MOSES INSTITUTE EXPERT SHARING SESSION #2

Design and Analysis of Steel Structural Piperacks

TRAINER

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HOST

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DESIGN & ANALYSIS OF PIPERACK STRUCTURES

By :

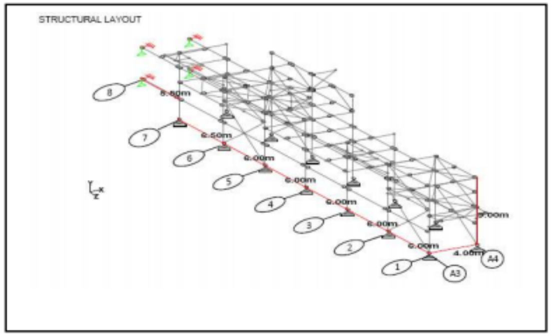
HENRY GUNAWAN

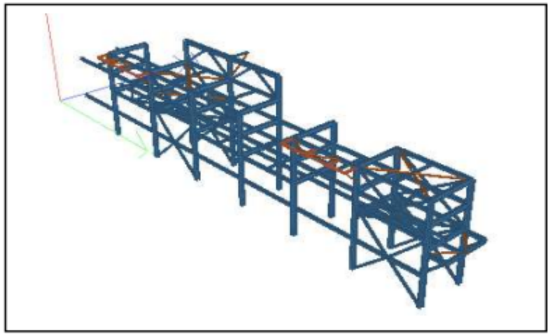
DEFINITION

Pipe Rack adalah struktur kerangka dari baja/beton yang mendukung pipa dan merupakan alat bantu di bidang oil & gas industri. Beban Pipa sangat bervariasi dari proyek ke proyek lainnya, hampir sama seperti beban angin dan gempa bumi yang bervariasi.

Komponen struktural dari Pipe Rack harus mampu menahan beban **aksial**, **geser**, dan **moment**. Sebuah analisis harus digunakan untuk menentukan kekuatan pada member Pipe Rack.

Komponen struktural utama dari Pipe Rack adalah **balok melintang, kolom, balok memanjang, dan bracing vertikal dan horizontal**.





Gbr. Staad Pro Model for Pipe Rack

CODE & REFERENCE

No.	Description	Remarks
1	TEP-TCS-SPE-001	General Specification for Civil and Structure
2	TEP-007-2014	Soil Investigation Block Station & Jene Station 2014
3	UBC 1997 Volume-2	Code
4	SNI-03-1726-2003	Code
5	ASCE 7/05	Code
6	ACI 318-02	Code
7	AISC-ASD 14th Edition	Code
8	Laporan Penyelidikan Tanah 2013	TEP-TCS-RPT-002
9	Tabel Profil Konstruksi Baja	by Ir. Rudy Gunawan
10	Piping Loading Data	
11	Electrical Loading Data	
12	Instrument Loading Data	

Quality of Material

No.	Name	Symbol	Value	Unit	Remarks
1	Concrete	fc'	21	MPa	Structural concrete
		fc'	14	MPa	Leveling concrete
2	Reinforcing Steel Bar	Fy	400	MPa	ASTM A-615 grade 60 (Deform)
3	Structural Steel	Fy	240	MPa	ASTM A36
4	Anchor Bolt	Fy	240	MPa	ASTM A307 grade C or JIS 3101 SS 400
5	Bolt	Ft	300	MPa	ASTM A325

Unit Weight of Material

No.	Name	Symbol	Value	Unit
1	Structural Concrete	γc	23.54	kN/m^3
2	Leveling Concrete	γpc	21.58	kN/m^3
3	Steel	γs	76.98	kN/m^3
4	Soil	γso	16.09	kN/m^3
5	Operating Liquid	γL	8.82	kN/m^3
6	Water	γw	9.81	kN/m^3
7	Sand Gravel	γg	18.14	kN/m^3

CODE & REFERENCE cont…

Pile Capacity

Please refer to Attachment C for Pile Bearing Capacity.
Allowable soil bearing capacity is assumed as below:

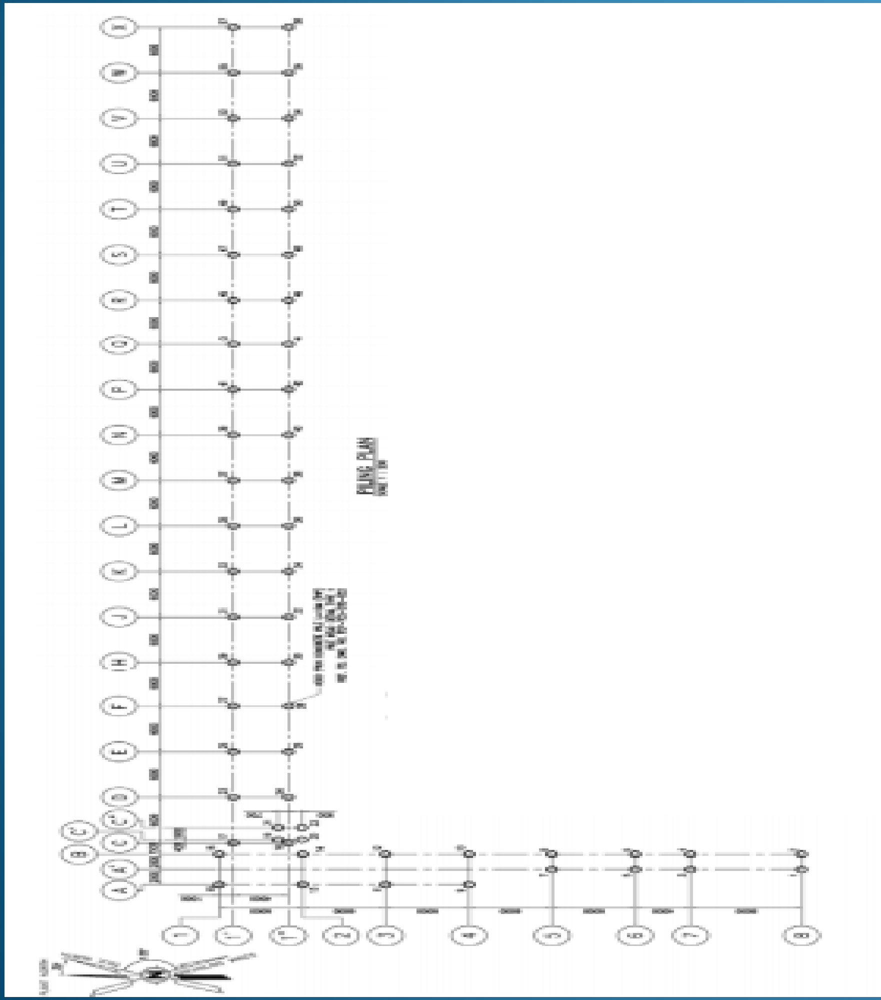
No.	Name	Symbol	Value	Unit	Remarks
1	Permanent condition	$q_{all-perm}$	117.23	kPa	
2	Temporary condition	$q_{all-temp}$	155.92	kPa	$= 1.33 * q_{all-perm}$

