-3 to >5x10-5 cm/sec and lugeon values between >10 to >20 (Manueke, 2019).
Based on the explanation above, it is necessary to have a grouting experiment (trial grouting) on strong weathered breccia–medium weathering to determine the effectiveness of grouting in reducing the value of lugeon by the required value in the construction of the Lugeon (Lu) dam < 3 (Irfan, Mochammad Solikin, & Sunaryono, 2022).

Project Overview

Administratively, the location of Meninting Dam, as seen in Figure 1, is located in two villages and two sub-districts, namely bukit tinggi village, Gunungsari District, and Gegerung Village, Lingsar District, West Lombok Regency and at the same time, geographically located at 8o31'11" LS and 116o9'10" BT.

From Mataram City, by road to the north, reach the location, passing the affection intersection approximately 6 km to Bukit Tinggi Village. Arriving at Bukit Tinggi Village, the journey continued by walking eastward approximately 300 m to the location of the Meninting Dam (Darmawan & Bakhtiar, 2023).

Built on the Meninting River, Meninting Watershed, with a watershed area of 32.77 km2, Meninting Dam is a random zonal Murugan-type dam with an upright core. The inundation area is 53.60 Ha, the maximum storage capacity is 122.18 million m3, and the average storage capacity is 9.91 million m3. Meninting Dam's height is 75 m, and dam length is 418 m, stretching from east to west.

In addition to the construction of the main dam, Meninting Dam has several other main structures, such as the dodge tunnel on the proper backrest that merges with the side spillway and the retrieval tunnel on the left backrest, as shown in Figure 3. The dodger tunnel has a diameter of 4 m in the shape of a horseshoe and a diameter of 7 m in a round shape with a length of 388.8 m. The retrieval tunnel has a diameter of 3 m with a length of 480.15 m.

Geological Overview

The geology of the Lombok area began with Tertiary volcanic rocks, namely the Early Miocene, consisting of the Kawangan Formation and the Penroll Formation, which pollute each other. The Kawangan Formation consists of sedimentary rocks (interspersed quartz sandstones, claystone, and breccia). In contrast, the Pengulung Formation consists of breccia, lava, and tuff with sulfide mineral limestone lenses and contains quartz veins. Both formations were penetrated by dacite and basalt of the Middle Miocene age.

Above it was deposited the Ekas Formation consisting of limestones of Upper Miocene age. Then, in the Upper Pliocene to Pleistocene, tufaan sandstone and tufa claystone with thin inserts of carbon belonging to the Selayar Member of the Kaliplung Formation were deposited. Kalipalung Formation is composed of interspersed limestone breccia and lava.

Along with the Kalipalung Formation, the Kalibabak Formation consisted of breccia and lava, and the Lekopiko Formation consisted of pumice tuff, lava breccia, and lava. Kalipalung Formation and Kalibabak Formation contaminate each other. When the Lower Holocene lava was deposited, the breccia and tuff included in the Inseparable Volcanic Rock were widespread in the north, surrounded by the Lekopiko Formation and the Kalibabak Formation.

