Efforts to Repair Groundsill Bantar River Progo Special Region of Yogyakarta Indonesia

Yoseph Susanto[1] Edy Sriyono[1,*] Ilham Purnomo[1] Tania Bhakty[1]

[1]*Civil Engineering Master's Program, Janabadra University Yogyakarta 55231, Indonesia*
[*]*Corresponding author. Email: edysriyono@janabadra.ac.id*
E-mail: ywidi.royo@gmail.com, ilham.purnomo@janabadra.ac.id, tania@janabadra.ac.id

ABSTRACT

Mount Merapi is one of the most active volcanoes in the world and produces large sediments when it erupts. The Progo River is included in the Mount Merapi area, so this river will be affected by material from the eruption and has the potential to significantly change the morphology of the Progo River. Bantar groundsill as a sediment control building on the Bantar Bridge is currently experiencing up to 92% damage in the riverbed area since its initial construction in 2010. This research was conducted based on direct observations using drone photos to determine the damage in the river bed area in 2018 and 2019 later. An inventory of the existing conditions in 2018 and 2019 was carried out which was then compared with the initial conditions of development accompanied by supporting data in the form of Observation of damage patterns in the river bed area; Bantar groundsill maps and Technical Planning. Efforts to improve the ground sill based on the results of this study are Replacement of concrete blocks installed on the damaged parts with the layout as during the initial construction. The subgrade is replaced with K-125 concrete so that there is no scour in the river bed area; The new concrete block uses concrete weighing 3.4 tons of K-175 quality and is connected by reinforcement; In addition, all the existing concrete blocks were moved downstream of the groundsill so that the sand miners could not approach the area downstream of the groundsill.

Keywords: *Local scouring, Concrete block, Riverbed area, Groundsill.*

1. INTRODUCTION

Mount Merapi is one of the most active volcanoes in the world. It produces large sediments when it erupts. Twenty-six (26%) of the Progo River watershed is included in the Mount Merapi area, so this river will be affected by material from its eruption and has the potential to significantly change the morphology of the Progo River, further disasters such as flooding and sedimentation have the potential to occur. The Progo River flows in the Province of Central Java and the Province of the Special Region of Yogyakarta. The Progo River has a watershed area of 2,300 km^2, and a total length of about 140 km. Mount Sindoro and Sumbing are the western boundaries and Mount Merbabu and Merapi are the eastern boundaries of the Progo watershed.

At the section of the Progo River in Bantar, there are state assets that cross the river, namely the Bantar Bridge (state road), Pertamina Pipeline Bridge for oil supply between Central Java - East Java, Surabaya - Jakarta Railway Bridge, and Special Region of Yogyakarta Provincial Road - Central Java. To protect state assets from scouring water carrying sedimentary material from the eruption of Mount Merapi, in 2008 – 2010 the Bantar Groundsill was built which is downstream from the above state asset building. On the way, due to illegal sand mining activities downstream of the groundsill, local scouring occurred in the riverbed area which greatly affected the performance of the groundsill.

This study aims to make efforts to improve the groundsill in the riverbed area, make improvements to the subgrade in the riverbed area, recalculate the ideal weight of concrete blocks as water energy absorbers in the river bed area, and make efforts to protect the downstream groundsill area against illegal sand mining activities.

2. BACKGROUND

Groundsill is a building built across a river that aims to reduce the speed of the current and increase the rate of sediment deposition in the upstream part of the groundsill. This is intended to secure the foundation of bridges or buildings that are upstream of the groundsill, so that building structures in the upper reaches of the river such as bridges or other water structures are safe against erosion [1]. Without a ground sill, the riverbed will experience degradation which will endanger the strength of the foundation and pillars as a support for the bridge above it [2].

Mining of river sand can also cause a decrease in the river bed which results in damage to public infrastructure. One of the efforts made to control river bed subsidence is the construction of groundsills [3].

Groundsill damage is caused by the inability of the groundsill to withstand the hydrodynamic force of the water flow. In addition to the groundsill body structure which appears to be only a pair of river stones, the absence of a downstream floor has caused the groundsill to have no protection against scouring the river bed downstream [4].

