Steel Chimney or Steel Stack Design

For Self-Supporting Chimneys [ASME]

Location Steel Stack H = 60 m. Bang Pakong-Chachoengsao

Engineer Mr.Sermpun Aimjaboak **Date** 1 March 2012

1. DATAS FOR DESIGN

1.1 High Of Chimney		=	60.00	m.
1.2 Lining Thick.: ……... (Corrosion Resistance)		=	0.00	mm.
1.3 Flow Rate Of Air/Smoke		=	29.31	$m.^3$/sec.
1.4 Temperature Of Air/Smoke	[200 < 310 Not Reduce]	=	200.00	C^o No Reduct. Coeff.
1.5 Local Mean Wind speed Above Ground 10.00 m.		=	25.00	m./sec.
	or	=	90.00	km./hr.

2. PROPERTIES OF MATERIALS

2.1 Ultimate Compressive Strength Of Concrete [ของฐานเดิม]		=	220.00	$kg./cm.^2$
2.2 Unite Weigth Of Reinforced Concrete		=	2,400.00	$kg./m.^3$
2.3 Yield Strength Of Steel (Corten B	[345 $N/mm.^2$]	=	3,517.77	$kg./cm.^2$
2.4 Unite Weigth Of Steel		=	7,850.00	$kg./m.^3$
2.5 Yield Strength Of Stainless (304H: Corrosion Resistance)		=	0.00	$kg./cm.^2$
2.6 Unite Weigth Of Stainless (304H: Corrosion Resistance)		=	0.00	$kg./m.^3$
2.7 Yield Strength Of Bolt		=	2,400.00	$kg./cm.^2$
2.8 Tensil Strength Of Welding (For E60-xx Only)		=	4,200.00	$kg./cm.^2$

3. Allowable Stress For Design

3.1 Bending Stress Of Steel & Tensile		=	2,110.66	$kg./cm.^2$	
3.2 Compressive Stress Of Steel	[For Control Buckling]	=	1,150.00	$kg./cm.^2$	[D/t]<130
3.3 Shearing Stress Of Steel		=	1,407.11	$kg./cm.^2$	

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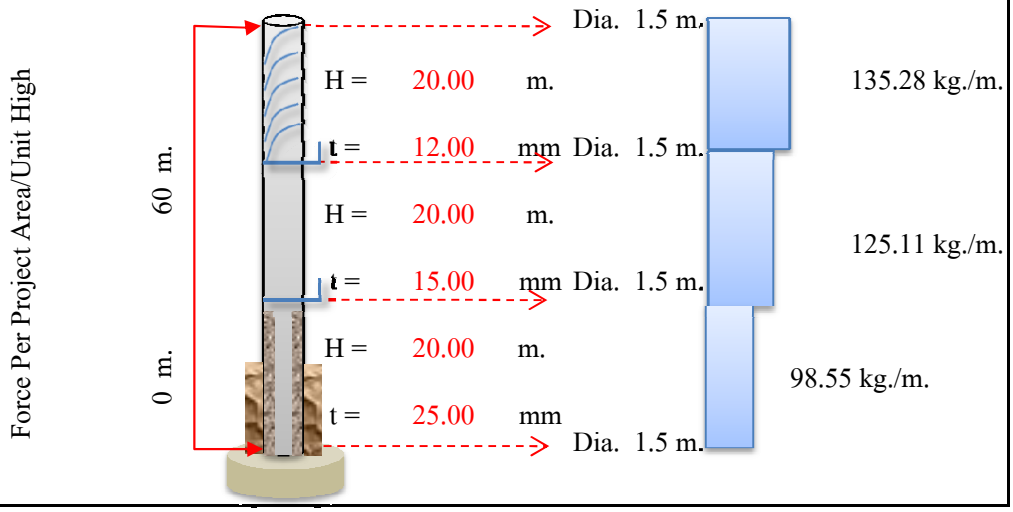
3. Allowable Stress For Design (Cont.)

3.4 Bending Stress Of Stainless & Tensile	=	0.00	kg./cm.^{2}
3.5 Compressive Stress Of Stainless	=	0.00	kg./cm.^{2}
3.6 Shearing Stress Of Stainless	=	0.00	kg./cm.^{2}
3.7 Shearing Stress Of Bolt	=	960.00	kg./cm.^{2}
3.8 Shearing Stress Of Welding	=	1,260.00	kg./cm.^{2}

4. Select Dimensions Of Steel Chimney

4.1 Total High Of Steel Chimney	=	60.00	m.	
4.2 High Of Conical (Flared) Portion	=	0.00	m.	
4.3 High Of Cylindrical Portion	=	60.00	m.	
4.4 Outside Diameter At Top Of Flared Portion	=	1.50	m.	
4.5 Outside Diameter At Base Of Flared Portion	=	1.50	m.	[1.60xD]
4.6 Outside Diameter At Top&Bott. Of Cylindrical Portion	=	1.50	m.	[60]/20
4.7 Max. Thick. Of Steel Chimney (Account For Corr. = 1/16")	=	20.00	mm.	[D/t]<130