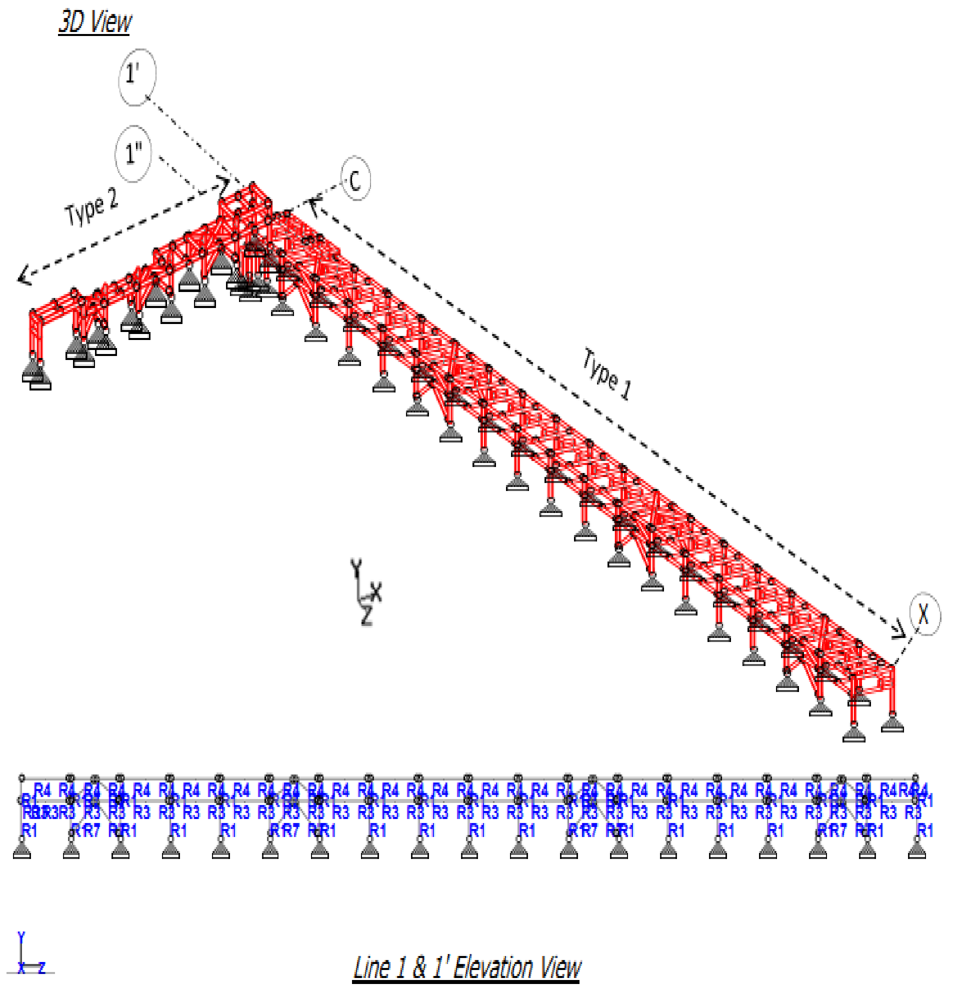
Design Criteria

- Unfactored loading combination is used for checking the axial and horizontal capacity of pile foundation.
- Reinforced concrete design shall be used Ultimate Strenght Design Method.
- Steel Structure design shall be used Allowable Stress Design (ASD) Method by AISC-2011

No.	Description	Remarks	
1	Earthquake Load	UBC 1997 Volume-2	
	Seismic zone	5	(based on SNI-03-1726-2003)
	Seismic zone factor Z	0.25	(based on SNI-03-1726-2003)
	Soil profile type	(SE)	(Ref.2, Table 4.3.2)
2	Wind Load	ASCE 07/05	
	Wind speed	28 m/s	
3	Structure type	Steel structure, Concrete structure, moment resisting frame, pile foundation	
4	Analysis	Static	
5	Concrete Design	ACI 318-02	
6	Steel Design	AISC-ASD	

PLAN & VIEW





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PLAN & VIEW cont..