The Bantar groundsill is a river cross-threshold structure as a sediment retaining structure that serves to reduce the flow rate of heavy river water so that there is no scour around the pillars of the Bantar bridge. Groundsill in Bantar village is expected to protect the Bantar Bridge (state road), Pertamina Pipeline Bridge for oil supply between Central Java-East Java Provinces, Surabaya-Jakarta Railway Bridge, and Special Region of Yogyakarta-Central Java Provincial Road. The groundsill building is very important, so the groundsill structure must be strong and safe [5].

In another case, it is stated that the ends of the groundsill in the fractured part are structures that are prone to damage; Therefore, it is necessary to immediately protect it. Protection can be done by placing gabions or installing sheet piles around the ends of the groundsill faults to reduce river bed erosion which can exacerbate damage in this area [6].

Guideline for Structural Design of *Groundsill*, Japan Institute of Country-ology and Engineering, 1998 as follows [7]:

$$\frac{R}{F} > 1.0 \tag{1}$$

$$F = C_D r_w e S \frac{V^2}{2g} \tag{2}$$

$$R = uW_b \tag{3}$$

$$W_b = \left(1 - \frac{r_w}{r_c}\right) W \tag{4}$$

with: F = dynamic water pressure (ton), R = friction (ton), W_b =: weight of concrete block in water (ton), W = weight of concrete block (ton), C_D = water pressure coefficient (1.00), τ_w = density of water (1.00 ton/m^3), r_c = density of concrete (2.30 ton/m^3), e = concrete block cover level (connected: 0.35∼0.40), S = concrete block projection area (Figure 5, m^2), V = velocity (6.217 m/s, see Table 1), g = gravitational acceleration (9.81 m/sec^2), and u = coefficient of friction (0.60).

Modification of river bed protection construction with gabions, masonry, or concrete must always refer to the size of the stone. For this type of beehive concrete block, the empirical formula is used as follows:

$$F_D = C_D \rho_w \varepsilon S \frac{u^2}{2g} \tag{5}$$

$$R = \mu\left(1 - \frac{\rho_o}{\rho_s}\right) W \tag{6}$$

with: F_D = weight of beehive in sabo dam (kN), C_D = drag coefficient, ρ_w = density of water (ton/m^3), ε = group coefficient, taken = 1 (for single beehive), S = concrete block surface area, taken S_A = 0,3534 L2 or Sn = 0,3789 L^2 depend on concrete block potition, u = average velocity (m/det), g = gravitational acceleration (m/det^2), R = drag force (kN), μ = coefficient of friction (taken 0,5), ρ_s = granular mass density (ton/m^3), and W = weight of concrete block (ton).

Table 1. Required length of riverbed protection

Q (m^3/s)	h_3(m)	Riverbed Protection Length	V_3(m)	Note
200	2.952	8.856~14.760	1.683	h3 - D<hc
400	3.530	10.590~17.650	2.531	h3 - D<hc
600	4.110	12.330~20.550	2.970	h3 - D<hc
800	4.637	13.911~23.185	3.245	h3 - D<hc
1,000	4.930	14.790~24.650	3.751	h3 - D<hc
1,200	5.196	15.588~25.980	4.245	h3 - D<hc
1,400	5.441	16.323~27.205	4.813	h3 - D<hc
1,600	5.716	17.148~28.580	5.368	h3 - D<hc
1,800	5.960	17.880~29.800	5.569	h3 - D<hc
2,000	6.196	18.588~30.980	5.753	h3 - D<hc
2,200	6.427	19.281~32.135	5.925	h3 - D<hc
2,400	6.653	19.959~33.265	6.085	h3 -

				D<hc
2,651	6.932	20.796~34.660	6.217	h3 - D<hc

3. RESEARCH METHODS

3.1. Bantar groundsill location

Progo river is a river that flows through Central Java and the Special Region of Yogyakarta in Indonesia. In the Special Region of Yogyakarta, this river is the natural boundary of the Kulonprogo Regency with Sleman and Bantul Regencies. The Progo River originates from the slopes of Mount Sindoro-Mount Sumbing which passes to the southeast and then to the south along 140 km

Bantar groundsill is located in Bantar village, Sentolo sub-district, Kulon Progo district, Special Region of Yogyakarta, Indonesia as shown in Figure 1.

Figure 1 Bantar groundsill location map.

3.2. Observation of groundsill damage in the field

Observations of groundsill damage are carried out directly in the field. To determine the development of groundsill damage from year to year, photo data from drone recordings that existed before this research was carried out were also used.

