



# Site Maturation Report for Retaining Wall Planning at Pura Luhur Pucak Les, Angseri Traditional Village, Tabanan, Bali

Ni Made Sintya Rani<sup>1</sup><sup>\*</sup>, I Made Wahyu Pramana<sup>1</sup>, I Gusti Wulan Krisna Dewi<sup>1</sup>,  
Anak Agung Ayu Asta Oktaviani Putri<sup>1</sup>, I Nyoman Ardika<sup>1</sup>, and  
Kadek Adi Parthama<sup>1</sup>

<sup>1</sup> Civil Engineering Department, Politeknik Negeri Bali, Bali, Indonesia  
sintyarani@pnb.ac.id

**Abstract.** Pura Luhur Pucak Les, a sacred temple located in the hilly terrain of Angseri Traditional Village, Baturiti District, Tabanan Regency, Bali, faces significant landslide vulnerability due to high rainfall intensity and the absence of adequate retaining structures along the riverbank. This paper presents a comprehensive site maturation and retaining wall design to mitigate these risks. Topographic mapping and cut-and-fill analyses were conducted to establish grading elevations. A geotechnical investigation characterized the local soil, yielding a unit weight ( $\gamma$ ) of 17.5 kN/m<sup>3</sup>, cohesion ( $c$ ) of 15 kPa, and an internal friction angle ( $\phi$ ) of 28°. Hydrological analysis based on a 50-year design storm return period necessitated the design of a reinforced concrete cantilever retaining wall equipped with a granular backfill drainage layer and PVC weep holes. Stability analyses using Bishop's simplified method demonstrated an improvement in the global slope safety factor from 1.12 (critical) to 1.65 (safe) post-installation. Furthermore, the structural design satisfies the factors of safety against sliding ( $FS > 1.5$ ), overturning ( $FS > 1.5$ ), and bearing capacity failure ( $FS > 3.0$ ). A detailed Budget Plan (RAB) based on regional unit prices totals IDR 752,013,000. The proposed engineering intervention ensures structural integrity, adequate drainage, and sustainable disaster mitigation for the temple complex.

**Keywords:** Cantilever Retaining Wall, Cut and Fill, Landslide Mitigation, Site Maturation, Slope Stability

## 1 Introduction

Kabupaten Tabanan is located in the southwestern part of Bali Island, Indonesia, with varied topography ranging from lowlands in the southern coast to mountainous regions in the north, with Mount Batukaru as the highest peak reaching 2,276 meters above sea level (Bali, 2024). Angseri Village, including Angseri Traditional Village, is administratively located in Baturiti District, Tabanan Regency, Bali. This village is renowned for its abundant natural potential, including natural hot springs that serve as tourist attractions, as well as fertile agricultural and plantation areas (Tabanan, 2024). Pura Luhur Pucak Les is one of the temples that serves as the center of religious activity for the community. Located in a hilly area at an elevation of approximately 700 - 900

meters above sea level, the temple offers beautiful natural panoramas and high spiritual value. Pura Luhur Pucak Les is a sacred place respected by the local community and frequently used for various religious ceremonies, including worship and prayer rituals (Angseri et al., 2018). To date, the area around the temple has not been optimally managed, which poses a potential danger to the safety of the community conducting religious activities at the temple. Access to the temple, which passes near the cliff area, is also threatened if the landslide expands. This condition shown in Figure 1 is exacerbated by the absence of adequate retaining wall structures along the riverbank.



