DESIGN AND LOAD BEHAVIOR ANALYSIS OF TOWER CRANE PILE FOUNDATIONS USING A SPREADSHEET APPLICATION IN IN-SERVICE AND OUT-OF-SERVICE CONDITIONS IN SOFT RIVERINE SOIL

Mr. Pirakpong Wongkum and Mr. Thongchai Supattaraphaisan
Advisors : Assoc. Prof. Dr. Suniti Suparp and Assoc. Prof. Dr. Sudnirun Phatcharat
Department of Civil Engineering, Faculty of Engineering, Srinakharinwirot University

Problem Statement

Tower crane pile groups on soft riverine clay face large uplift from overturning moments, and pile positions on site often deviate from the design. Manual stability checks are slow, so a spreadsheet tool was developed to calculate compression and uplift from the actual pile coordinates, helping site engineers make fast, safe decisions

Design Objectives

1. Develop an Excel application to assess compression and uplift forces in eccentric pile groups
2. Reaction Force Analysis of 12-Pile Foundations in Soft Riverine Soil under In-Service and Out-of-Service Conditions
3. Establish mitigation guidelines as a decision-support tool for site engineers when design capacities are exceeded

Project Scope

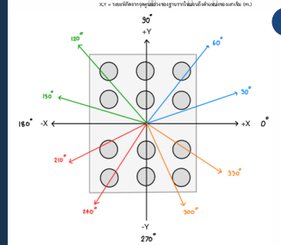
1. Compression and uplift distribution in the F12 tower crane pile group
2. Reaction forces in In-Service and Out-of-Service conditions
3. Riverine soft clay sites, focusing on biaxial pile eccentricity

Key Courses Used

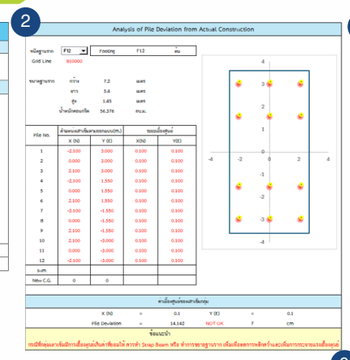
- Structural Analysis: pile reactions
- Foundation Engineering: pile capacity, uplift
- Reinforced Concrete Design: punching and wide-beam shear
- Steel Design: J-Bolt anchorage (M48)
- Computer Programming: Excel tool

Project Methodology

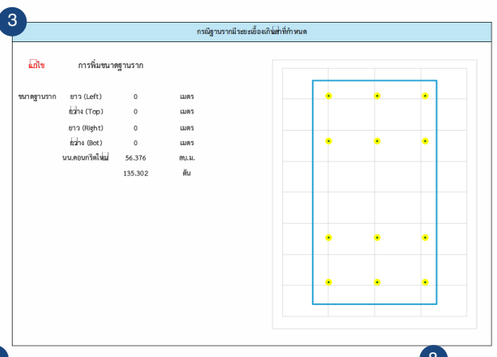
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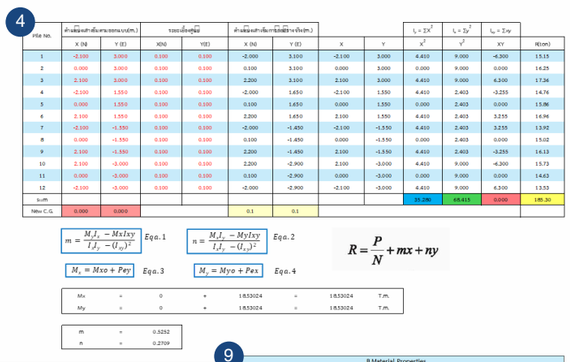
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5

การประเมินเสถียรภาพของฐานรากในสภาวะขณะใช้งานและหยุดใช้งาน
ขณะใช้งาน (In-Service)

องศาการสวิง (θ)	โมเมนต์ตามแนวแกน X (T-m)	โมเมนต์ตามแนวแกน Y (T-m)	Mx Net (T-m)	My Net (T-m)
30°	244.62	141.23	263.15	159.76
60°	141.23	244.62	159.76	263.15
90°	0.00	282.47	18.53	301.00
120°	141.23	244.62	122.70	263.15
150°	244.62	141.23	226.09	159.76
180°	282.47	0.00	263.94	18.53
210°	244.62	141.23	226.09	122.70
240°	141.23	244.62	122.70	226.09
270°	0.00	282.47	18.53	263.94
300°	141.23	244.62	159.76	226.09
330°	244.62	141.23	263.15	122.70
360°	282.47	0.00	301.00	18.53