By using drone photos, groundsill damage can also be observed and known. Photos of groundsill damage from drone recordings in 2018 as much as 74% can be seen in Figure 2 [8] and groundsill damage from drone recordings in 2019 as much as 92% can be seen in Figure 3 [9].

Figure 2 Groundsill damage in 2018 (74%).

Figure 3 Groundsill damage in 2019 (92%).

3.3. Groundsill damaged inventory

Based on the results of direct observations in the field and photos of groundsill damage recorded by drones from the previous year, groundsill damage can be inventoried, both for the type of damage, damaged construction, the position of the damage, and the volume of damaged construction.

All groundsill damage data is recorded and collected and will be used to determine the type and method of repairing the groundsill.

3.4. Revisiting groundsill planning

The 2008 groundsill planning data will be used as an initial guideline for repairing the groundsill damage. Figure 4 below shows the Bantar groundsill site plan.

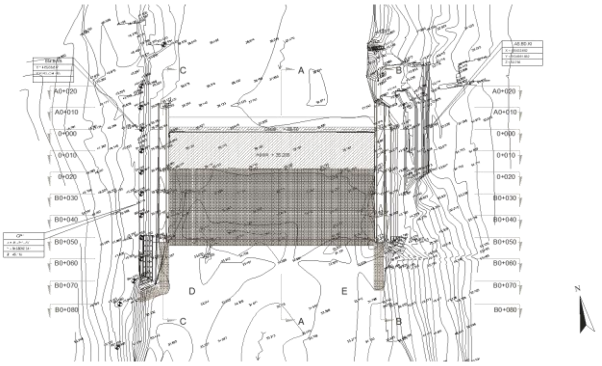

Figure 4 Site plan of Bantar groundsill.

3.5. Establish groundsill repair construction

By studying the initial planning of the Bantar groundsill and based on the results of the groundsill damage inventory, it can be determined that the construction of the groundsill repair can consist of:

1. Repair groundsill subgrade
   The subgrade needs to be repaired because it will be the foundation of the groundsill concrete block.
2. Analysis of groundsill concrete blocks
   The stability of the concrete block against dynamic water pressure will be checked using empirical formulas (1) to (5).
3. Arrangement of the groundsill downstream area
   Former old concrete blocks can be placed downstream of the groundsill in such a way as to prevent sand miners from approaching the groundsill area.

4. RESULTS AND DISCUSSION

4.1. River bed Area Concrete Block Weight Analysis

Based on the calculation method described in Chapter 3, the stability of the concrete block is verified as follows:

S = (1.4 x 0.7) + ((0.5 + 0.7) x 0.3 / 2) = 1.16 (m^2)

$F = C_D r_w eS\dfrac{V^2}{2g}$ = 1.00 x 1.00 x 0.40 x 1.16 x (6.217^2) / (2 x 9.81) = 0.914 (ton)

W = {concrete block volume} x r_c = ((1.40^2 - 0.12^2) x 0.7 + (0.70^2 + 0.50^2) x 0.3 / 2) x 2.30 = 3.387 (ton)

$W_b = \left(1 - \dfrac{r_w}{r_c}\right)W$ = (1 - 1.00 / 2.30) x 3.387 = 1.914 (ton)

$R = uW_b$ = 0.60 x 1.914 = 1.148 (ton)

$\dfrac{R}{F}$ = 1.148 / 0.914 = 1.26 > 1.0 --- OK (Stable)

The dimensions of the concrete block can be seen in Figure 5.

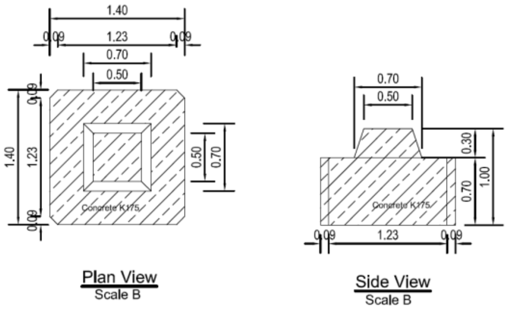

Figure 5 Concrete block dimensions.