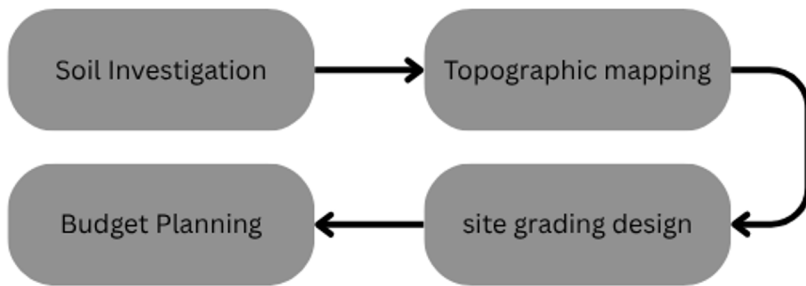
**Figure 1.** Existing Condition of Pura Luhur Pucak Les

Retaining walls function to hold soil and prevent it from landslide hazards. A retaining wall is a wall used to withstand vertical soil loads or against certain slopes (Maitimu et al., 2025). To prevent future disasters, improvement or restoration of public facilities is required, including footpaths, construction of retaining walls, and continuous foundation walls for temple retaining walls. To support mitigation and protection of the river/spring area, the next stage requires riverbank reinforcement and river normalization (Rani et al., 2023). Site maturation, or land preparation, is a critical preliminary phase before retaining wall construction can commence (Rani et al., 2025). This process involves site clearing, grading through cut-and-fill operations to achieve the desired elevation, and soil compaction to create a stable foundation platform (Pramana et al., 2025). Proper site maturation ensures that the subsequent retaining wall construction has a level and stable base, adequate drainage, and minimal risk of differential settlement. The cut-and-fill method balances earthwork volumes by excavating soil from higher areas (cut) and using it to fill lower areas (fill), optimizing material usage and reducing the need for imported fill materials (Roihan, 2025). The planning of site maturation at Pura Luhur Pucak Les is essential for several reasons. First, the existing topography features significant elevation differences that require grading to create functional areas for temple activities and access paths. Second, proper site grading enables effective surface water drainage, reducing water infiltration that

could destabilize slopes. Third, the site maturation plan provides the necessary platform for retaining wall construction, ensuring the walls are built on prepared, stable ground. Fourth, the cut-and-fill analysis determines the volume of earthwork required, which directly impacts the project cost and construction methodology.

## 2 Methodology

The methodology for this site maturation planning follows a systematic approach comprising soil investigation, hydrological analysis, topographic mapping, site grading design, structural calculation, and budget planning (Figure 2).



**Figure 2.** Methodological Framework for Site Maturation Planning

Soil investigation is a critical component of retaining wall planning, as the stability of the structure depends heavily on the geotechnical properties of the underlying soil (Afasedanja & Patandean, 2020). The soil investigation program was designed to evaluate site stability, settlement potential, and drainage requirements before designing the retaining wall (Wahyudi et al., 2023). Topographic mapping was conducted to obtain accurate geometric data of the site as the basis for planning. Next step is Site Grading design, where Site grading design involves determining the finished grade elevations and calculating the earthwork volumes required to achieve those elevations. The Budget Plan (Rencana Anggaran Biaya/RAB) was prepared based on the site maturation design and the retaining wall construction requirements.

### 2.1 Topographic Mapping and Site Grading

Topographic mapping was conducted to obtain accurate geometric data of the site as the basis for planning. Measurements were taken using a Total Station (Sokkia Set-65) tied to the national geodetic datum. Site grading design involves determining the finished grade elevations and calculating the earthwork volumes. The cut-and-fill volume computations were executed using AutoCAD Civil 3D software applying the composite volume method based on 1-meter contour intervals.

## 2.2 Soil Investigation

Soil investigation is a critical component of retaining wall planning, as the stability of the structure depends heavily on the geotechnical properties of the underlying soil. Undisturbed soil samples were extracted at depths of 1.5 m and 3.0 m. Laboratory testing was conducted in accordance with ASTM D3080 for direct shear tests to determine cohesion ( $c$ ) and internal friction angle ( $\phi$ ), and ASTM D2937 for soil unit weight ( $\gamma$ ).

## 2.3 Hydrological Analysis

Rainfall data from the nearest Baturiti weather station over a 15-year period was analyzed using the Gumbel distribution to determine a 50-year return period design storm. The resulting rainfall intensity was used to design the sub-surface drainage system of the retaining wall to prevent hydrostatic pressure buildup.

