Optimum height of the retaining gravity wall

by F Bari

Optimum height of the retaining gravity wall

To cite this article: F Bari *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **708** 012020

Optimum height of the retaining gravity wall

F Bari[1], J A Repadi[1], F A Ismail[2], Andriani[2] and A Hakam[2]

[1]Doctoral Program, Dept. Of Civil Eng, Faculty Of Engineering, Andalas University, Indonesia.
[2]Lecturer, Dept. Of Civil Eng, Faculty Of Engineering, Andalas University, Indonesia.

Corresponding author: fathol.bari1564@gmail.com

Abstract. Many failure cases of retaining walls caused by some factors, which are soil condition, planning design that did not meet the safety requirements, and the lack of knowledge or indecisiveness towards the selection of the retaining walls type for a specified height. In this research, the optimum height of a retaining wall of gravity wall type for sandy soil was planned. The research methodology was done by calculating external and internal stability from a stone gravity retaining wall. From the external stability analysis of 4 - 14 meters heights, it is known that the retaining wall still safe. The internal stability analysis obtained from 8 meters heights did not meet the safety requirements. Therefore, it is recommended from the research to use the height of 7 meters for the stone gravity retaining wall. The optimum height of retaining wall is planned in this research as the guidelines for engineers in planning the right retaining wall for the height as planned.

1. Introduction

Indonesia is a country that is prone to disasters due to Indonesia's geographic location which is surrounded by the Asia Pacific ring of fire, resulting in almost all regions in Indonesia that have the potential for natural disasters.

Disasters in West Sumatra are dominated by earthquakes, floods and landslides. Of the three disasters, floods and landslides dominate the largest number of disasters in 2020, according to BNPB's Disaster Information Data (DIBI). Landslides have many impacts and losses, one of which is on roads. In addition to disrupting traffic access due to landslide materials, it is also damaging the construction of road attachments, namely retaining walls.

The failure of the retaining wall construction that has occurred so far is a challenge for planners to minimize the collapse of the structure. The collapse of the construction of retaining walls is not only caused by pressure due to landslide materials or due to natural disasters, but many other things also affect it.

We can see the various causes of retaining wall failure from several cases of collapse of the retaining wall in many regions. The first case is the collapse of the retaining wall which occurred on 25 May 2006 in Kahramanmaras, Turkey due to the low quality of the materials used, the construction method that was not good and the construction design was not made following the Turkish Standard 7984 [1].

The second case collapsed on 10 February 2017 in Bantas Hamlet, Songan B Village, Kintamani District. The collapse occurred a day after four days of extreme rain that flushed the area. From field observations and numerical analysis, it was found that the failure of the DPT was caused by the dimensions of the DPT which were too slim so that it could not withstand active soil pressure when it

IOP Conf. Series: Earth and Environmental Science **708** (2021) 012020 doi:10.1088/1755-1315/708/1/012020

was saturated with water. Besides, another factor that resulted in the collapse was the failure of the drainage to function so that rainwater that entered the ground caused the erosion of the DPT foundation [2].

The second case occurred on February 20, 2018, in Baringin sub-district, Sawahlunto. The collapse occurred on the dam of a periodic maintenance project of the road on the mess road section of Japan to the camera peak area. It is suspected that the cause was not strong enough to receive water spills. Deri Asta, Chairman of Commission III of the Sawahlunto City Council, assessed the quality incompatible with the quality of the work required [3].

In some cases the collapse of the ground retaining wall caused by several factors namely errors in the design, inappropriate implementation methods, lack of labour skills, low quality of work then the future needs to be considered in making the ground retaining wall so that problems do not happen again.

Solehuddin, Tifani, and Zulkarnaen (2018) [4] have previously performed the analysis of gravity soil retaining walls located on clay soil where it was obtained the result that gravity is more stable and economical compared to cantilevers at a depth of 2.7 meters.

Agustian, Habir and Panjaitan (2018) [5] analyzed gravity and cantilever retaining walls for avalanche management planning on the Sanga-Sanga Dondang STA road. 4+000 Kutai Kertanegara. The comparison of cantilever retaining wall stability with gravity on clay soil is obtained at a depth of 5 meters cantilevered ground retaining wall is safe stability against overturning , shear and ground support. In contrast, gravity retaining wall does not meet safety standards.