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5. DESIGN LOAD

5.1 Dead Load Of Steel/Unit High = 3.14*Dia.*20*7850 kg./m.

5.2 Dead Load Of Stainless/Unit High = 3.14*Dia.*20*0 kg./m.

5.3 Dead Load Of Platform/Access Ladder/Helical Strake = 100.00 $kg./m.^2$

5.4 Live Load (For Personal) = 100.00 $kg./m.^2$

5.5 Live Load (For Wind) = UBC Formula (18-1) Section 1618

= $P = C_e C_q q_s I$ -----> F=PA

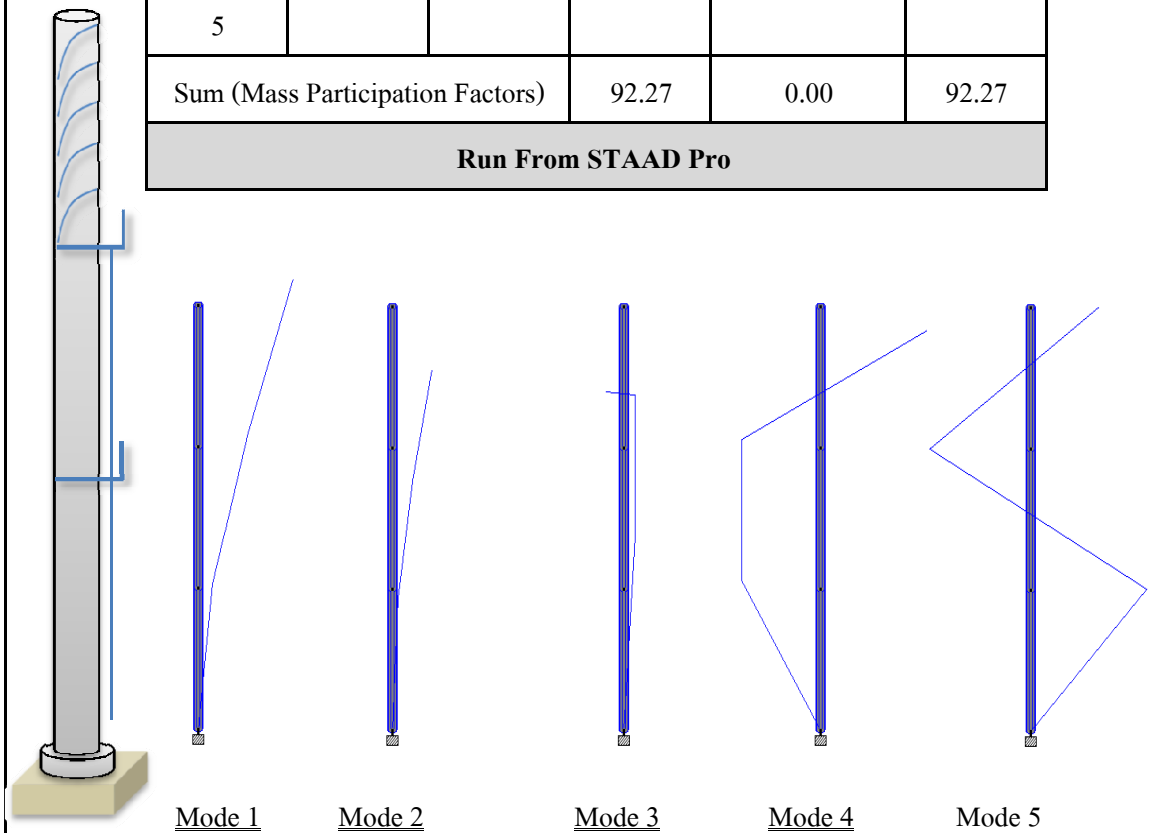
Shape Factor (S.F.) = 0.80

F_{avg}(kg./m.)	H (m.)	C_e	C_q	q_s	I	S.F.	A ($m.^2$/m.)	F(kg./m.)
98.55	0 - 4.57	1.39	1.30	39.09	1	0.80	1.50	84.76
	4.57 - 6.10	1.45	1.30	39.09	1	0.80	1.50	88.42
	6.10 - 7.62	1.50	1.30	39.09	1	0.80	1.50	91.47
	7.62 - 9.14	1.54	1.30	39.09	1	0.80	1.50	93.91
	9.14 - 12.19	1.62	1.30	39.09	1	0.80	1.50	98.79
	12.19 - 18.29	1.73	1.40	39.09	1	0.80	1.50	113.61
	18.29 - 24.38	1.81	1.40	39.09	1	0.80	1.50	118.87
125.11	24.38 - 30.48	1.88	1.40	39.09	1	0.80	1.50	123.46
	30.48 - 36.58	1.93	1.40	39.09	1	0.80	1.50	126.75
132.66	36.58 - 48.77	2.02	1.40	39.09	1	0.80	1.50	132.66
137.91	48.77 - 60.96	2.10	1.40	39.09	1	0.80	1.50	137.91
146.45	60.96 - 91.44	2.23	1.40	39.09	1	0.80	1.50	146.45