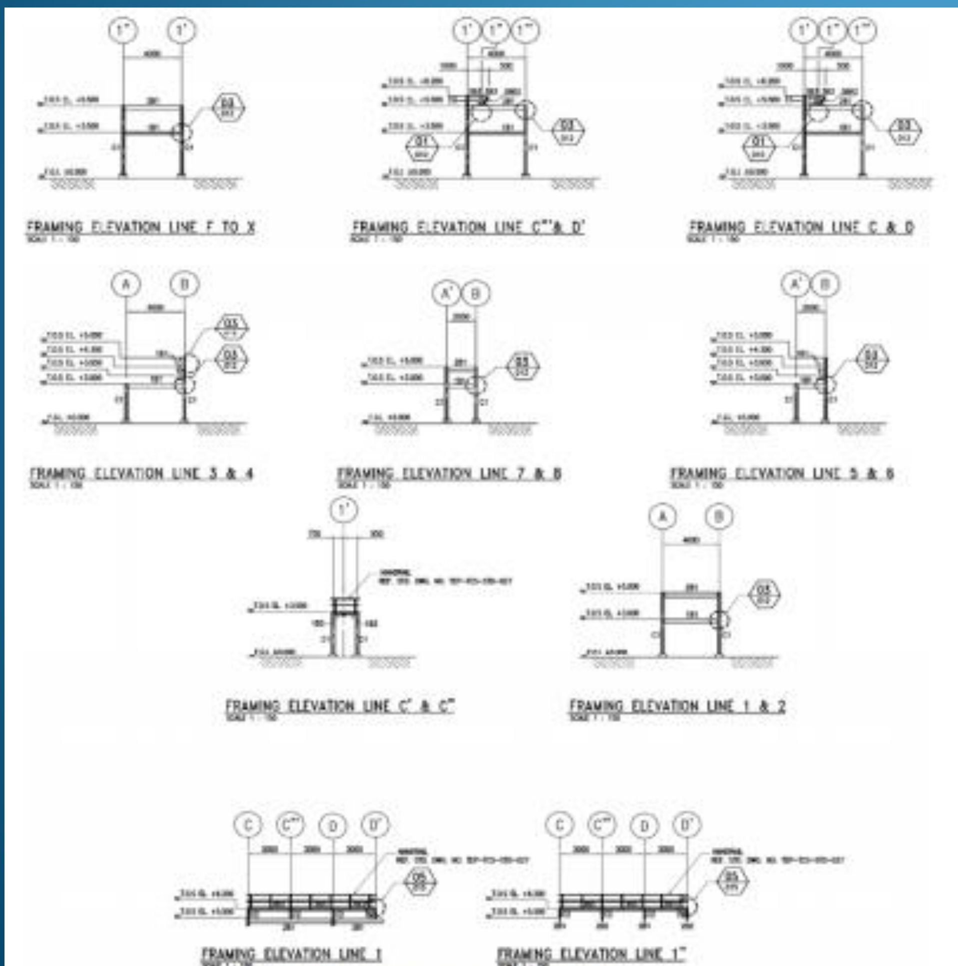
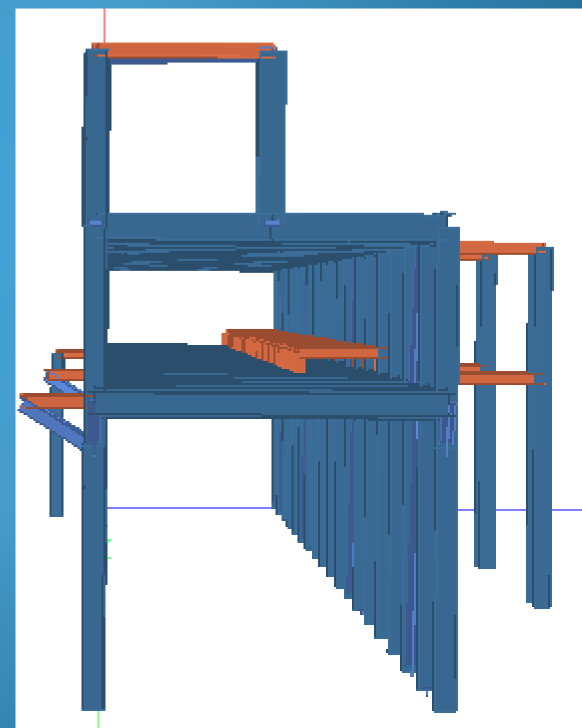


Figure 5. – Pipe Rack Framing Elevation



PLAN & VIEW cont..

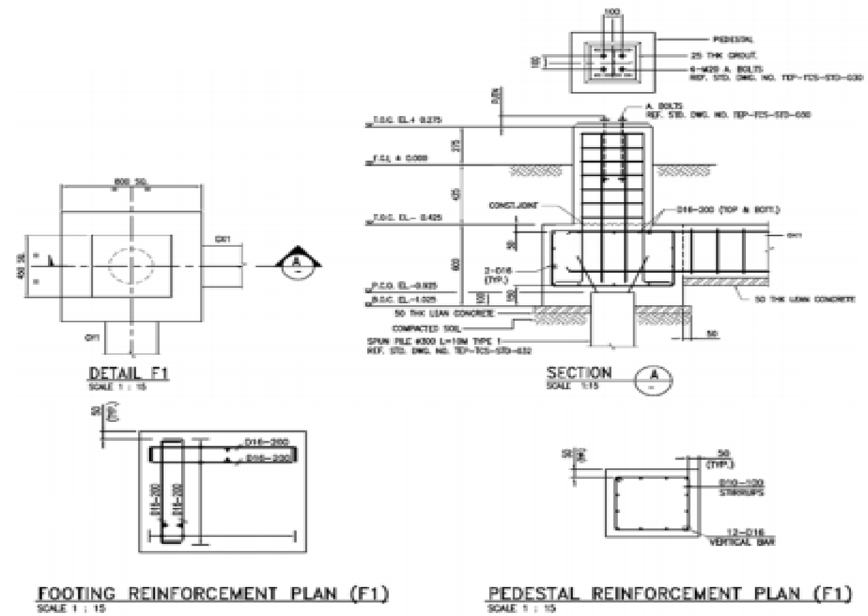


Figure 8. – Foundation F1 Typical F2

TABLE OF BEAM

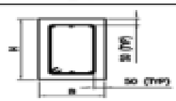
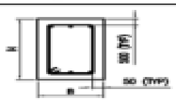
MARK	GX1/GY1	
POSITION	END	MID
		
BxH	350 x 400	
TOP	3 D16	3 D16
BOTOM	3 D16	3 D16
TIES	–	–
STIRUP	D10–150	D10–150

Figure 9. – Detail of Tie Beam GX1 and GY1

Based on design and calculation, pile cap and pedestal dimension and reinforcement of structure are :

Pile cap dimension	=	0.8 m width x 0.8 m length x 0.6 m height
Pedestal dimension	=	0.45 m width x 0.45 m length x 0.7 m height
Pile cap flexural reinf.	=	Use D16 - 200 mm or 4-D16 for top and bottom flexural reinforcement.
Pile cap shear reinf.	=	Since flexural reinforcement is larger than shear reinforcement and can be covered so no shear reinforcement required
Pedestal axial-flexural reinf.	=	Use 12 D 16
Pedestal shear reinf.	=	Use 2 leg D10-100 mm shear reinforcement.