Sebastian and Suhendra (2019) [6] analyzed four types of earth retaining walls namely gravity, cantilever, gabion, and geogrid on the land of fittings to obtain a kind of ground retaining wall that is effectively used in projects in Bogor based on stability and cost aspects. For the four types of retaining walls with a height of 6 meters safe against global stability, rolling, shearing and ground carrying capacity while reviewed from the cost aspect geogrid are rated the most economical.

From previous research on gravity walls, especially on the soil of the fitting is still limited to depths of up to 6 meters and mostly only analyzed against external stability. However, in this study, analysis of external stability and internal stability of gravity walls on the sandy soil from a depth of 4 meters to 14 meters.

2. Retaining wall

Ground retaining walls are constructions used to provide soil stability or other materials whose material mass conditions do not have a natural slope, and are also used to hold or sustain landfills or other material deposits [4].

The retaining wall serves to prevent landslide-indicated soil mass either due to rainwater, the weight of the soil itself or due to the load that works on it so as not to move. These ground retaining walls are generally for soil avalanche management and are rarely used to withstand flow. The type of construction used to withstand the flow of soil is usually planned in two functions which are to hold solid material and pass liquid material [5].

Other explanations about the types of soil retaining walls put forward by [7] include gravity wall. Gravity walls are an arrangement of stone pairs, pedal concrete, reinforced concrete, and wire stone pairs (gabion). This wall relies on its weight to withstand the thrust given by the soil behind it and is very commonly used in Indonesia due to its ease of working. The height of the gravity wall should be limited, i.e. 6 meters for the gravity of the pair of stone times and 8 meters for the gravity of concrete walls [5], [8] and [9] also reinforces the revelation that gravity walls are not safe to withstand high ground.

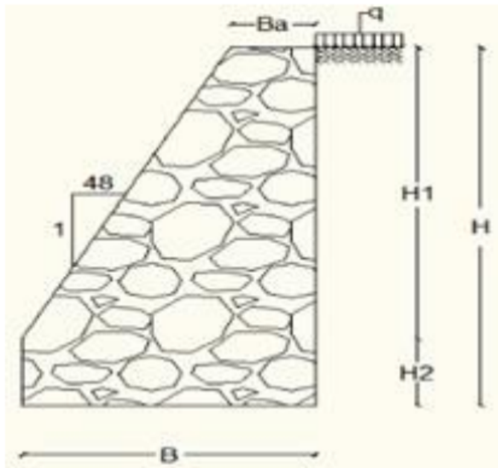

Figure 1. Gravity retaining wall

3. Eksternal and internal stability

In analyzing soil restraints' stability, it is necessary to calculate the styles caused by soil pressure. Working ground pressure is determined based on lateral soil pressure theory. The theory of lateral soil pressure calculation due to its weight was initially developed by a coulomb. Rankine then proposed a more straightforward calculation procedure based on his observations in the laboratory.

The amount of active soil pressure, according to Rankine, is as follows:

$$K_a = tan^2\left(45 - \frac{\emptyset}{2}\right) \quad (1)$$

For non-cohesive soil (c = 0), the resultant active press force that works behind the wall up to the depth of Z=H is only donate by its own weight, namely:

$$P_{a,\gamma} = \frac{1}{2}\gamma H^2 K_a \quad (2)$$

The amount of passive ground pressure, according to Rankine, is as follows:

$$K_p = tan^2\left(45 + \frac{\emptyset}{2}\right) \quad (3)$$

For non-cohesive soils (c=0), passive lateral soil pressure can write as follows:

$$\sigma_p = \sigma_v K_p \quad (4)$$

Thus, resultant passive press force that works on the wall up to the depth of Z=H is only donate by the weight of the soil itself, namely:

$$P_p = \frac{1}{2}\gamma H^2 K_p \quad (5)$$

According to [8], the review of the external stability of the retaining wall is:

1. Stability against overturning

$$FS\ Overturning = \frac{Resisting\ moment}{Overturning\ moment} \geq 2.0 \quad (6)$$

2. Stability against sliding

$$FS\ Sliding = \frac{Resisting\ force}{Driving\ force} \geq 1.5 \quad (7)$$

3. Stability of ground carrying capacity

$$FS\ Bearing\ Capacity = \frac{Q_u}{Q} \geq\ 3.0 \quad (8)$$

The dimensions of the retaining wall must make so that there is no tensile tension on the wall's body. Therefore, at each point on the piece, the voltages that occur on the wall are calculated. Here's a review of the visible body of the ground retaining wall or the internal stability of the ground retaining wall:
a. The voltage of the pressure on the wall body, as in the Equation below:

$$\sigma = \frac{V}{B}\left(1 + \frac{6e}{B}\right) \leq Stronger\ for\ permission \quad (9)$$