6. Analysis (Modal Analysis) And Result

[A Steel Chimney Is Modeled As A Cantilevered, Thin Wall Steel Cylinder, Fixed Base With Free End]

Natural Frequency Of Steel Chimney (Dead Load Only)					
Mode	Freq, Hz	Period, sec	Parti, X %	Parti, Y %	Parti, Z %
1	0.4830	2.0692	64.78	0.00	1.24
2	0.4830	2.0692	1.24	0.00	64.78
3	2.3360	0.4280	9.98	0.00	16.27
4	2.3360	0.4280	16.27	0.00	9.98
5					
Sum (Mass Participation Factors)			92.27	0.00	92.27
Run From STAAD Pro					



Mode 1 Mode 2 Mode 3 Mode 4 Mode 5

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6.3 Check Resonance & Vortex Shedding

Mode	Mode 1	Mode 2	Mode 3	Mode 4
Freq, Hz	0.4830	0.4830	2.3360	2.3360
Period, sec	2.0692	2.0692	0.4280	0.4280

Vortex Shedding Frequency (Fs = S*V/Dia.) = 3.3333 Hz $\neq$ 2.3360 Hz (f1)

Strouhal Critical Velocity (Vcr = f1*Dia./S) = 17.52 m./sec. < 1.3*25 Critical

Reynold Number (Re = V*Dia./v) = 2.39E+06 < Critical Range >

< Critical Range >

$3x10^5 < Re < 3.5x10^6$
LAMINAR BOUNDARY LAYER HAS UNDERGONE TURBULENT TRANSITION AND WAKE IS NARROWER AND DISORGANIZED

Result: Risk For Vortex Shedding (Use Dynamic Control)

6.4 Support Reaction At Base (Use For Design Foundation Block)

Axial Force	Fy	=	63,343.88	kg.
Shear Force	Fx	=	17,291.48	kg.
Bending Force	Mz	=	460,188.17	kg.-m.

6.5 Internal Forc At Any Level

At Level 0.00 m. = Member 0-20 m.

Axial Force	Fy	=	38,975.00	kg.
Shear Force	Fx	=	11,230.00	kg.
Bending Force	Mz	=	226,406.00	kg.-m.

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At Level 20 m.			=	Member 20-40 m.		
Axial Force		Fy	=	18,924.00	kg.	
Shear Force		Fx	=	6,423.00	kg.	
Bending Force		Mz	=	79,424.00	kg.-m.	
At Level 40 m.			=	Member 40-60 m.		
Axial Force		Fy	=	4,421.00	kg.	
Shear Force		Fx	=	2,310.00	kg.	
Bending Force		Mz	=	16,412.00	kg.-m.	

6.6 Check Design Of Chimney Shell Thickness

At Level	=	40.00	m.	Diameter	=	1.50	m.	
Stress Due To Chimney Weight					=	15.70	kg./cm.^{2}	
Stress Due To Weight Of Lining					=	0.00	kg./cm.^{2}	
Stress Due To Max.					=	77.36	kg./cm.^{2}	
Max. Compressive Stress					=	93.06	kg./cm.^{2} <	1,150.00
Max. Tension Stress					=	77.36	kg./cm.^{2} <	2,110.66
Allowable Bending Moment					=	56,855.01	kg.-m. >	16,412.00
At Level	=	20.00	m.	Diameter	=	1.50	m.	
Stress Due To Chimney Weight					=	31.40	kg./cm.^{2}	
Stress Due To Weight Of Lining					=	0.00	kg./cm.^{2}	
Stress Due To Max.					=	299.51	kg./cm.^{2}	
Max. Compressive Stress					=	330.91	kg./cm.^{2} <	1,150.00
Max. Tension Stress					=	299.51	kg./cm.^{2} <	2,110.66
Allowable Bending Moment					=	88,656.85	kg.-m. >	79,424.00

1: LC 1: DL
2: LC 2: LL
3: LC 3: WL
4: LC 4: EQ
5: LC 5: TP
6: LC 6: DL+LL+WL+TP
7: LC 7: DL+LL+EQ+TP

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At Level	=	0.00	m.	Diameter	=	1.50	m.	
Stress Due To Chimney Weight					=	47.10	kg./cm.^{2}	
Stress Due To Weight Of Lining					=	0.00	kg./cm.^{2}	
Stress Due To Max.	1: LC 1: DL 2: LC 2: LL 3: LC 3: WL 4: LC 4: EQ 5: LC 5: TP 6: LC 6: DL+LL+WL+TP 7: LC 7: DL+LL+EQ+TP				=	512.27	kg./cm.^{2}	
Max. Compressive Stress					=	559.37	kg./cm.^{2} <	1,150.00
Max. Tension Stress					=	512.27	kg./cm.^{2} <	2,110.66
Allowable Bending Moment					=	244,610.65	kg.-m. >	226,406.00

8. DESIGN BASE PLATE AND ANCHOR BOLTS

8.1 Width Of Base Plate

Max. Compressive Force/Unit Circumf. Length	=	134.37	kg./m.
Allowable Compressive Strength Of Foundation	=	55.00	kg./cm.^{2}
Req. Width Of Base Plat[So Total Dia. = 1.52 m.]	=	2.44	cm./m.
Use Base Plate Width	=	20.00	cm.