For structure, tie beam shall be 350 mm x 400 mm using 3-D16 flexural reinforcement.

LOADING COMBINATION

Factored Load Combination

The following factored load combinations are used for reinforced concrete design by Ultimate Streng Design method.

Load ID	Description	Remarks
200-203	0.9 (D + EE + PE) + 1.6 W	Temporary
204-207	0.9 (D + E(E) + P(E)) + 1.0 EQ/1.4	Temporary
208-211	1.2(D + EO + PO + AF + F) + 1.6L	Permanent
212-215	1.4(D + EO + PO + AF + F)	Temporary
216-219	0.9(D + EO + PO + AF) + 1.6W	Temporary
220-223	1.2(D + EO + PO + AF) + L + 1.6W	Temporary
224-227	0.9(D + EO + PO + AF) + EQ	Temporary
228-231	1.2(D + EO + PO + AF) + L + EQ	Temporary
232	1.4(D + ET + PT)	Permanent
233-236	1.2(D + ET + PT) + 1.6W	Temporary
237-240	1.2(D + ET + PT) + L + 1.6W	Temporary
241	1.4 D	Permanent

Unfactored Load Combination

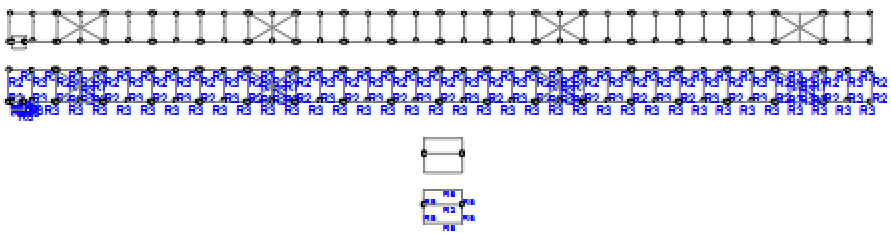
The following unfactored loading combinations are used for steel design, deflection and support reactions for foundation design by Allowable Stress Design.

Load ID	Description	Increase in Allowable Stress	Remarks
100-103	1.0 D + 1.0 E(E) + 1.0 P(E) + 1.0 W	33%	Temporary
104-107	1.0 D + 1.0 E(E) + 1.0 P(E) + 1.0 EQ/1.4	33%	Temporary
108-111	1.0 D + 1.0 E(O) + 1.0 P(O) + 1.0 AF + 1.0 F + 1.0 L	0%	Permanent
112-115	1.0 D + 1.0 E(O) + 1.0 P(O) + 1.0 AF + 1.0 W	33%	Temporary
116-119	0.9 D + 0.9 E(O) + 0.9 P(O) + 0.9 AF + 1.0 W	33%	Temporary
120-123	1.0 D + 1.0 E(O) + 1.0 P(O) + 1.0 AF + 0.75(L + W)	33%	Temporary
124-127	1.0 D + 1.0 E(O) + 1.0 P(O) + 1.0 AF ± 1.0 EQ/1.4	33%	Temporary
128-131	0.9(D + EO + PO + AF) + 1.0 EQ/1.4	33%	Temporary
132-135	1.0 D + 1.0 E(O) + 1.0 P(O) + 1.0 AF + 0.75(L + 1/1.4EQ)	33%	Temporary
136	1.0 D + 1.0 E(T) + 1.0 P(T) + 1.0 L	0%	Permanent
137-140	1.0 D + 1.0 E(T) + 1.0 P(T) + 0.75(L + W)	33%	Temporary
141	1.0 D + 1.0 L +1.0 E(O) + 1.0 P(O)	0%	Permanent

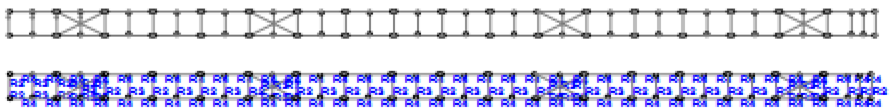
Where :

- D : Dead Load
- L : Live Load
- P : Piping Load
- F : Friction Load
- W : Wind Load
- EQ : Earthquake Load
- Af : Anchor Force

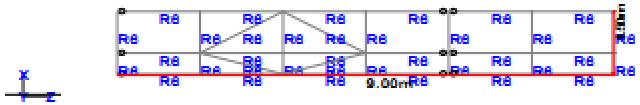
STEEL FRAME DESIGN



Elevation TOS +3500 Plan View



Elevation TOS +5500 Plan View



Elevation TOS +6200 Plan View

Pipe Rack Type-1

Sym.	mension	Material	Remarks
R1	WH 200 x 200 x 8 x 12	Structural Steel A-36	Main Column
R2	SH 300 x 150 x 6.5 x 9	Structural Steel A-36	Transv'l. Main Beam
R3	SH 250 x 125 x 6 x 9	Structural Steel A-36	Bottom Longitudinal Beam & Transv' Sec. Beam
R4	SH 300 x 150 x 6.5 x 9	Structural Steel A-36	Upper Longitudinal Beam
R5	SH 200 x 100 x 5.5 x 8	Structural Steel A-36	Upper Platform Column
R6	C 150 x 75 x 6.5 x 10	Structural Steel A-36	Platform Beam
R7	CT 150 x 150 x 6.5 x 9	Structural Steel A-36	Vert'l & Hor'l Bracing
R8	C 100 x 50 x 5 x 7.5	Structural Steel A-36	Instrument Tray Support

DESIGN CALCULATION cont..

Grating Dead Load

Wr Grating weight (Assumed) = 1.50 kN/m^2

Live Load (DL)

LL Live Load (400kg/m2) = 3.92 kN/m^2 (Reference 1)

Piping Load (P)

Piping load consists of pipe weight at empty, operating and test condition.