According to [10]:

$$\sigma_{ijin} \leq 0.33\sqrt{\sigma'_{bk}} \quad (10)$$

b. Pull voltage on the wall, as shown in the Equation below:

$$\sigma = \frac{V}{B}\left(1 - \frac{6e}{B}\right) \geq 0\ bila\ e\ \leq \frac{B}{6} \quad (11)$$

$$\sigma = \frac{2V}{3(B-2e)}\ bila\ e \geq \frac{B}{6} \quad (12)$$

According to [10]:

$$\sigma_{ijin} \leq 0.36\sqrt{\sigma'_{bk}} \quad (113)$$

c. The shear voltage on the wall body, as in the following equations:

$$\tau = \frac{H}{B} \leq kuat\ geser\ ijin \quad (14)$$

According to [10]:

$$\tau_{ijin} \leq 0.43\sqrt{\sigma'_{bk}} \quad (125)$$

Description:

V, H	: Vertical and horizontal style components
B	: The width of the structure was reviewed.
e	: Eccentricity
W	: Heavy own ground retaining wall

IOP Conf. Series: Earth and Environmental Science **708** (2021) 012020 doi:10.1088/1755-1315/708/1/012020

σ'_{bk} : Strong press mortar

4. Methodology

1. Literature review
   The literature review contains discussions related to previous theories and research used as guidelines for preparing research frameworks. Review literature is use so that research can be scientifically accounted for.
2. Determination of land properties
   The soil used in the analysis is a type of sandy soil.
3. Determine the dimensions of the ground retaining wall and then conduct a stability test until it gets the retaining wall's dimensions that meet the safety requirements.
4. External stability
   External stability requirements use the required conditions [9].
5. Internal stability
   The requirements of permitted voltage, the pull voltage of the permit, and the shear voltage of the permit use the requirements of [10]

5. Result And discussion

The followings are the parameter data of soil embankment reinforced by retaining wall:

1. Unit weight (γ) : 1.45 ton/m^3
2. Cohession (c) : 0
3. Friction angle ($\emptyset$) : 29.31°
   Specifications and data on the planning of land retaining walls are as follows:
   1. The original soil and landfill behind the retaining wall of the soil is the land of the fitting.
   2. The dimensions of gravity soil retaining wall used are the criteria of Indonesian National Standard 8460:2017 on geotechnical design requirements.
   3. The stability analysis considered only static loads, for the influence of earthquake loads is excluding.
   4. Variations in slope height were analyzed at altitudes of 4 meters to 14 meters.
   5. DPT yang digunakan Type Gravity Wall
   6. DPT made of pair of stone times
   7. Weight of stone volume γbatukali : 2.2 tons/m3
   8. Load divided evenly (q) : 1.2 tons /m2
   9. Mortar press strength : 50 kg/cm2

5.1 Stability of gravity wall

5.1.1 External stability The safety factor value of the retaining wall's external stability from a height of 4 meters to 14 meters is obtained as in Table 1.

Table 1. External stability wall gravity

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
Fs Overturning	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
Fs sliding	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
Fs Bearing Capacity	33.3	33.8	33.6	33.9	33.6	33.1	33.9	33.3	34.2	34.8	31.8
	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

5.1.2 Internal stability Internal stability requirements in the form of the voltage, tensile voltage, and shear voltage required in PBI 1971 are requirements at the time of DPT strength condition 100% of the plan strength, i.e. DPT power on the 28th day. However, the conditions of implementation in the field on the 3rd day have carried out hoarding, which means the new DPT power reaches 40% of the power of the plan, so the allowed permit voltage is as follows:
License voltage: (165 tons/m2)*40% = 66 tons/m2
Pull Voltage clearance: (25 tons/m2)*40% = 10 tons/m2
Shear voltage clearance: (30 tons/m2)*40% = 12 tons/m2
Description:

This means that if the Ground Retaining Wall designed exceeds the permitted voltage, then the Ground Retaining Wall cracks or deformation occurs on the retaining wall.