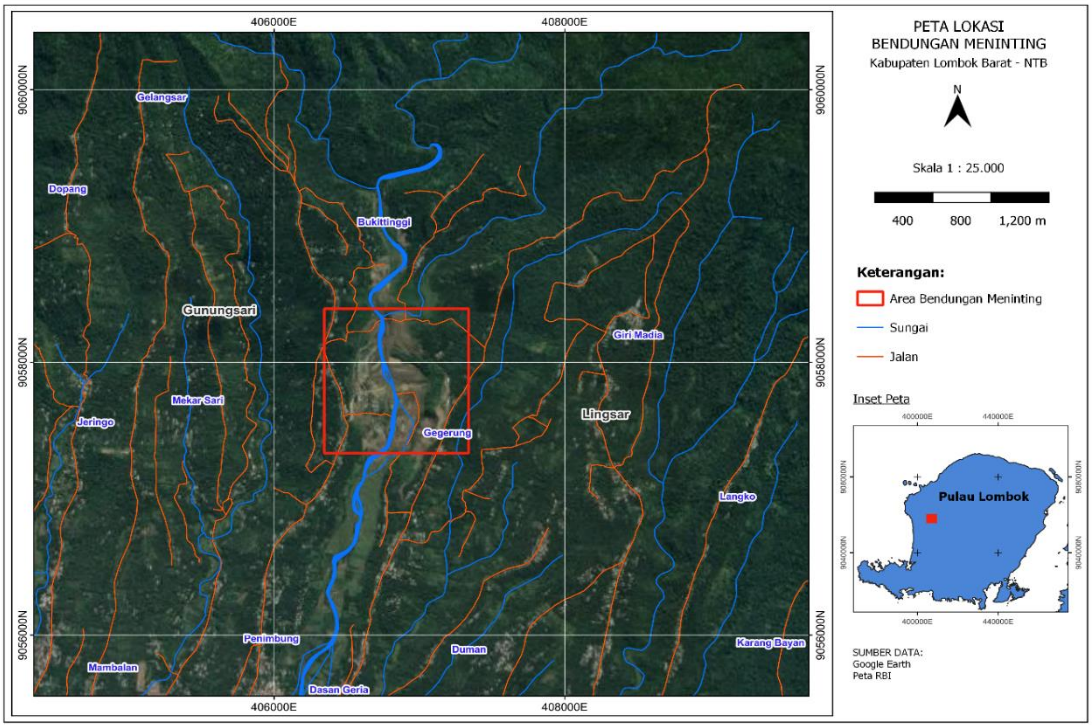

Figure 1. Map of Meninting Dam

Hole Pattern

The drilling hole pattern is selected taking into account the drilling method (rotary or percussion), rock type, drill hole diameter, available grouting area, drilling hole depth, and permeability conditions. Generally, grouting holes are arranged in linear, triangular, and square shapes.

boron (drilling)

Rotary method drilling uses a hydraulic rotary drilling machine with a capacity to reach the planned curtain grouting depth. Coral retrieval is required for pilot holes and check holes with drill diameters ranging from 56 mm to 66 mm.

The type of drill bit used depends on the hardness of the drilled rock. Hard rock (class A-B) must use diamond bits, while soft rock (class C-D) is sufficient with metal drill bits. In order to get this full (100% core recovery), a single-core or double-core tube is used, depending on the rock.

Research Methods

This type of research uses literature studies. This method has a scope of activities that correlates with the method of data collection, recording, reading, and processing of what will be the material of research (Broccardo, Culasso, & Mauro, 2019). Literature review is a mandatory activity in research, especially academic research with the main aim of developing theoretical aspects and also practical application aspects. Each researcher conducts a literature study to find a foundation to collect and build theoretical foundations and reflection frameworks and identify temporary hypotheses, also called research hypotheses. By conducting a literature study, researchers have a broader and deeper deepening of the problem to research. A thorough literature review can help set the foundation of current research based on previous research. This research literature study will review several previous studies and journals to analyze the relevance of change to the development of the study and its issues with update analysis. This is in line with what has been stated by (Snyder, 2019) that literature studies have a significant role that can serve as a basis for knowledge development, policy making, implementation, and provide an overview of the impact of the results of a study.

Results and Discussion

Data analysis is carried out on the results of investigations into grouting experiment work after all grouting points have been completed (post-grouting conditions.

At point G1, the highest Lu value was obtained at stage 10 or a depth of 45-50 m below the ground surface of 16.22 l / min / m, and the amount of injected cement was 234 kg or 46.8 kg / m. While the lowest Lu value is obtained at stage 2 or a depth of 5-10 m below the ground surface of 0.33 l / min / m where the Lu value is smaller or equal to 3 l / min / m, there is no need for grouting (cement injection).

Table 4
Cement injection quantity

Stage	Depth	Grout Take (kg)			Jul
	(m)	G-1	G-2	G-3	Total
1	0 ~ 5	*No grout*	62.83	*No grout*	**62.83**
2	5 ~ 10	*No grout*	112.16	*No grout*	**112.16**
3	10 ~ 15	*No grout*	58.93	138.74	**197.67**
4	15 ~ 20	*No grout*	*No grout*	60.13	**60.13**
5	20 ~ 25	87.83	61.63	87.84	**237.30**
6	25 ~ 30	61.63	87.83	58.92	**208.38**

Stage	Depth	Grout Take (kg)			Jul
	(m)	G-1	G-2	G-3	Total
7	30 ~ 35	61.63	61.63	185.93	**309.19**
8	35 ~ 40	60.12	137.16	87.84	**285.12**
9	40 ~ 45	85.53	181.29	87.83	**354.65**
10	45 ~ 50	234.00	135.57	87.84	**457.41**
11	50 ~ 55	181.29	181.29	60.12	**422.70**
12	55 ~ 60	184.76			**184.76**
Sum		956.79	1080.32	855.19	**2,892.30**
		Cement injection 2,892.30 kg or 2.89 tons			
		Injeksi semen rerata 21,42 kg/m			