Weight Piping Loads on the Pipe Rack are as follows (see in Attach.G) :

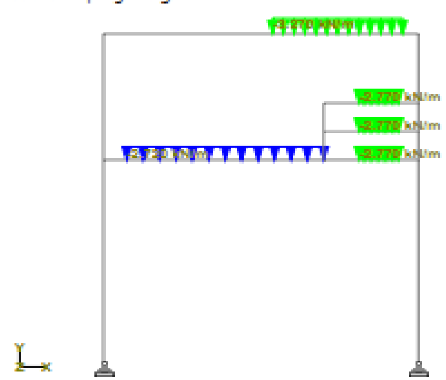
East - West Pipe Rack

L Pipe Rack = 108 m B Pipe Rack = 2.5 m

A = 270.00 m2

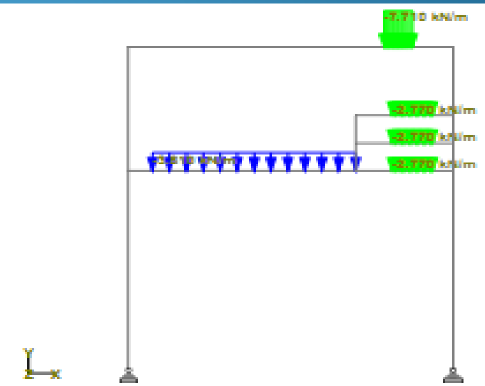
Empty = 25000 kg = 245.17 kN

W_{pipe}	Piping weight	=	0.91 kN/m2
S_{pipe}	Span of Piping weight	=	3.00 m
U_{pipe}	Uniform load of Piping weight	=	2.72 kN/m



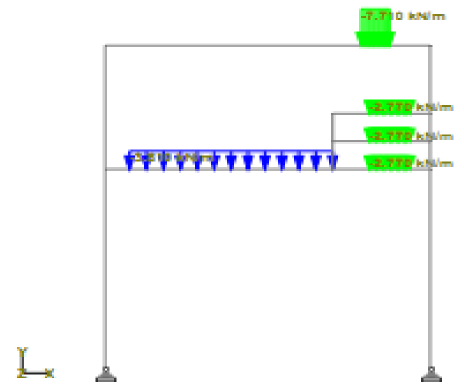
Operating= 10000 kg = 98.07 kN + 245.17 kN = 343.23 kN

W_{pipe}	Piping weight	=	1.27 kN/m2
S_{pipe}	Span of Piping weight	=	3.00 m
U_{pipe}	Uniform load of Piping weight	=	3.81 kN/m



Test = 35000 kg = 343.23 kN

W_{pipe}	Piping weight	=	1.27 kN/m2
S_{pipe}	Span of Piping weight	=	3.00 m
U_{pipe}	Uniform load of Piping weight	=	3.81 kN/m



DESIGN CALCULATION cont..

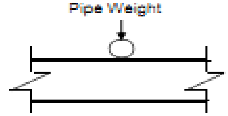
Operating Condition (Based on Piping Stress Analysis, see in Attach.G)
Test Condition (Assumed the Loading refer to Operating Condition)

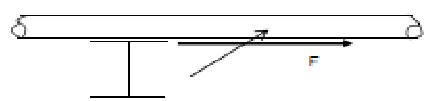
In addition to axial piping load, there is also a lateral piping load caused by friction due to pipe expansion. Lateral load will be applied both perpendicular and normal to pipe.

Pipe rack friction forces caused by the sliding of pipes, horizontal vessels or heat exchangers on their supports due to thermal expansion.
Thermal or friction loads are calculated with friction coeffficients (μ) as follows:

Coeficient of friction	=	μ	(Steel to Steel)	=	35%	(Longitudinal Dir.)
Coeficient of friction	=	μ	(Assumed)	=	5%	(Transversal Dir.)

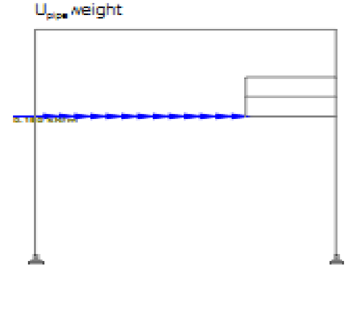
F : μ x total pipe load
: heaviest single pipe
or whicever is greater x μ

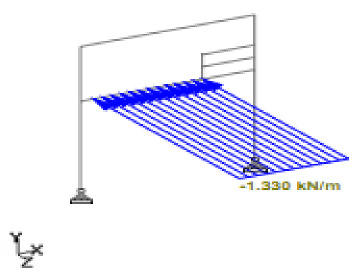




W_{pipe} weight	=	1.27 kN/m2		
S_{pipe} weight	=	3 m		
U_{pipe} weight	=	3.81 kN/m	x	0.35
	=	1.33 kN/m	(Longitudinal Dir.)	

W_{pipe} weight	=	1.27 kN/m2		
S_{pipe} weight	=	3 m		
U_{pipe} weight	=	3.81 kN/m	x	0.05
	=	0.19 kN/m	(Transversal Dir.)	

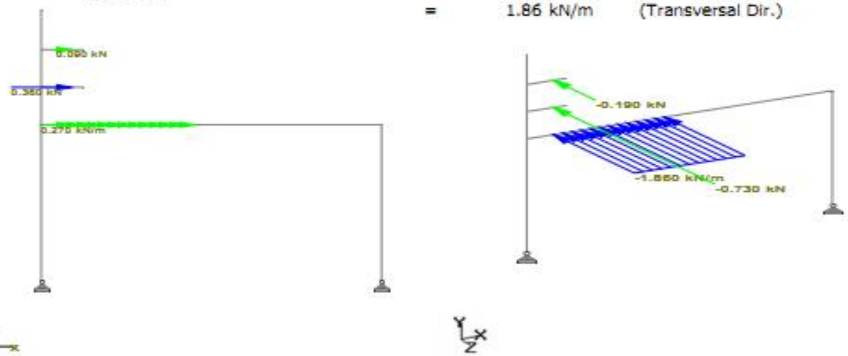




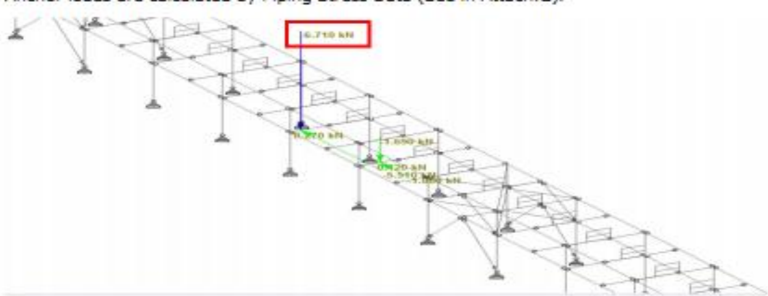
DESIGN CALCULATION cont..