6

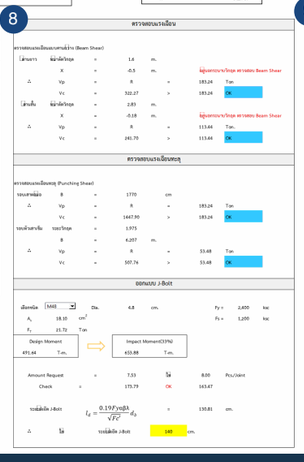
การประเมินเสถียรภาพของฐานรากในสภาวะขณะใช้งานและหยุดใช้งาน
ขณะหยุดใช้งาน (Out Of Service)

องศาการสวิง (θ)	โมเมนต์ตามแนวแกน X (T-m)	โมเมนต์ตามแนวแกน Y (T-m)	Mx Net (T-m)	My Net (T-m)
30°	425.77	245.82	444.30	264.35
60°	245.82	425.77	264.35	444.30
90°	0.00	491.64	18.53	510.17
120°	245.82	425.77	227.29	444.30
150°	425.77	245.82	407.24	264.35
180°	491.64	0.00	473.11	18.53
210°	425.77	245.82	407.24	227.29
240°	245.82	425.77	227.29	407.24
270°	0.00	491.64	18.53	473.11
300°	245.82	425.77	264.35	407.24
330°	425.77	245.82	444.30	227.29
360°	491.64	0.00	510.17	18.53

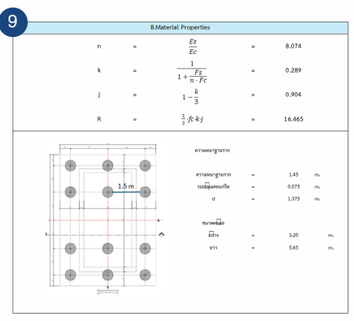
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Status	In Service (Ton)	Out Of Service (Ton)
Max Load	38.11	53.48
Min Load	-7.23	-22.60

8



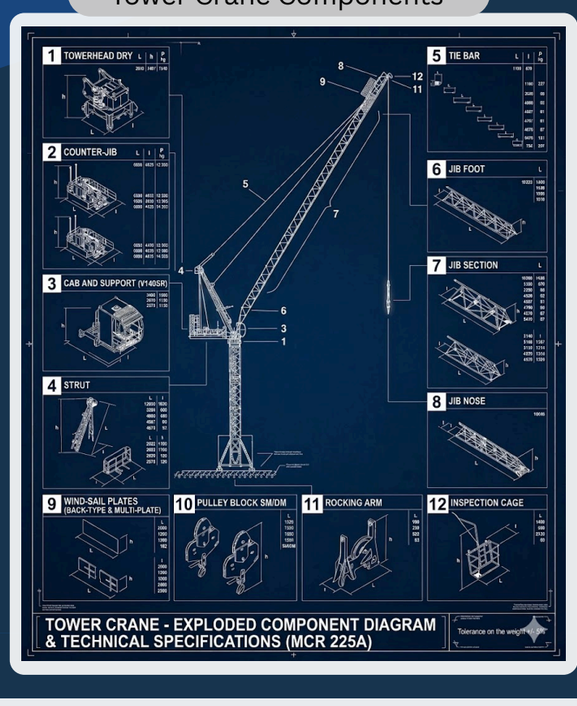
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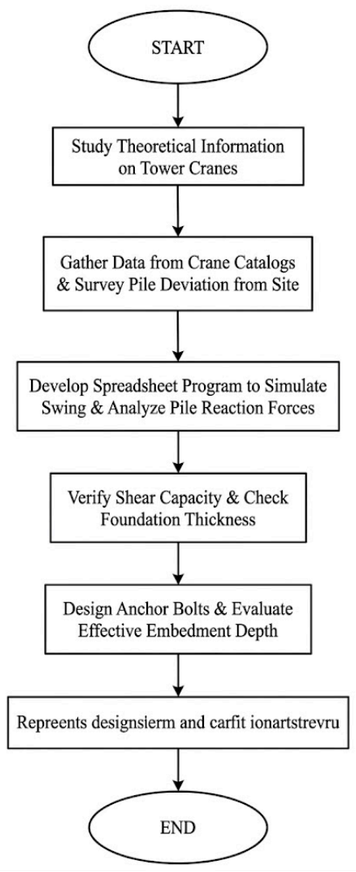
Engineering Standard