5.1.2.1 Calculation of internal stability when active lateral earth pressure Internal stability calculations on the Ground Retaining Wall are performed on cross section A-A', B-B' and O-O' Where cross section A-A', B-B' and O-O' are as shown in Figure 2:

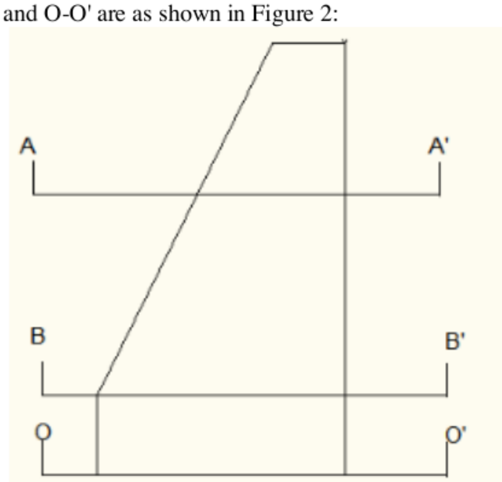

Figure 2. Cross section A-A', B-B' and O-O'

Calculation results of internal stability in cross section A-A ', B-B' and O-O 'are shown in Table 2, Table 3 and Table 4.

It can be concluded from the calculation of internal stability when the active soil conditions of A-A ', B-B' and O-O ' cross section at a height of 4 meters to a height of 14 meters still allowable.

Table 2. Internal stability of gravity wall in active lateral earth pressure (cross section A-A')

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
σ Desak (ton/m2)	1.4	1.6	1.9	2.2	2.5	2.8	3.0	3.3	3.6	3.9	4.1
σ Desak ijin (ton/m2)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
σ Desak< σ Desak ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
σ Tarik (ton/m2)	1.4	1.8	2.1	2.3	2.8	3.3	3.5	4.0	3.9	4.1	6.4
σ Tarik ijin (ton/m2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
σ tarik < σ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
τ geser (ton/m2)	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.6
τ geser ijin (ton/m2)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
τ tarik < τ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

IOP Conf. Series: Earth and Environmental Science **708** (2021) 012020 doi:10.1088/1755-1315/708/1/012020

Table 3. Internal stability of gravity wall in active lateral earth pressure (cross section B-B')

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
Internal Stability	6.1	7.3	8.6	9.9	11.3	12.8	13.8	15.5	16.5	17.5	21.5
σ Compressive allowable (ton/m2)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
σ Compressive < σ Compressive allowable (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
σ Tensile (ton/m2)	2.7	3.5	4.2	4.9	5.7	6.4	7.3	7.9	8.4	9.2	10.1
σ Tensile allowable (ton/m2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
σ Tensile < σ tensile allowable (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
τ shear (ton/m2)	1.8	2.1	2.5	2.9	3.2	3.6	4.0	4.4	4.7	5.1	5.7
τ shear allowable(ton/m2)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
τ tarik < τ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

Table 4. Internal stability of gravity wall in active lateral earth pressure (cross section O-O')

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
σ Desak (ton/m2)	10.5	12.7	15.2	17.5	20.1	22.8	24.8	27.8	29.8	31.9	36.7
σ Desak ijin (ton/m2)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
σ Desak< σ Desak ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
σ Tarik (ton/m2)	0.9	1.4	1.7	1.9	2.2	2.4	2.9	2.8	3.0	3.5	3.6
σ Tarik ijin (ton/m2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
σ tarik < σ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
τ geser (ton/m2)	2.3	2.8	3.3	3.8	4.3	4.8	5.3	5.8	6.3	6.7	7.5
τ geser ijin (ton/m2)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
τ tarik < τ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

Calculation of internal stability when lateral earth pressure at rest Results calculation of internal stability in lateral earth pressure at rest at cross-section A-A ', B-B' and O-O '. Calculation of internal stability can be seen in Table 5**,** Table 6, and Table 7**.**

Table 5. Internal stability of gravity wall in lateral earth pressure at rest (cross section A-A')

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
σ Desak (ton/m2)	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.2	3.6	3.9	4.3
σ Desak ijin (ton/m2)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
σ Desak< σ Desak ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
σ Tarik (ton/m2)	1.8	2.1	2.4	2.6	2.7	3.5	3.6	3.7	3.9	4.0	4.1
σ Tarik ijin (ton/m2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
σ tarik < σ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
τ geser (ton/m2)	0.4	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8
τ geser ijin (ton/m2)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
τ tarik < τ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

Table 6. Internal stability of gravity wall in lateral earth pressure at rest (cross section B-B')