W_{pipe} weight	=	1.77 kN/m2	
S_{pipe} weight	=	3 m	
U_{pipe} weight	=	5.31 kN/m	x 0.05
	=	0.27 kN/m	(Transversal Dir.)

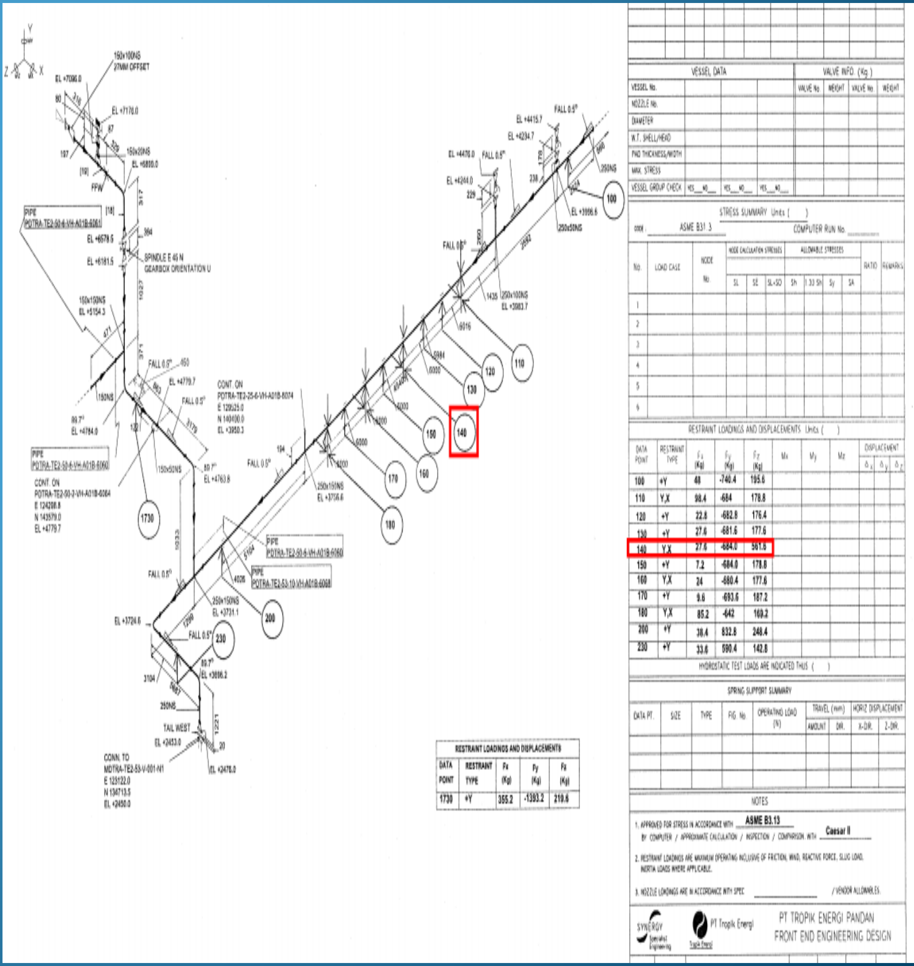
W_{pipe} weight	=	1.77 kN/m2	
S_{pipe} weight	=	3 m	
U_{pipe} weight	=	5.31 kN/m	x 0.35
	=	1.86 kN/m	(Transversal Dir.)



Anchor loads are calculated by Piping Stress Data (See in Attach.G).



East - West Pipe Rack



DATA POINT	RESTRAINT TYPE	Fx (Kg)	Fy (Kg)	Fz (Kg)	Mx	My	Mz	DISPLACEMENT Δx	Δy	Δz
100	+Y	48	-740.4	195.6						
110	Y,X	98.4	-684	178.8						
120	+Y	22.8	-682.8	176.4						
130	+Y	27.6	-681.6	177.6						
140	Y,X	27.6	-684.0	561.6						
150	+Y	7.2	-684.0	178.8						
160	Y,X	24	-680.4	177.6						
170	+Y	9.6	-693.6	187.2						
180	Y,X	85.2	-642	169.2						
200	+Y	38.4	832.8	248.4						
230	+Y	33.6	590.4	142.8						

RESTRAINT LOADINGS AND DISPLACEMENTS

DATA POINT	RESTRAINT TYPE	Fx (Kg)	Fy (Kg)	Fz (Kg)
1730	+Y	355.2	-1393.2	219.6

DESIGN CALCULATION cont..

Earthquake Load (EQ)
Earthquake load is calculated in accordance with UBC 1997.

Seismic zone	=	5	(Ref. 1 Sect. 8.8)
Seismic zone factor Z	=	0.25	(Ref. 1 Sect. 8.8)
Soil profile type	=	Soft Soil (SE)	(Ref. 1 Sect. 8.8)

Ca	Seismic coefficient	=	0.35
Cv	Seismic coefficient	=	0.74
I	Importance factor for hazardous facilities	=	1.25
Rx	Numerical coefficient factor at X-dir for steel special moment-resisting frame system	=	8.50
Rz	Numerical coefficient factor at Z-dir for steel moment-resisting frame system	=	4.50
T	Fundamental Period = $0.0488\ h^{3/4}$	=	0.168 s

Design base shear for pipe rack will be calculated by using equation below:
Total design base shear shall be:

$$V_s = \frac{C_v \times I \times \sum W_t}{R_x \times T} = 0.648 \times \Sigma W_t$$

$$V_s = \frac{C_v \times I \times \sum W_t}{R_z \times T} = 1.223 \times \Sigma W_t$$