8.2 Thickness Of Base Plate

Allowable Bending Stress Of Plate (0.75Fy)	=	2,638.33	kg./cm.^{2}
Req. Thickness Of Base Plate	=	2.50	cm.
Use Thickness Of Base Plate	=	2.50	cm.

8.3 Anchor Bolts (For Overturning Moment Increased to 1.50 Times Use Dia. 40.00 mm.

So Spacing Of Bolts [ASTM A325 Type3]	=	13.26	⇒	12.50	cm.
Req. No. Of Bolts [DL 81.06 cm./bolt]	=	38.00	⇒	40.00	bolts

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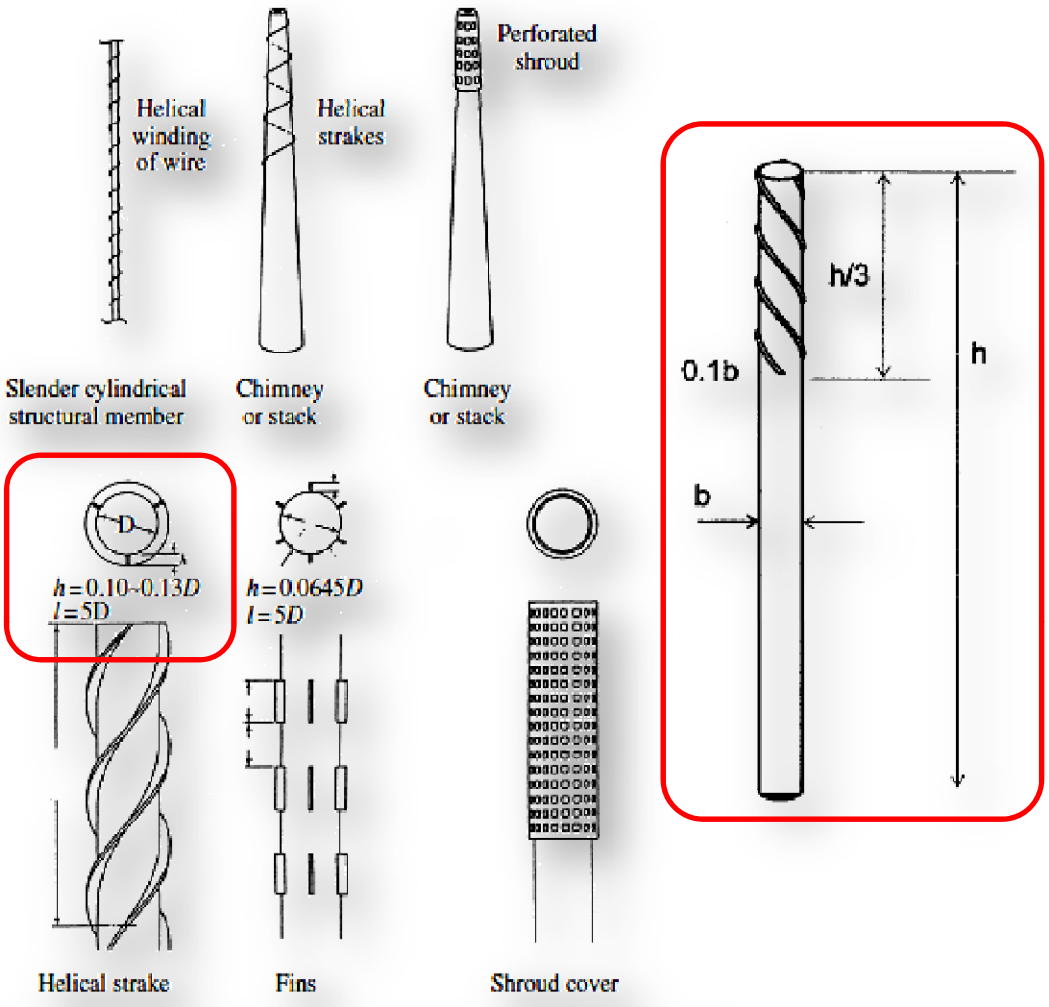
Vortex Shedding Control Method