## 2.4 Slope Stability & Structural Design

Global slope stability was analyzed using limit equilibrium methods (Bishop's Simplified Method) in GeoStudio SLOPE/W, evaluating the Factor of Safety (FS) before and after wall placement. The retaining wall was designed as a reinforced concrete cantilever structure. External stability checks included sliding, overturning, and bearing capacity failures.

## 2.5 Budget Planning

The Budget Plan (Rencana Anggaran Biaya/RAB) was prepared based on the site maturation design and the retaining wall construction requirements. Unit prices were derived from the Tabanan Regency HSPK (Harga Satuan Pokok Kegiatan) 2025 standard.

# 3 Result and Discussion

## 3.1 Result

**Geotechnical and Hydrological Parameters.** Laboratory soil testing revealed the site consists predominantly of silty clay with volcanic ash deposits. The derived geotechnical parameters utilized for the design are:

- Unit weight of soil ( $\gamma$ ): 17.5 kN/m<sup>3</sup>
- Cohesion ( $c$ ): 15 kPa
- Internal friction angle ( $\phi$ ): 28°
- Allowable bearing capacity ( $q_{all}$ ): 120 kPa

Hydrological calculations for a 50-year return period storm indicated a peak daily rainfall of 145 mm/day. To mitigate seepage and hydrostatic pressure, a 300 mm thick granular drainage layer was specified behind the wall stem, connected to 50 mm (2-inch) diameter PVC weep holes spaced at 2.0 m intervals horizontally and vertically.

**Retaining Wall Structure Design and Stability Analysis.** A reinforced concrete cantilever retaining wall was selected to accommodate the required height and soil earth pressures. The site grading plan dictates retaining walls along the riverbank at elevations from +14.435 m to +29.924 m. The representative cross-section for the critical zone requires a wall height ( $H$ ) of 4.5 m.

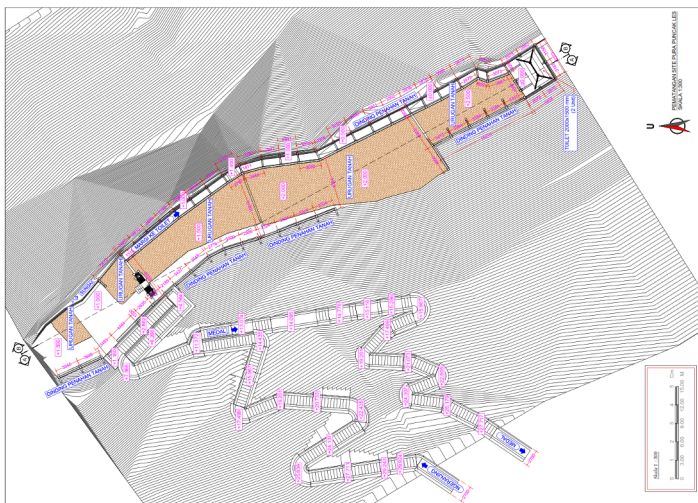
- Wall Dimensions: Base width ( $B$ ) = 2.8 m; Stem thickness at top = 0.3 m; Stem thickness at base = 0.45 m; Base slab thickness = 0.4 m.
- Material: Concrete compressive strength ( $f'_c$ ) = 25 MPa; Steel yield strength ( $f_y$ ) = 400 MPa.

The external stability safety factors were calculated using Rankine's active earth pressure theory:

1. Overturning: Calculated  $FS_{\text{overturning}} = 2.1$  (Requires  $> 1.5$ ) - Safe
2. Sliding: Calculated  $FS_{\text{sliding}} = 1.65$  (Requires  $> 1.5$ ) - Safe
3. Bearing Capacity: Calculated  $FS_{\text{bearing}} = 3.2$  (Requires  $> 3.0$ ) - Safe

**Slope Stability Factor of Safety.** A slip-circle analysis using Bishop's simplified method was conducted. The existing, natural slope under saturated conditions yielded a critical Factor of Safety (FS) of 1.12, indicating a high risk of imminent failure. Following the introduction of the modeled cantilever wall and proper grading, the global slope FS increased to 1.65, numerically demonstrating the effective mitigation of the landslide risk.

