

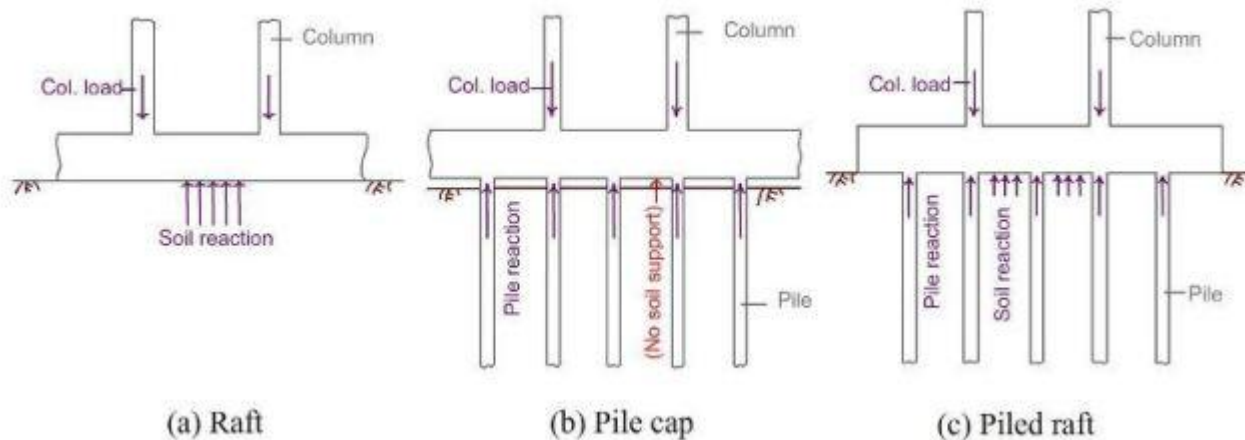
Design of Pile Raft Flat Slab for Heavy Load Applications

Using the JAYA Algorithm for Cost-Efficient Engineering Design

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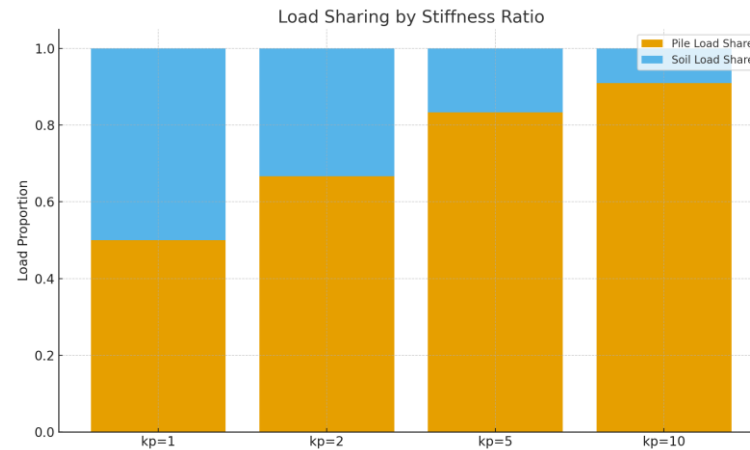
Introduction to Pile Raft Foundation

- Combines piles and raft to share vertical loads
- Suitable for sites with soft clay or mixed soil profiles
- Reduces total settlement and improves safety margin
- Can reduce the number and length of piles compared to pile-only design



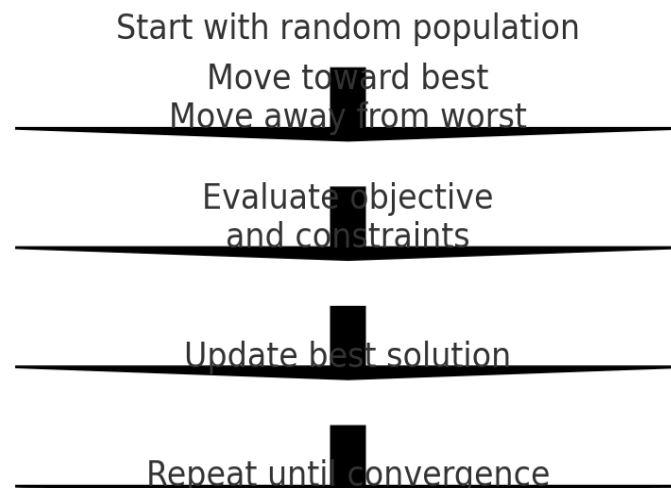
Load Sharing by Stiffness Proportion

- Total load shared between pile and soil based on stiffness ratio:
- $Q_{\text{pile}} = k_p / (k_p + k_s) \times \text{Total Load}$
- $Q_{\text{soil}} = k_s / (k_p + k_s) \times \text{Total Load}$
- Accurate modeling avoids overestimating either component
- Enables efficient design optimization under real-world soil conditions