Examples of countermeasure for vortex-excited vibration of a circular cylinder

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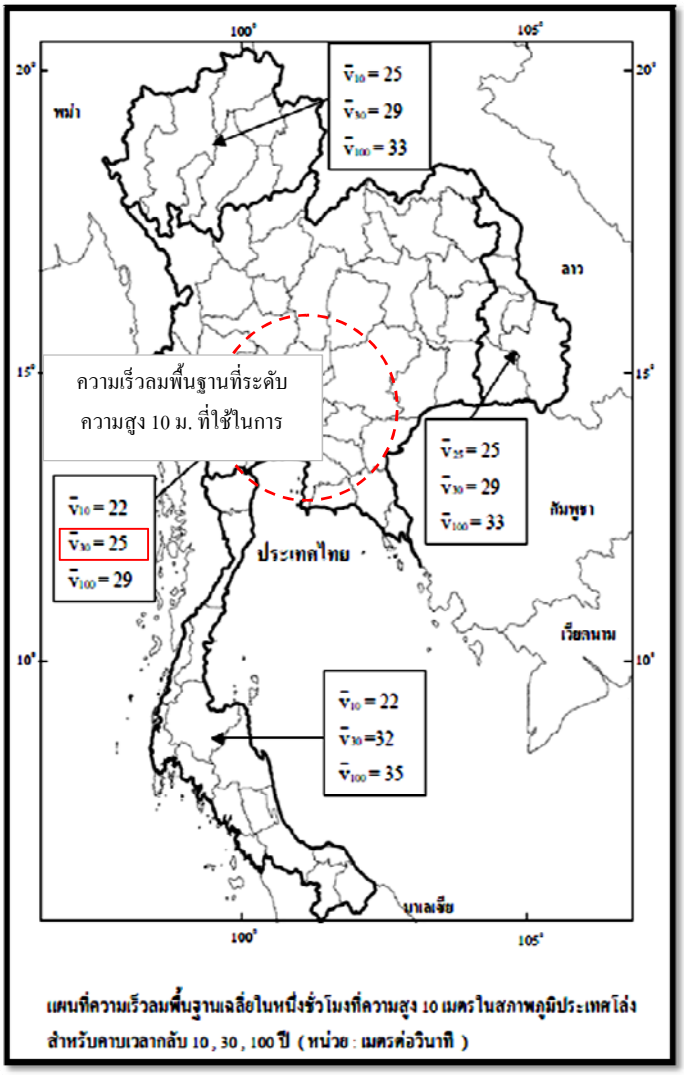

แผนที่ความเร็วลมพื้นฐานเฉลี่ยในหนึ่งชั่วโมงที่ความสูง 10 เมตรในสภาพภูมิประเทศโล่ง
สำหรับคาบเวลากลับ 10 , 30 , 100 ปี (หน่วย : เมตรต่อวินาที)

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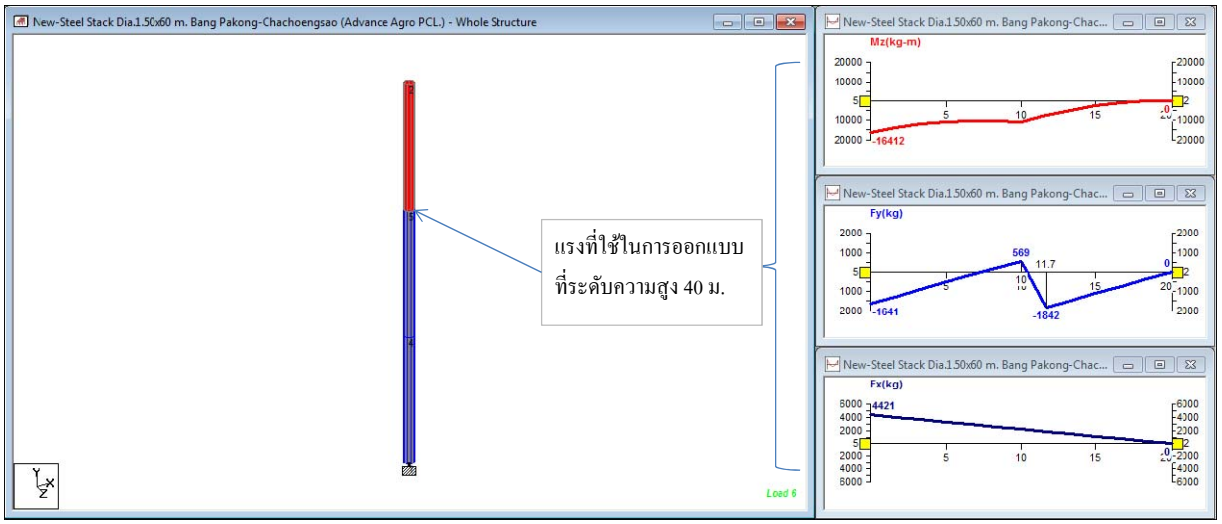