- Ministerial Regulation on Structural Design, B.E. 2566 (2023)
- Ministerial Regulation on Foundations and Soil, B.E. 2566 (2023)
- DPT 1252-51 & 1551-51 (Pile Load and Integrity Tests - Seismic Test)
- ACI 318 / EIT Standard (Engineering Institute of Thailand)

Tower Crane Components



Design Approach



Results

Reaction (T) ขณะใช้งาน

องศาการสวิง (θ)	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12
30°	17.47	26.98	36.49	11.89	21.40	30.91	-0.03	9.48	18.99	13.41	3.90	-5.61
60°	6.78	22.45	38.11	3.40	19.06	34.73	-3.84	11.82	27.49	24.10	8.44	-7.23
90°	-1.66	16.25	34.17	-2.05	15.86	33.78	-2.89	15.02	32.94	32.55	14.63	-3.29
120°	-5.60	10.06	25.73	-3.00	12.66	28.33	2.56	18.22	33.89	36.49	20.82	5.16
150°	-3.98	5.53	15.04	0.81	10.32	19.83	11.05	20.56	30.07	34.87	25.36	15.85
180°	2.77	3.87	4.97	8.36	9.46	10.57	20.32	21.42	22.52	28.12	27.02	25.91
210°	12.83	5.53	-1.78	17.62	10.32	3.02	27.87	20.56	13.26	18.05	25.36	32.66
240°	23.52	10.06	-3.40	26.12	12.66	-0.80	31.68	18.22	4.76	7.36	20.82	34.28
270°	31.96	16.25	0.54	31.57	15.86	0.15	30.73	15.02	-0.69	-1.08	14.63	30.34
300°	35.91	22.45	8.99	32.52	19.06	5.60	25.28	11.82	-1.64	-5.02	8.44	21.89
330°	34.28	26.98	19.68	28.71	21.40	14.10	16.78	9.48	2.18	-3.40	3.90	11.21
360°	27.54	28.64	29.74	21.16	22.26	23.36	7.52	8.62	9.73	3.35	2.24	1.14

สัญลักษณ์สีและความหมาย
น้อยกว่า 0 ตัน
0 - 80 ตัน
80 - 107 ตัน
มากกว่า 107 ตัน

In-Service: Max compression 38.11 t, max uplift -7.23 t

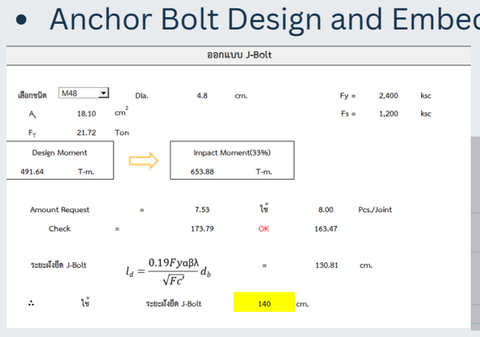
Reaction (T) ขณะหยุดใช้งาน

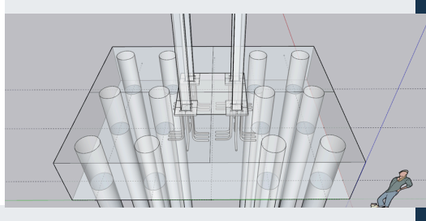
องศาการสวิง (θ)	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12
30°	19.19	34.92	50.66	9.77	25.51	41.24	-10.36	5.38	21.11	11.69	-4.04	-19.78
60°	0.59	27.03	53.48	-5.02	21.43	47.88	-16.99	9.45	35.90	30.30	3.85	-22.60
90°	-14.11	16.25	44.62	-14.51	15.86	46.23	-15.35	15.02	45.39	45.00	14.63	-17.74
120°	-20.97	5.48	31.92	-16.15	10.29	36.74	-5.86	20.59	47.04	51.86	25.41	-1.04
150°	-18.15	-2.42	13.32	-9.52	6.22	21.95	8.93	24.67	40.40	49.03	33.30	17.56
180°	-6.41	-5.30	-4.20	3.62	4.72	5.83	25.06	26.16	27.26	37.29	36.19	35.08
210°	11.11	-2.42	-15.94	19.74	6.22	-7.31	38.20	24.67	11.14	19.77	33.30	46.83
240°	29.72	5.48	-18.77	34.53	10.29	-13.95	44.83	20.59	-3.65	1.17	25.41	49.65
270°	44.42	16.25	-11.91	44.02	15.86	-12.30	43.18	15.02	-13.14	-13.53	14.63	42.79
300°	51.27	27.03	2.79	45.67	21.43	-2.81	33.69	9.45	-14.79	-20.39	3.85	28.09
330°	48.45	34.92	21.40	39.04	25.51	11.98	18.90	5.38	-8.15	-17.57	-4.04	9.49
360°	36.71	37.81	38.92	25.90	27.00	28.10	2.78	3.88	4.99	-5.83	-6.93	-8.03