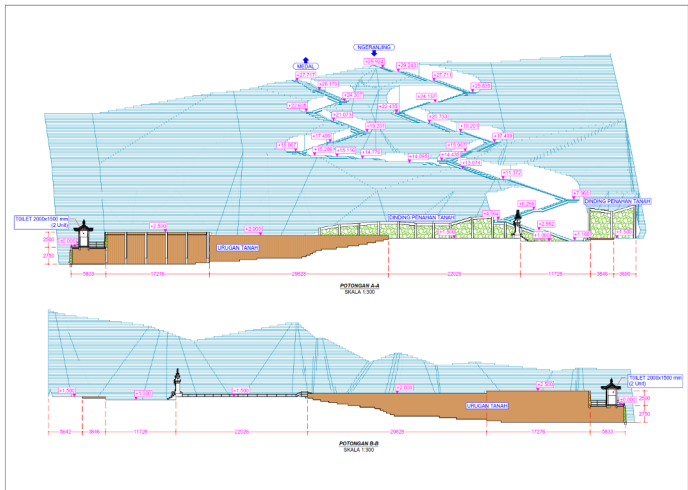
**Site Grading and Earthwork Computation.** The design incorporates cut-and-fill balance with 1,298.31 m<sup>3</sup> of cut and fill each, plus 145.68 m<sup>3</sup> of additional embankment. The soil embankment ranges at elevations from +1.000 m to +2.500 m relative to the local datum.



**Figure 3.** Site Layout Plan

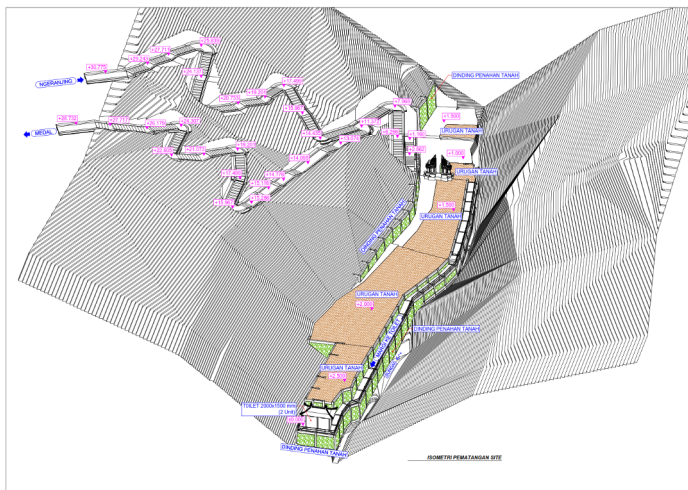
*Site Layout.* The site layout drawing shows the overall arrangement of the site maturation plan at a scale of 1:300 (Figure 3). Key features include Elevation Grading, Soil Embankment Area, Retaining wall locations, access path and toilet facilities.

*Cross-Section.* Two cross-sections (A-A and B-B) were developed to illustrate the vertical profile of the site maturation plan (Figure 4).



**Figure 4.** Cross Section A-A and B-B

*Isometric Views.* The isometric views provide three-dimensional representations of the site maturation plan (Figure 5).



**Figure 5.** Isometric View of Site Maturation Plan

**Budget Plan (RAB) with Unit Rate Transparency.** The budget was meticulously planned using the regional unit price standard. Table 1 provides the condensed breakdown of the project costs, demonstrating that retaining wall construction constitutes the major portion of the budget.