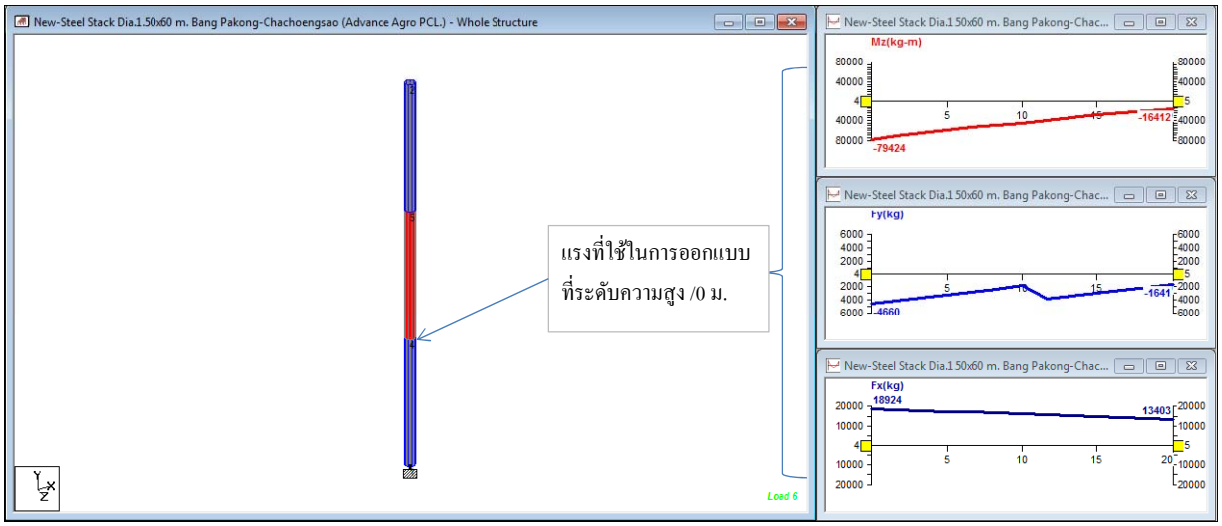

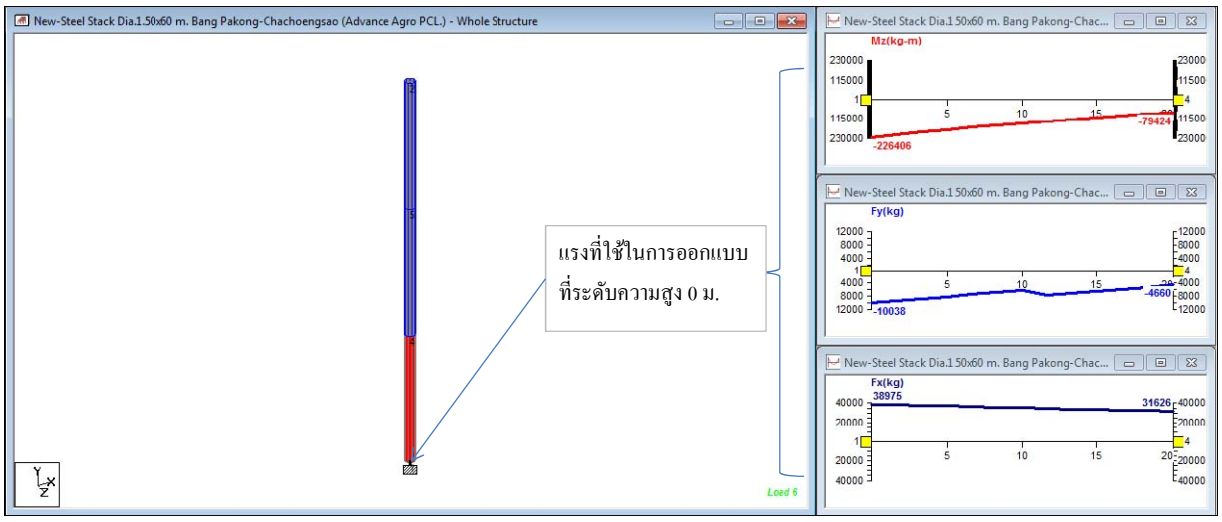

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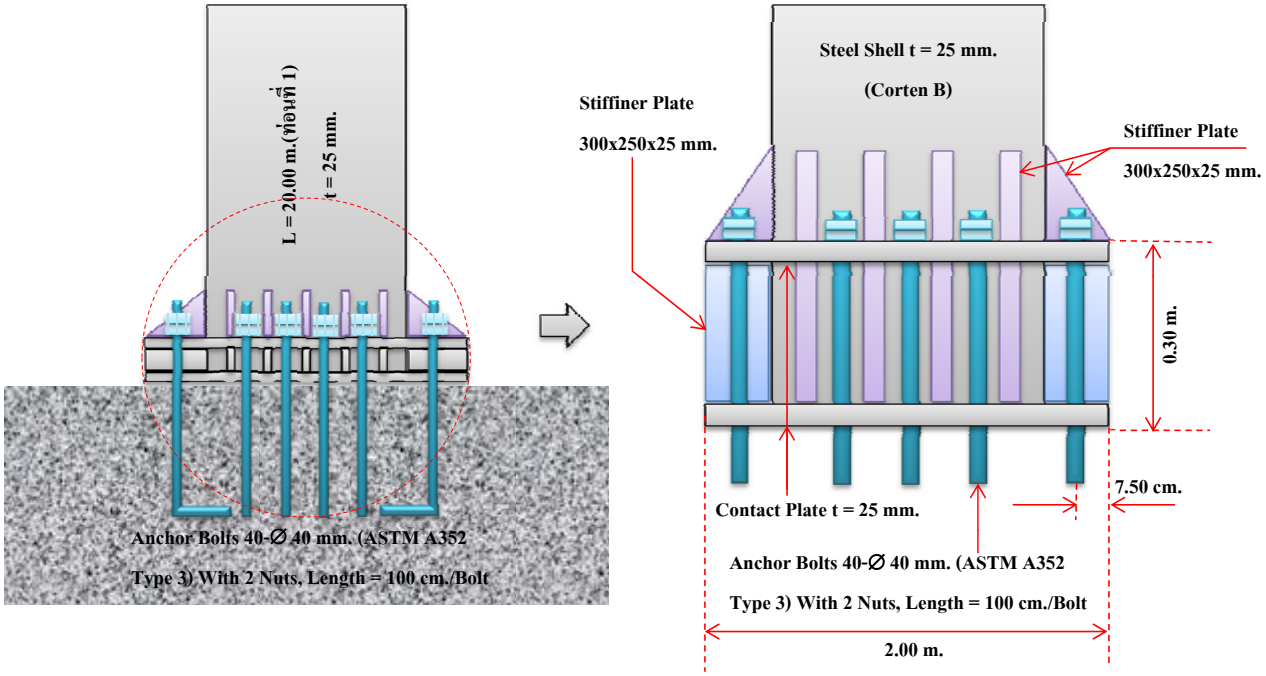

