THE DESIGN OF A CANTILEVER RETAINING WALL FOR A RESIDENTIAL PROJECT UNDER VARYING RETAINED SOIL HEIGHTS

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PROBLEM STATEMENT/RATIONALE/MOTIVATION

Low-rise housing projects in Chonburi Province need retaining walls to handle ground level differences, prevent soil erosion and keep slopes stable. Cantilever retaining walls are often designed with very high safety factors, which wastes material and raises cost, while cutting dimensions too far can make the wall unstable. This study compares cantilever wall designs at different safety levels, checking overturning, sliding and bearing capacity together with cost, to find a safe and economical design guideline for similar sites.

DESIGN OBJECTIVES

- The design of cantilever retaining walls under different soil height levels by evaluating structural stability, including overturning, sliding, and soil bearing capacity.
- Understanding the proper design principles for cantilever retaining walls, taking into account both engineering safety and economic efficiency.

DESIGN SPECS

Success criteria: overturning, sliding and bearing capacity, with each design placed in one of three levels.

- **Minimum Safety Requirements**

Inspection	Factor of Safety (FS)
Overturning Stability	FS ≥ 2.00
Sliding Stability	FS ≥ 1.50
Bearing Capacity	FS ≥ 3.00

- **Design Classification Criteria**

Design type	Overturning (FS)	Sliding (FS)	Bearing Capacity (FS)
Economical Design	2.00 - 4.00	1.50 - 1.70	≥ 3.00
Balanced Design	4.00 - 5.00	1.80 - 2.00	≥ 3.00
Conservative Design	≥ 5.00	≥ 2.00	≥ 3.00

DESIGN CONSTRAINTS

Technical Constraints

- Working Stress Design (WSD) to ACI 318-63
- Retained soil heights: 0.90 m, 1.05 m and 1.40 m
- Unit Strip Method, per 1 m wall length
- f'c = 240 ksc, fy = 4,000 ksc
- Soil (Boring Log BH-01): γ = 17.69 kN/m³, φ = 31°, c = 0 kN/m²
- Groundwater at 0.70 m depth; surcharge 10 kN/m²
- Base width 0.5H to 0.7H, minimum embedment 0.60 m
- Site: Supalai Palm Ville Sukhumvit-Rong Po, Bang Lamung, Chonburi

Non-technical Constraints

- Earthwork cost excluded, since all cases share the same retained heights
- Material prices from the Department of Internal Trade (TPSO), Chonburi Province

BOQ / COST ESTIMATION

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 0.90 m, Economical Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	2,078.80	0.00	2,078.80
2	Reinforcement DB12 / DB16 SD40	1.00	m	2,571.24	0.00	2,571.24
3	Formwork (sawn timber)	1.00	m	2,333.99	0.00	2,333.99
	Total cost per 1 m of wall					**6,984.03**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 0.90 m, Balanced Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	2,448.81	0.00	2,448.81
2	Reinforcement DB12 / DB16 SD40	1.00	m	3,162.29	0.00	3,162.29
3	Formwork (sawn timber)	1.00	m	2,423.18	0.00	2,423.18
	Total cost per 1 m of wall					**8,034.28**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 0.90 m, Conservative Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	2,825.55	0.00	2,825.55
2	Reinforcement DB12 / DB16 SD40	1.00	m	3,703.53	0.00	3,703.53
3	Formwork (sawn timber)	1.00	m	2,747.76	0.00	2,747.76
	Total cost per 1 m of wall					**9,276.84**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 1.05 m, Economical Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	2,253.71	0.00	2,253.71
2	Reinforcement DB12 / DB16 SD40	1.00	m	2,757.60	0.00	2,757.60
3	Formwork (sawn timber)	1.00	m	2,393.45	0.00	2,393.45
	Total cost per 1 m of wall					**7,404.76**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 1.05 m, Balanced Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	2,670.82	0.00	2,670.82
2	Reinforcement DB12 / DB16 SD40	1.00	m	3,411.55	0.00	3,411.55
3	Formwork (sawn timber)	1.00	m	2,747.76	0.00	2,747.76
	Total cost per 1 m of wall					**8,830.13**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 1.05 m, Conservative Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	3,155.20	0.00	3,155.20
2	Reinforcement DB12 / DB16 SD40	1.00	m	4,086.38	0.00	4,086.38
3	Formwork (sawn timber)	1.00	m	2,851.82	0.00	2,851.82
	Total cost per 1 m of wall					**10,093.40**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 1.40 m, Economical Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	2,744.82	0.00	2,744.82
2	Reinforcement DB12 / DB16 SD40	1.00	m	3,390.68	0.00	3,390.68
3	Formwork (sawn timber)	1.00	m	2,807.23	0.00	2,807.23
	Total cost per 1 m of wall					**8,942.73**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 1.40 m, Balanced Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	3,431.03	0.00	3,431.03
2	Reinforcement DB12 / DB16 SD40	1.00	m	4,117.59	0.00	4,117.59
3	Formwork (sawn timber)	1.00	m	3,206.13	0.00	3,206.13
	Total cost per 1 m of wall					**10,754.75**

BILL OF QUANTITIES
Project Cantilever retaining wall, soil height 1.40 m, Conservative Design (per 1 m of wall)

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1	Ready-mix concrete 240 ksc	1.00	m	4,285.42	0.00	4,285.42
2	Reinforcement DB12 / DB16 SD40	1.00	m	5,228.40	0.00	5,228.40
3	Formwork (sawn timber)	1.00	m	3,590.18	0.00	3,590.18
	Total cost per 1 m of wall					**13,104.00**

KEY COURSES USED IN THE PROJECT

- Soil Mechanics: earth pressure
- Foundation Engineering: FS checks
- Structural Analysis: forces per metre
- Reinforced Concrete Design: WSD
- Construction Cost Estimation: cost/m

ENGINEERING STANDARDS

- Rankine Earth Pressure Theory
- ACI 318-63 (Working Stress Design: WSD)
- Building Control Act B.E. 2522
- Ministerial Regulation on Building Foundations and Supporting Soil B.E. 2566

DESIGN APPROACH/METHODOLOGY

1. **Literature Review and Data Collection**
Study Earth Pressure Theory and reinforced concrete design standards (ACI 318-63).