**Table 1.** Condensed Budget Plan Breakdown (HSPK Tabanan)

| No | Work Item                          | Volume   | Unit           | Unit Rate (Rp) | Total Cost (Rp)       |
|----|------------------------------------|----------|----------------|----------------|-----------------------|
| 1  | Earthworks (Cut and Fill)          |          |                |                | <b>119.714.801,09</b> |
|    | - Site Clearing & Excavation       | 1.298,31 | m <sup>3</sup> | 45.500         | 59.073.105,00         |
|    | - Embankment & Compaction          | 1.443,85 | m <sup>3</sup> | 42.000         | 60.641.696,09         |
| 2  | Retaining wall construction        |          |                |                | <b>563.933.675,34</b> |
|    | - Reinforced Concrete (f'c 25 MPa) | 115,4    | m <sup>3</sup> | 4.150.000      | 478.910.000           |
|    | - Granular Backfill & Weep Holes   | 1        | ls             | 85.023.675,34  | 85.023.675,34         |
|    |                                    |          |                | Real Cost      | 683.684.476,43        |
|    |                                    |          |                | PPN 10 %       | 68.364.847,64         |
|    |                                    |          |                | Total          | 752.013.324,07        |
|    |                                    |          |                | Rounded        | 752.013.000,00        |

The total budget for the site maturation and retaining wall project is IDR 752,013,000 (Seven Hundred Fifty-Two Million Thirteen Thousand Rupiah). The cost distribution shows that retaining wall construction (75.0%) constitutes the major portion of the budget, while earthworks (15.9%) and taxes (9.1%) make up the remainder.

### 3.2 Discussion

The site maturation planning for Pura Luhur Pucak Les addresses the critical need for slope stabilization and site preparation before retaining wall construction can proceed. The integration of rigorous soil investigation, topographic mapping, and cut-and-fill analysis provides a comprehensive approach to ensure the structure is built on a stable foundation.

**Comparative Approach.** A reinforced concrete cantilever wall was selected over alternative methods such as gravity walls, gabions, or bioengineering. While bioengineering (e.g., deep-rooted vegetation) offers ecological benefits, it was deemed insufficient as a standalone solution due to the sheer vertical drop and highly saturated soil conditions during peak monsoon seasons. Furthermore, a cantilever wall was chosen over a massive gravity wall because it optimizes material usage—significantly reducing concrete volumes and transport logistics in the difficult hilly terrain—while utilizing the weight of the backfill soil for stability (Das, 2019).

**Limitations and Practical Implications.** A notable limitation of this study is the assumption of static geotechnical parameters. Tropical volcanic soils in Bali often

exhibit seasonal variability; prolonged desiccation in the dry season followed by rapid saturation can induce micro-fissures, slightly altering cohesion ( $c$ ) over time (Terzaghi et al., 1996). Future maintenance must ensure that the weep holes and the drainage layer remain unlogged, as blocked drainage can double the hydrostatic pressure behind the wall, quickly deteriorating the 1.65 safety factor.

Despite these limitations, the site maturation plan effectively serves as the foundation for the subsequent retaining wall construction. The prepared site ensures that retaining wall foundations are placed on stable, compacted soil, proper drainage is established to prevent water accumulation, and access for construction equipment is facilitated.

## 4 Conclusion

This paper has presented the site maturation planning for retaining wall construction at Pura Luhur Pucak Les, Angseri Traditional Village, Tabanan, Bali.

- 1) The site grading plan balances 1,298.31 m<sup>3</sup> of cut and fill each, plus 145.68 m<sup>3</sup> of additional embankment.
- 2) Quantitative geotechnical and hydrological analyses dictated the implementation of a 4.5m-high reinforced concrete cantilever retaining wall with an integrated weeping drainage system.
- 3) Limit equilibrium modeling verified that the proposed intervention increases the global slope Factor of Safety from a critical 1.12 to a stable 1.65. External stability checks for sliding, overturning, and bearing capacity all exceed minimum standard requirements.
- 4) The total project cost is mathematically justified at IDR 752,013,000, comprising earthworks (IDR 119,714,801.09) and retaining wall construction (IDR 563,933,675.34), inclusive of a 10% tax.

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