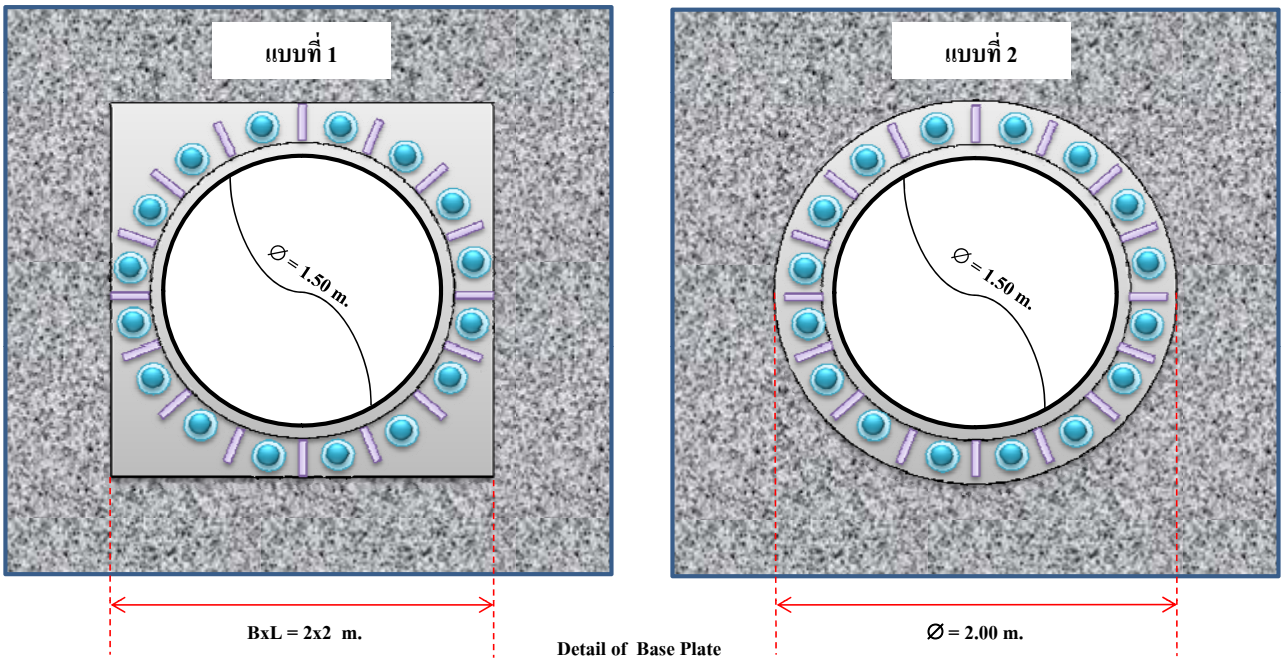

Detail of Base Plate

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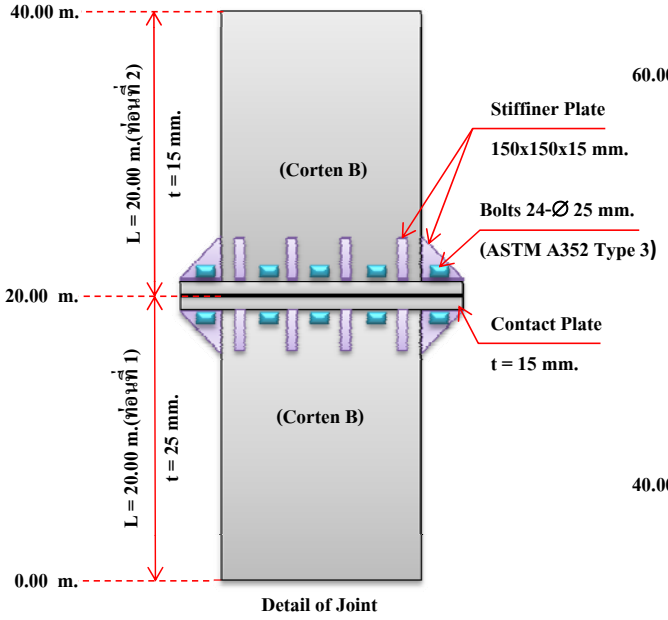
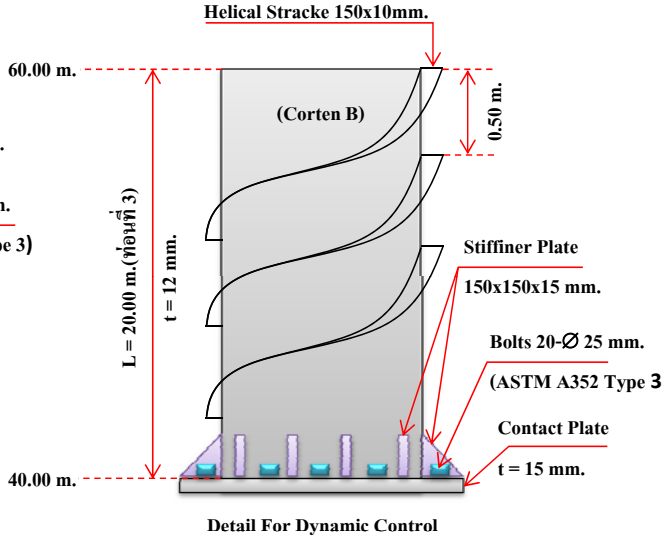