JAYA Algorithm (Simple Overview)

- Population-based algorithm (like PSO or GA)
- Each candidate moves toward the best and away from the worst solution
- No tuning parameters (no inertia, crossover, etc.)
- Extremely easy to implement and effective
- Ideal for structural optimization problems



Optimization Problem

- Design Variables:
 - s_x = pile spacing in X direction
 - s_y = pile spacing in Y direction
 - P_a = pile capacity (discrete selection)
 - Objective:
 - Minimize total pile cost
 - Constraints:
 - Pile load $\leq P_a$
 - Soil bearing $\leq q_a$
 - Settlement $\leq s_a$
- *Load sharing based on k_p and k_s

Case Study

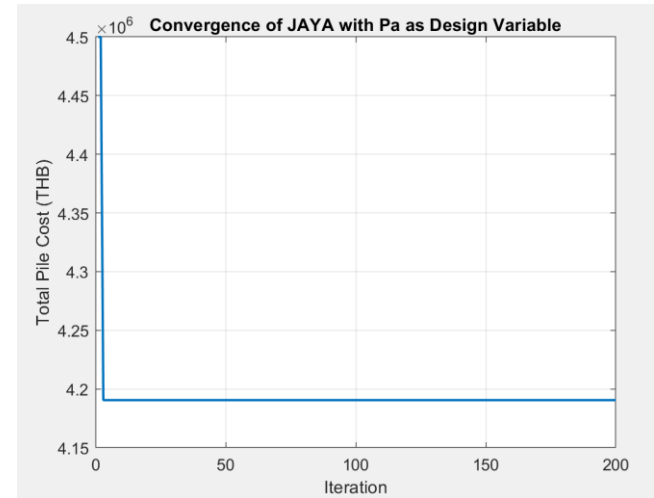
[40x70 m² slab with 50 kPa superimposed load]

Command Window

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Iter 191 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 192 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 193 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 194 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 195 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 196 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 197 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 198 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 199 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350
Iter 200 - Cost = 4190500 THB at spacing [2.51, 2.45] with Pa = 350

--- Final Best Design ---
sx = 2.51 m, sy = 2.45 m
Selected Pa = 350 kN, Unit Cost = 8500 THB
Number of piles = 484
Total pile cost = 4190500 THB
Pile Load = 344.38 kN, Soil Pressure = 0.00 kPa, Settlement = 0.0098 m
```

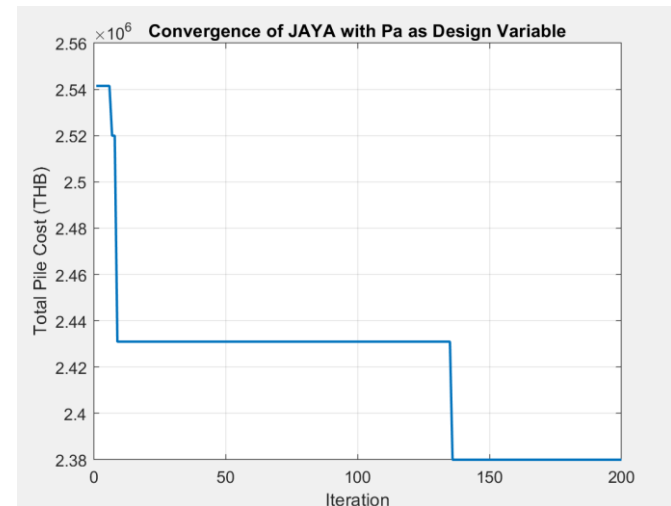
Pile foundation



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Iter 191 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 192 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 193 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 194 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 195 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 196 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 197 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 198 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 199 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350
Iter 200 - Cost = 2380000 THB at spacing [3.64, 3.01] with Pa = 350

--- Final Best Design ---
sx = 3.64 m, sy = 3.01 m
Selected Pa = 350 kN, Unit Cost = 8500 THB
Number of piles = 270
Total pile cost = 2380000 THB
Pile Load = 344.24 kN, Soil Pressure = 24.59 kPa, Settlement = 0.0098 m
t>>
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Pile raft foundation



Case Study: Cost Comparison (THB)

- Slab-on-Pile (per m²): 3,972.32 THB
- Pile Raft Flat Slab (per m²): 3,408.68 THB
- Total for 70×40 m² (2,800 m²):
- Slab-on-Pile: 11,124,400 THB
- Pile Raft Flat Slab: 9,542,400 THB
- Savings: 1,582,000 THB (≈14.2%)

Conclusions

- JAYA-based optimization allows automated selection of cost-efficient pile layouts
- Pile raft design significantly reduces cost while ensuring structural and geotechnical performance
- Stiffness-based load sharing and discrete pile design levels integrated in one workflow
- Ideal for industrial slabs and heavy load applications with large footprint