4.2. Concrete block casting

Concrete blocks are cast in the groundsill area for easy mobilization. The total number of concrete blocks is 1,650 pieces. The concrete block casting location can be seen in Figure 6.

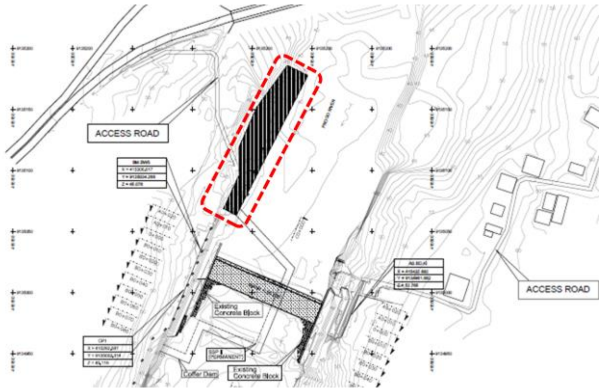

Figure 6 Concrete Block Casting Location.

4.3. Existing Concrete Block Removal

Along with the concrete block molding process, the existing concrete blocks began to be moved according to the specified area. The location for the removal of the existing concrete block can be seen in Figure 7.

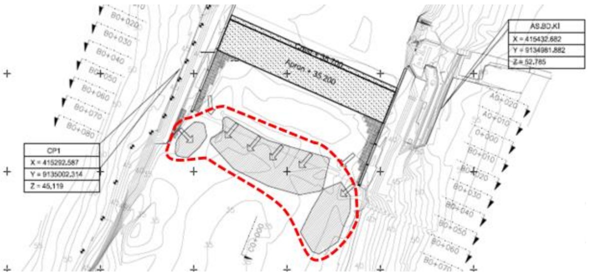

Figure 7 Existing Concrete Block Removal Location

4.4. Groundsill Subgrade Improvement

The subgrade of the river bed area which was originally sand is replaced with K-125 concrete and the lock is in the form of steel sheet piles so that they are no longer eroded by the flow of the Progo River. K-125 concrete application can be seen in Figure 8.

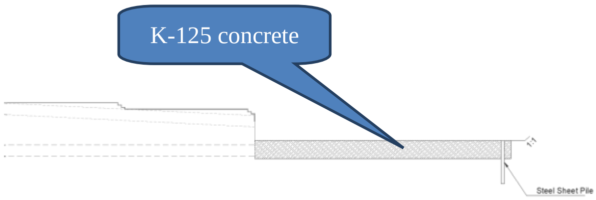

Figure 8 K-125 Concrete Application

4.5. Cofferdam installation

A cofferdam is a building that functions to drain river water from upstream to downstream so as not to interfere with the implementation of groundsill construction. The installation of the cofferdam can be seen in Figure 9.

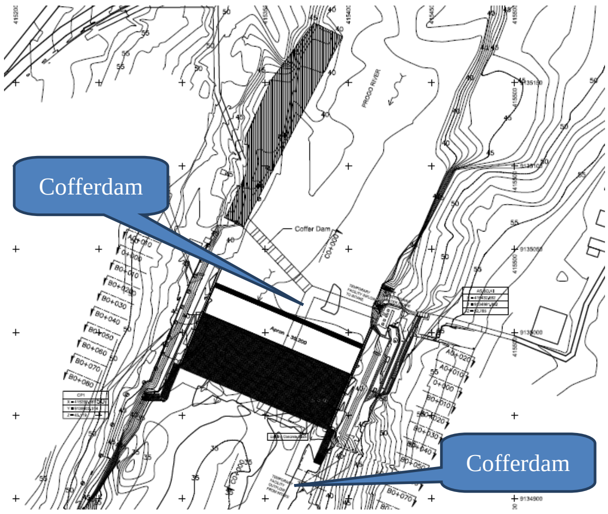

Figure 9 Cofferdam installation.

4.6. Installation of new concrete blocks

Installation of new concrete blocks according to the initial layout. The layout of the new concrete block can be seen in Figure 10.