สัญลักษณ์สีและความหมาย
น้อยกว่า 0 ตัน
0 - 80 ตัน
80 - 107 ตัน
มากกว่า 107 ตัน

Out-of-Service (60° swing): 53.48 t compression, -22.60 t uplift (governs J-Bolts)
Anchor Bolts: 8 × M48 per joint, 140 cm embedment

- Anchor Bolt Design and Embedment Depth





The design specifies 8 anchor bolts (M48) per joint with a total embedment depth of 140 cm to safely resist the critical uplift forces.

Recommendations

- Add VBA macros to export the calculation automatically as a PDF report.
- Add a database of common tower crane models and a soil bearing check for spread footings.
- Check uplift under minimum vertical load and link the eccentricity limit to the 75 mm rule.

Conclusion

Validation of the F12 foundation model confirms the program's precision in multiple functions: eccentricity alerts, 360° critical force analysis, and safety verification of pile capacities. The tool also evaluates punching and wide-beam shear strength, while integrating critical uplift values for J-Bolt design and embedment length (Ld). This comprehensive approach prevents bond failure and guarantees total structural stability.

Scan Now

BOQ / Cost Estimation

BILL OF QUANTITIES

Project: Tower crane pile foundation F12, Chapter Charoenkrung Riverside

No.	Description	Qty	Unit	Material (THB/unit)	Labour (THB/unit)	Amount (THB)
1. Bored piles						
1.1	Wet-process bored piles Ø0.60 m, 34.00 m deep (408 m in total)	12.00	piles	28,000.00	4,500.00	390,000.00
1.2	Seismic integrity test, 100% of piles (DPT 1551-51)	12.00	piles	500.00	300.00	9,600.00
1.3	Dynamic load test (DPT 1252-51)	1.00	pile	35,000.00	10,000.00	45,000.00
2. Pile cap, 7.20 × 5.40 × 1.45 m						
2.1	Structural concrete f'c = 280 ksc	56.38	m³	2,400.00	450.00	160,671.60
2.2	Lean concrete 1:3:5, 0.10 m	3.89	m³	1,800.00	350.00	8,359.20
2.3	Compacted coarse sand, 0.10 m	3.89	m³	550.00	150.00	2,721.60
2.4	Formwork	36.54	m²	350.00	180.00	19,366.20
2.5	Main bars DB25 / DB32 (fy = 5,000 ksc)	6,200.00	kg	32.00	5.00	229,400.00
2.6	Ties and mesh DB12 / RB9	1,150.00	kg	30.00	5.00	40,250.00
3. Pedestals and anchorage						
3.1	Pedestal concrete f'c = 280 ksc (3.20 × 5.65 m)	8.00	m³	2,400.00	450.00	22,800.00
3.2	J-bolts M48, Ld = 1.40 m (8 per leg × 4 legs)	32.00	sets	3,800.00	800.00	147,200.00
3.3	Pedestal bars DB25 / DB20	1,250.00	kg	32.00	5.00	46,250.00
4. Testing and certification						
4.1	On-site tower crane load test	1.00	job	25,000.00	15,000.00	40,000.00
4.2	Safety documents and inspection (Por.Jor. 1)	1.00	job	12,000.00	5,000.00	17,000.00
				Direct cost (materials + labour)		1,178,618.60
				Overhead, contingency and profit	15%	176,792.79
				GRAND TOTAL		**1,355,411.39**