Total design base shear need not exceed the following:

$$V_s = \frac{2.5 \times C_a \times I}{R_x} \times \sum W_t = 0.129 \times \Sigma W_t$$

$$V_s = \frac{2.5 \times C_a \times I}{R_z} \times \sum W_t = 0.243 \times \Sigma W_t$$

but shall not be less then:

$$V_s = 0.11 \times C_a \times I \times \sum W_t = 0.048 \times \Sigma W_t$$

Taken :
$V_s = 0.129 \times \Sigma W_t$ (X Direction)
$V_s = 0.243 \times \Sigma W_t$ (Z Direction)

Based on UBC' 97, the zone for Earthquake Z = 0.30 , so the value will be changed :

Ca	Seismic coefficient	=	0.36
Cv	Seismic coefficient	=	0.84

$$V_s = \frac{2.5 \times C_a \times I}{R_x} \times \sum W_t = 1.125 \times \Sigma W_t$$

$$V_s = \frac{2.5 \times C_a \times I}{R_z} \times \sum W_t = 1.125 \times \Sigma W_t$$

$$\left.\begin{array}{l} R_x = 8.743 \\ R_z = 4.629 \end{array}\right\} \text{Will be input by Staad Pro}$$

DESIGN CALCULATION cont..

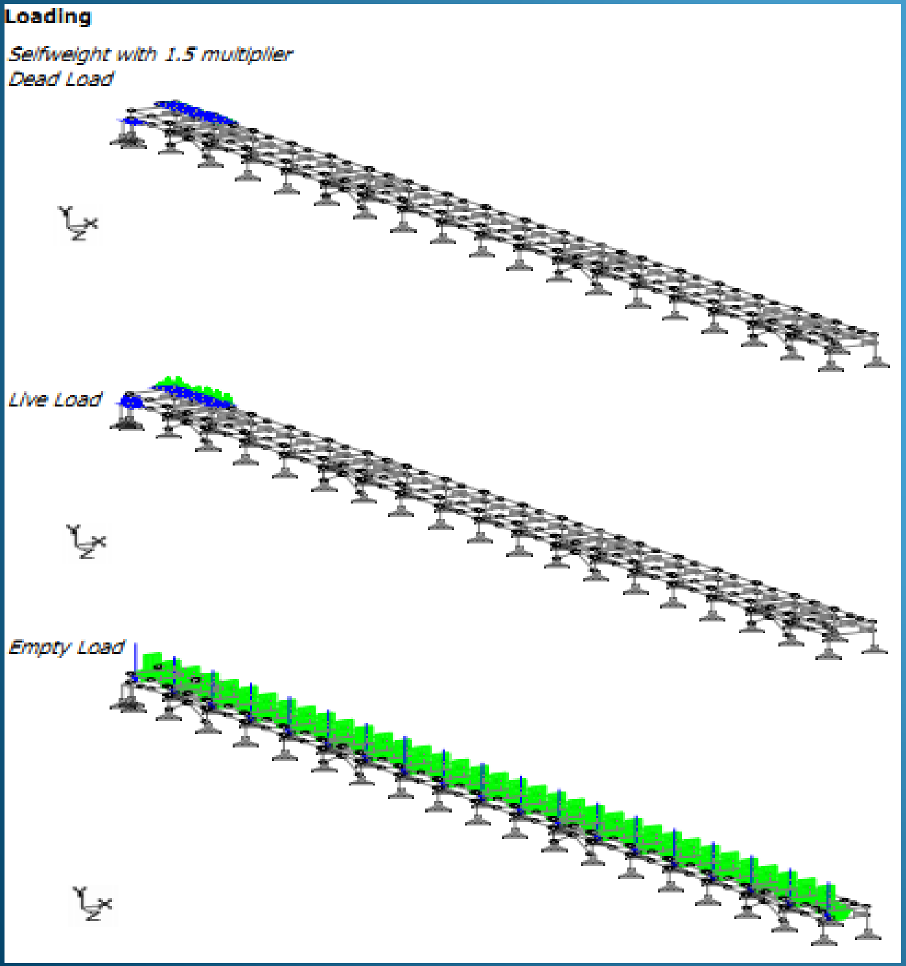
Tabel 12 – Faktor R, C_d, dan Ω_0 untuk sistem pemikul gaya seismik (lanjutan)