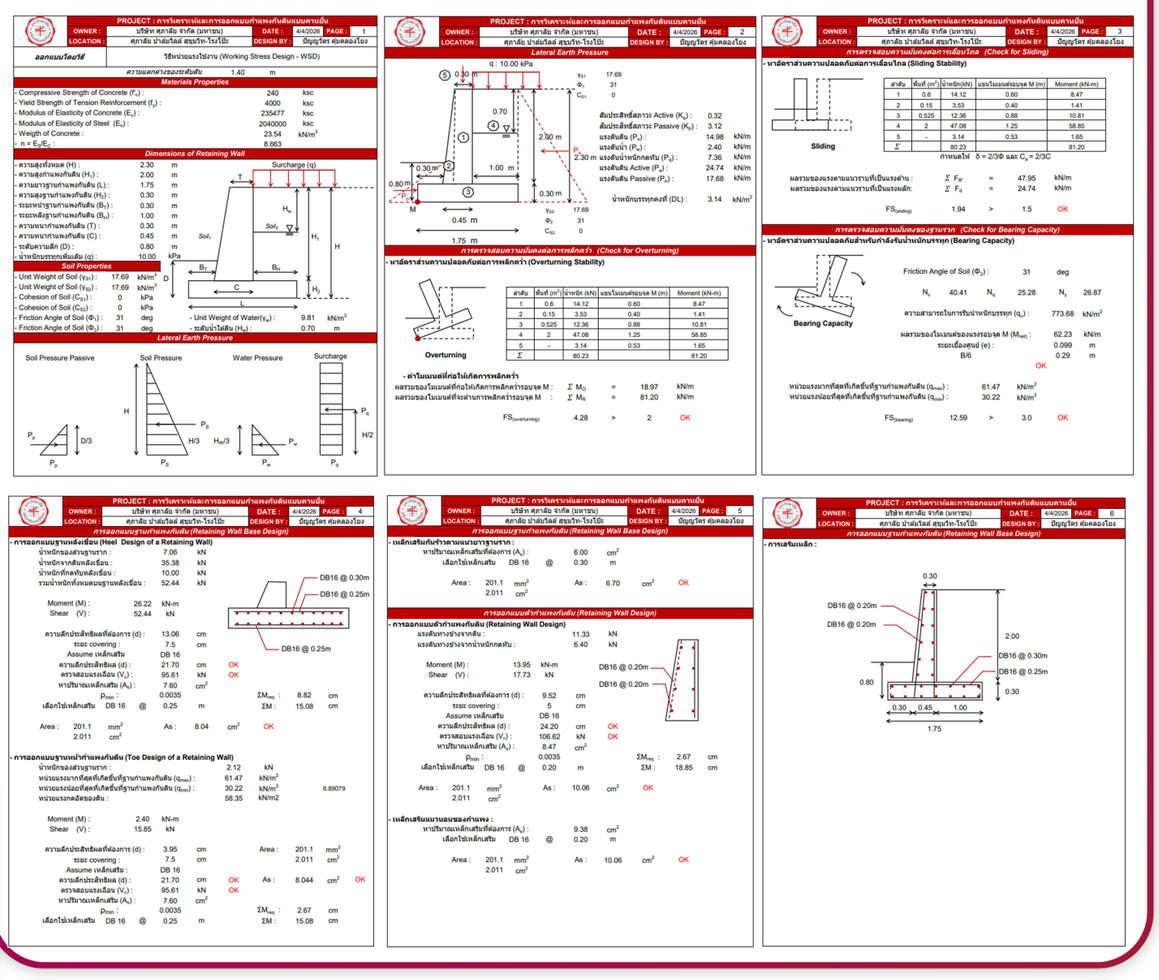
2. **Scope Definition and Case Study**
Define the analysis of a cantilever retaining wall. The soil heights are divided into 3 cases: 0.90 m, 1.05 m, and 1.40 m.

3. **Structural Design and Analysis**
Design the cantilever retaining wall and check structural stability, including overturning, sliding, and bearing capacity.

4. **Comparison and Cost Analysis**
Analyze the Factor of Safety (FS) and compare construction costs for each design case.

5. **Conclusion and Presentation**
Summarize the results in tables and graphs and prepare a report for presentation.

DESIGN DELIVERABLES / RESULTS



CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Cantilever retaining walls for soil heights of 0.90, 1.05 and 1.40 m were designed with three approaches: Economical, Balanced and Conservative. All cases passed the overturning, sliding and bearing capacity checks. Higher soil means larger earth pressure, bigger sections and higher cost in every approach. The Economical Design was the cheapest but close to the minimum safety limits, while the Conservative Design was the safest but the most costly.

RECOMMENDATIONS

1. Use the Balanced Design for practical projects, as it gives the best mix of safety and cost.
2. Extend the study to taller walls and other soil conditions.
3. Test site soil properties and consider groundwater, traffic vibration and earthquake loads.