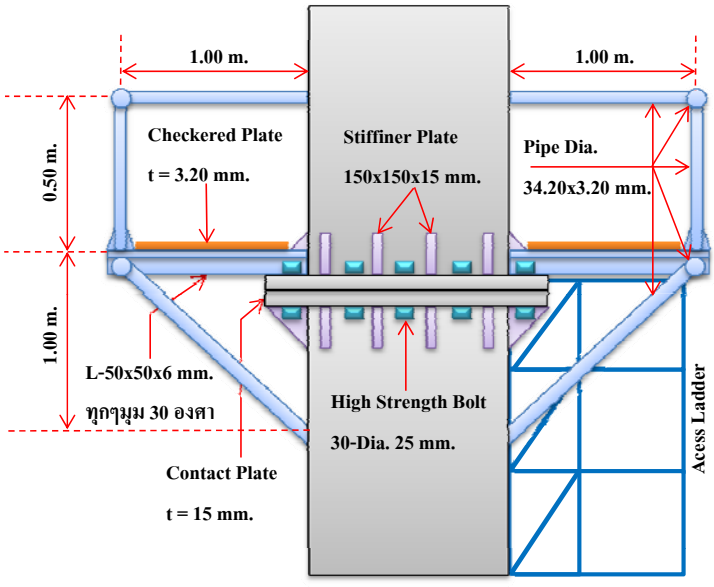


Detail of Joint



Detail For Dynamic Control



Detail For Acces Platform

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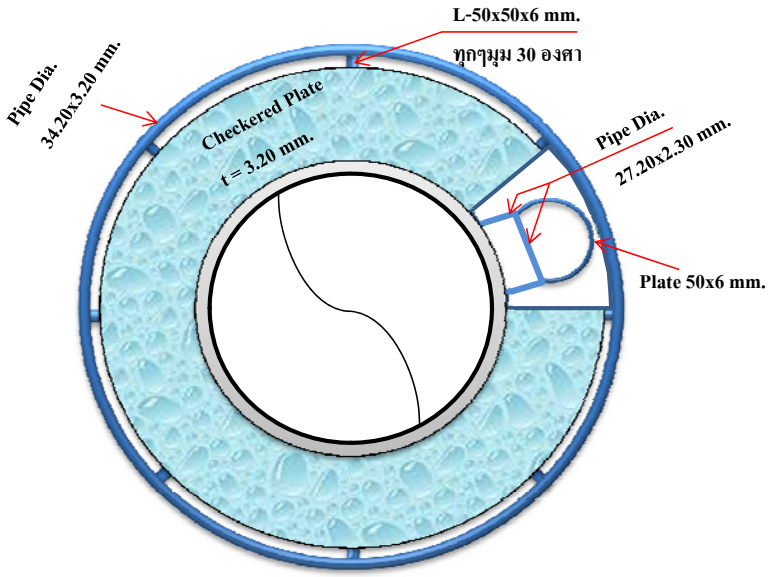

Detail For Acess Ladder