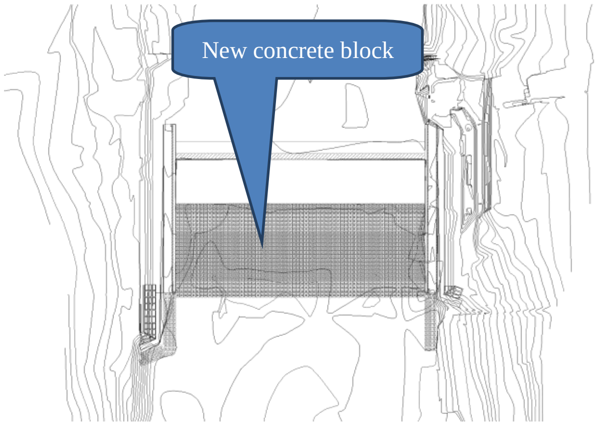

Figure 10 Layout concrete blocks.

4.7. Groundsill Downstream Arrangement

The location of the sand miners is determined based on the Decree of the Director-General of Irrigation No. 176/KPTS/A/1987 concerning Instructions for the Implementation of Provisions for River Protection concerning the Mining of Group C Minerals as follows:

Mining location located upstream of the river building, at least 500 m from the building concerned.

The mining location is located downstream of the river building, at least 1,000 m from the building in question.

The exact distance of the mining position to a river building is determined based on research and calculations, both upstream and downstream or sideways in the transverse direction of the river.

5. CONCLUSION

1. New concrete blocks are installed on the damaged parts with the layout as at the time of construction.
2. The existing subgrade is replaced with K-125 concrete so that it does not scour in the riverbed area.
3. Concrete blocks using concrete weighing 3.4 tons and made of reinforced concrete K-175. Each concrete block is connected by reinforcement.
4. All existing concrete blocks must be moved downstream of the groundsill in such a way that sand miners cannot approach the area downstream of the groundsill.

AUTHORS' CONTRIBUTIONS

Yoseph Widi Anjas Susanto contributed to the survey and inventory of groundsill problems, secondary data collection, data analysis, and preparation of research results and reports.

Edy Sriyono contributed to data analysis, discussion of research results, and preparation of international seminar papers.

Ilham Purnomo contributed to assisting the preparation of research reports as a whole.

Tania Edna Bhakty contributed to providing input to the overall research report.

ACKNOWLEDGMENTS

We would like to thank the Dean of the Faculty of Engineering and the Chancellor of the University of Janabadra Yogyakarta for their financial support in the research and publication of international seminars.

REFERENCES

[1] Peliang, A. Marbawie., S. Mawardi., U. Zahrul, 2016, Tinjauan Ulang Perencanaan Pembangunan Groundsill Sungai B atang Agam Kota Payakumbuh, 2016, https://www.ejurnal.bunghatta.oc.id/-Vol.1, No.1.

[2] Istiarto, 2008. *Groundsill* Pengaman Jembatan Kretek Yogyakarta.

[3] Susilo Budi dkk, 2017. Efektifitas *Groundsill* Terhadap Penyebaran Sedimen Sungai Grindulu Kabupaten Pacitan.

[4] Istiarto, 2011. Jembatan Kebonagung, Sleman, Yogyakarta.

[5] Sarsin, 2012. Kontrol Stabilitas *Groundsill*bantardi Kali Progo Kabupaten Bantul.

[6] Istiarto, Desain Teknis Rehabilitasi Groundsill Kretek di Sungai Opak, 2007.

[7] Guideline for Structural Design of *Groundsill*, Japan Institute of Country-ology and Engineering Halaman 70-74, 1998.

[8] Santoso, D.H., Gomareuzzaman, M., 2018, Kelayakan Teknis Penambangan Pasir Pada Wilayah Pertambangan Rakyat di Sungai Progo, Kabupaten Kulon Progo, Jurnal Geografi Vol. 15 NO. 2.DOI ://doi.org/10.15294/jg.v15i2.15454.

[9] Ikhsan, J., Wardhana, C., and Widiyarto, D.K., 2019, Sediment Characteristics of Bed Load Transport in Downstream of Progo River, Indonesia, First International Conference of Construction, Infrastructure, and Materials, IOP Conf. Series: Materials Science and Engineering 650 012062, IOP Publishing, doi:10.1088/1757-899X/650/1/012062.

[10] Keputusan Direktur Jenderal Pengairan Nomor 176/KPTS/A/1987 tentang Petunjuk Pelaksanaan Ketentuan Pengamanan Sungai dalam Hubungan dengan Penambangan Bahan Galian Golongan C.