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
σ Desak (ton/m2)	5.3	6.8	8.6	10.4	12.2	14.4	15.9	17.8	19.3	21.3	22.9
σ Desak ijin (ton/m2)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
σ Desak< σ Desak ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
σ Tarik (ton/m2)	3.5	3.9	4.2	4.3	4.4	4.9	5.2	5.3	5.6	5.7	5.8
σ Tarik ijin (ton/m2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
σ tarik < σ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
τ geser (ton/m2)	1.8	2.3	2.8	3.3	3.9	4.5	5.0	5.5	6.0	6.6	7.1
τ geser ijin (ton/m2)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
τ tarik < τ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

Table 7. Internal stability of gravity wall in lateral earth pressure at rest (cross section O-O')

DESAIN CASE	WALL HEIGHT (m)										
	4	5	6	7	8	9	10	11	12	13	14
σ Desak (ton/m2)	9.8	12.6	15.9	19.0	22.4	26.2	29.0	32.4	35.3	38.8	41.7
σ Desak ijin (ton/m2)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
σ Desak< σ Desak ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE
σ Tarik (ton/m2)	1.6	1.4	0.9	0.3	11.2	13.1	14.5	16.3	17.7	19.6	21.1
σ Tarik ijin (ton/m2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
σ tarik < σ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	NOTOKE	NOTOKE	NOTOKE	NOTOKE	NOTOKE	NOTOKE	NOTOKE
τ geser (ton/m2)	2.5	3.2	3.9	4.6	5.4	6.2	6.9	7.6	8.3	9.1	9.8
τ geser ijin (ton/m2)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
τ tarik < τ tarik ijin (ton/m2)	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE	OKE

The internal stability calculation above shows the voltage of the strain, tensile voltage, and shear voltage from a height of 4 meters to a height of 14 meters still meet the requirements. While in Table 7, pieces O-O' voltage and shear voltage meets the requirements from a height of 4 meters to a height of 14 m, but tensile voltage at an altitude of 8 meters no longer meets the requirements.

6. Conclusion

From external stability analysis, it can note that the gravity retaining wall meets safety requirements up to a height of 14 meters. Meanwhile, the internal stability analysis of gravity retaining walls at the height of 8 meters no longer meets the safety requirements. It can infer the optimal height of the gravity-type ground retaining wall with stone material times is 7 meters. For height above 7 meters, it is recommended to use another type of soil retaining wall.

References

[1] Binici, Hanifi 2010 *Retaining wall failure due to poor construction and design aspect a case study Electronic Journal of Construction Technologies* **6** no. 1 pp. 46-61

[2] Sinarta, I Nengah and I Wayan Ariyana Basoka 2019 *Collapse of soil retaining wall and slope mitigation in Bantas Village, Songan B Village, Kintamani District, Journal of Infrastructure & Facilities Asset Management* **3** no. 1 pp. 2615-1839

[3] Indrawati, Nita 2018 Road maintenance project restraint dam in Sawahlunto collapsed https://padangmedia.com/dam-penahan-proyek-pemeliharaan-jalan-di-sawahlunto-ambruk/

[4] Solehuddin, Dedek, et al., 2018 Land retaining wall planning (Case Study: Jalan Lingkar Barat Duri) (Bengkalis: SNIT)

[5] Agustian, Irpan, et al., 2018 Study comparison of kantiliver type retaining wall With gravity type on avalanche handling planning sanga-sanga road – dondang sta.4+000 Kutai kartanegara, (Samarinda: Civil Engineering Engineering Faculty 17 Agustus 1945 University)

[6] Sebastian , juan, et al., 2019 *Effectiveness of land retaining wall on project in Bogor Civil Engineering Journal Mitra* **2** no. 4 pp. 203-210

[7] Hakam, Abdul 2010 Slope stability and ground retaining Wall (Padang : Andalas University Press)

[8] National Standardization Agency 2017 SNI 8460:2017 Geotechnical design requirements, (Jakarta : National Standardization Agency)

[9] Das, Braja M 2014 Principles of foundation engineering (United States of America: Global Engineering)

[10] Foundation building matter investigation agency 1971 *Indonesian Reinforced Concrete Regulation 1971* (Directorate of Building Problems Investigation)

Optimum height of the retaining gravity wall

ORIGINALITY REPORT

8%	9%	6%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Program Pascasarjana Universitas Negeri Yogyakarta Student Paper	5%
2	www.astron.pref.gunma.jp Internet Source	4%

Exclude quotes	On	Exclude matches	< 3%
Exclude bibliography	On		