Point G1 is also a Pilot Hole (PH) so that at the time of drilling, the rock core (coring) is carried out to determine the stratification of rocks and types of rocks that are below the ground surface along with the type of engineering geology, primarily related to the physical condition of rocks (weathering rates, rock fractures, and rock/soil pores). Lugeon's pattern during the Lugeon test shows that the condition of the rocks in hole G1 alternates with degrees of weathering and cementation so that they experience dilation and leached flow (Houlsby, 1990). At point G2, the highest Lu value was obtained at stage 9 or a depth of 40-45 m below the ground surface of 14.95 l / min / m, and the amount of injected cement was 181.29 kg or 36.25 kg / m. At the same time, the lowest Lu value is obtained at stage 4 or a depth of 15-20 m below the ground surface of 2.20 l / min / m. At the G2 point, no rock unit is taken, so drilling is only limited to open holes without coring.

At point G3, the highest Lu value was obtained at stage 3 or a depth of 10 – 15 m below the ground surface of 13.50 l / min / m, and the amount of injected cement was 138.50 kg or 27.74 kg / m. The lowest Lu value is obtained at stage 1 or a 0 – 5 m depth below the ground surface of 1.99 l / min / m.

At the Check Hole (CH) point, the Lu value at all stages (1 – 12) shows a number below Lu 3 so that from the total drilling depth as deep as 60 m below the ground surface, there is no need for grouting (cement injection).

The effectiveness of grouting can be achieved by comparing the lugeon value before grouting, represented by the PH / G1 point, with the lugeon value after grouting, represented by the CH point. From the comparison results, the most excellent grouting effectiveness was obtained at stage 10 (45 – 50 m), where the value before grouting Lu 16.22 l / min / m became Lu 2.81 l / min / m or the percentage of effectiveness reached 83% with the influence of GOOD grouting. The average grouting effectiveness is 65.1%, which is still included in the category of GOOD grouting influence. A detailed comparison of PH and CH tests can be seen in Table 5, and a summary of the results of curtain grouting experiments that have been carried out can be seen in Figure 2.

Figure2
Comparison of Lugeon test results before and after grouting

Conclusion

From the results of the curtain grouting experiment that has been carried out, several

Stage	Kedalaman (M)	Sebelum Grouting PH/G-1	Sesudah Grouting CH	Efektifitas Grouting (%)	Rerata (%)
1	0 ~ 5	K = 4.68E-06	K = 2.28E-06	51	65.1
		Lu = 0.35	Lu = 0.17	51	
2	5 ~ 10	K = 4.40E-06	K = 1.19E-06	73	
		Lu = 0.33	Lu = 0.09	73	
3	10 ~ 15	K = 2.45E-05	K = 1.89E-05	23	
		Lu = 1.84	Lu = 1.42	23	
4	15 ~ 20	K = 3.24E-05	K = 1.01E-05	69	
		Lu = 2.44	Lu = 0.76	69	
5	20 ~ 25	K = 7.46E-05	K = 2.13E-05	71	
		Lu = 5.61	Lu = 1.60	71	
6	25 ~ 30	K = 8.22E-05	K = 2.37E-05	71	
		Lu = 6.18	Lu = 1.78	71	
7	30 ~ 35	K = 6.98E-05	K = 2.66E-05	62	
		Lu = 5.24	Lu = 2.00	62	
8	35 ~ 40	K = 7.51E-05	K = 2.69E-05	64	
		Lu = 5.65	Lu = 2.02	64	
9	40 ~ 45	K = 7.57E-05	K = 3.40E-05	55	
		Lu = 5.69	Lu = 2.55	55	
10	45 ~ 50	K = 2.16E-04	K = 3.74E-05	83	
		Lu = 16.22	Lu = 2.81	83	
11	50 ~ 55	K = 1.92E-04	K = 3.37E-05	82	
		Lu = 14.45	Lu = 2.53	82	
12	55 ~ 60	K = 1.56E-04	K = 3.52E-05	77	
		Lu = 11.7	Lu = 2.65	77	

things are described as follows:

1. Curtain grouting experiments on the Meninting Dam Foundation showed effectiveness reaching 65.1% or GOOD with an average cement injection of 21.43 kg/m. According to Technical Specifications, They saw a semi-logarithmetically significant decline of Lugeon towards the target of < 3.
2. The foundation geology of Meninting Dam consists of volcanic breccia rocks with varying degrees of weathering.
3. Conventional curtain grouting made from Portland Cement Type-I, without additives, turned out to be effective and efficient for repairing the foundation of the Meninting Dam

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