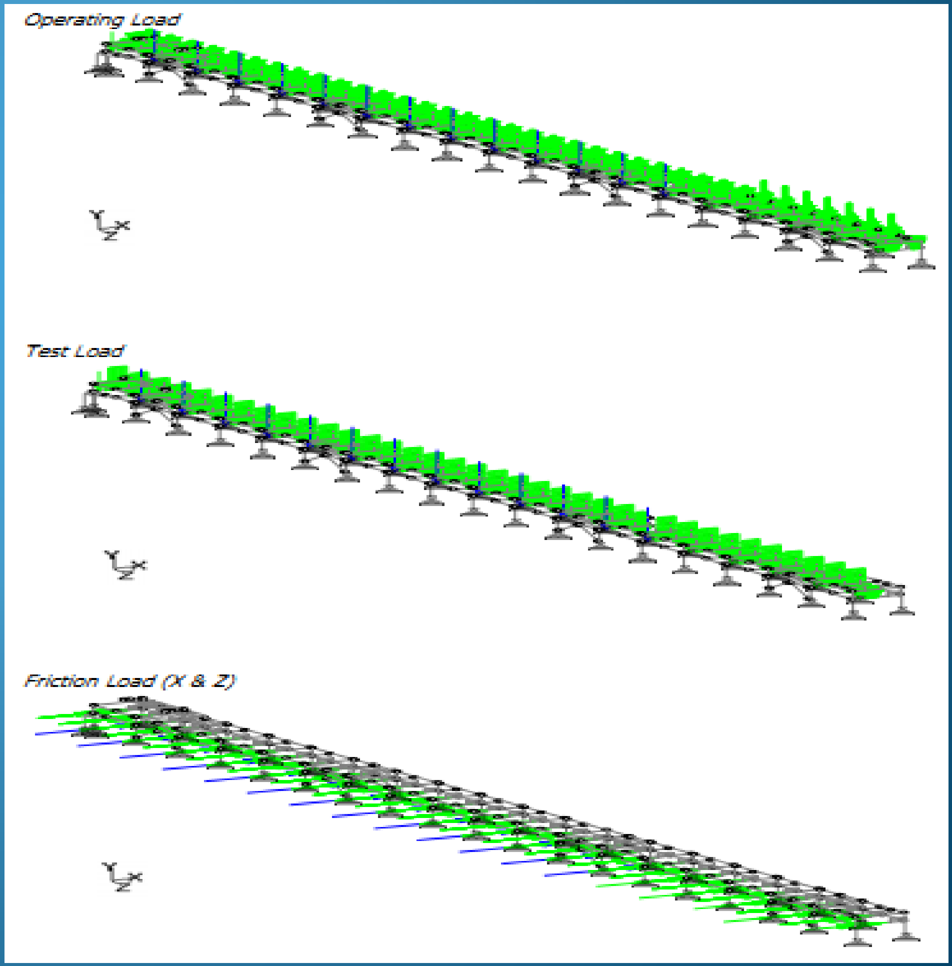
Sistem pemikul gaya seismik	Koefisien modifikasi respons, R[a]	Faktor kuat lebih sistem, Ω_0[b]	Faktor pembesaran defleksi, C_d[c]	Batasan sistem struktur dan batasan tinggi struktur, h_n (m)[d] – Kategori desain seismik: B	C	D[e]	E[e]	F[f]
19. Dinding geser batu bata polos didetail	2	2½	2	TB	TI	TI	TI	TI
20. Dinding geser batu bata polos biasa	1½	2½	1¼	TB	TI	TI	TI	TI
21. Dinding geser batu bata prategang	1½	2½	1¾	TB	TI	TI	TI	TI
22. Dinding rangka ringan (kayu) yang dilapisi dengan panel struktur kayu yang dimaksudkan untuk tahanan geser	7	2½	4½	TB	TB	22	22	22
23. Dinding rangka ringan (baja canai dingin) yang dilapisi dengan panel struktur kayu yang dimaksudkan untuk tahanan geser, atau dengan lembaran baja	7	2½	4½	TB	TB	22	22	22
24. Dinding rangka ringan dengan panel geser dari semua material lainnya	2½	2½	2½	TB	TB	10	TB	TB
25. Rangka baja dengan bresing terkekang terhadap tekuk	8	2½	5	TB	TB	48	48	30
26. Dinding geser pelat baja khusus	7	2	6	TB	TB	48	48	30
C. Sistem rangka pemikul momen								
1. Rangka baja pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
2. Rangka batang baja pemikul momen khusus	7	3	5½	TB	TB	48	30	TI
3. Rangka baja pemikul momen menengah	4½	3	4	TB	TB	10[k]	TI[k]	TI[k]
4. Rangka baja pemikul momen biasa	3½	3	3	TB	TB	TI[l]	TI[l]	TI[l]
5. Rangka beton bertulang pemikul momen khusus[m]	8	3	5½	TB	TB	TB	TB	TB
6. Rangka beton bertulang pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
7. Rangka beton bertulang pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
8. Rangka baja dan beton komposit pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
9. Rangka baja dan beton komposit pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
10. Rangka baja dan beton komposit terkekang parsial pemikul momen	6	3	5½	48	48	30	TI	TI
11. Rangka baja dan beton komposit pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
12. Rangka baja canai dingin pemikul momen khusus dengan pembautan[n]	3½	3[o]	3½	10	10	10	10	10
D. Sistem ganda dengan rangka pemikul momen khusus yang mampu menahan paling sedikit 25 % gaya seismik yang ditetapkan								
1. Rangka baja dengan bresing eksentris	8	2½	4	TB	TB	TB	TB	TB
2. Rangka baja dengan bresing konsentris khusus	7	2½	5½	TB	TB	TB	TB	TB
3. Dinding geser beton bertulang khusus[g,h]	7	2½	5½	TB	TB	TB	TB	TB
4. Dinding geser beton bertulang biasa[g]	6	2½	5	TB	TB	TI	TI	TI
5. Rangka baja dan beton komposit dengan bresing eksentris	8	2½	4	TB	TB	TB	TB	TB

Tabel 12 – Faktor R, C_d, dan Ω_0 untuk sistem pemikul gaya seismik (lanjutan)

Sistem pemikul gaya seismik	Koefisien modifikasi respons, R[a]	Faktor kuat lebih sistem, Ω_0[b]	Faktor pembesaran defleksi, C_d[c]	Batasan sistem struktur dan batasan tinggi struktur, h_n (m)[d] – Kategori desain seismik: B	C	D[e]	E[e]	F[f]
E. Sistem ganda dengan rangka pemikul momen menengah mampu menahan paling sedikit 25 % gaya seismik yang ditetapkan								
1. Rangka baja dengan bresing konsentris khusus[e]	6	2½	5	TB	TB	10	TI	TI
2. Dinding geser beton bertulang khusus[g,h]	6½	2½	5	TB	TB	48	30	30
3. Dinding geser batu bata bertulang biasa	3	3	2½	TB	48	TI	TI	TI
4. Dinding geser batu bata bertulang menengah	3½	3	3	TB	TB	TI	TI	TI
5. Rangka baja dan beton komposit dengan bresing konsentris khusus	5½	2½	4½	TB	TB	48	30	TI
6. Rangka baja dan beton komposit dengan bresing biasa	3½	2½	3	TB	TB	TI	TI	TI
7. Dinding geser baja dan beton komposit biasa	5	3	4½	TB	TB	TI	TI	TI
8. Dinding geser beton bertulang biasa[g]	5½	2½	4½	TB	TB	TI	TI	TI
F. Sistem interaktif dinding geser-rangka dengan rangka pemikul momen beton bertulang biasa dan dinding geser beton bertulang biasa[g]	4½	2½	4	TB	TI	TI	TI	TI
G. Sistem kolom kantilever didetail untuk memenuhi persyaratan untuk :								
1. Sistem kolom baja dengan kantilever khusus	2½	1¼	2½	10	10	10	10	10
2. Sistem kolom baja dengan kantilever biasa	1¼	1¼	1¼	10	10	TI[i]	TI[i]	TI[i]
3. Rangka beton bertulang pemikul momen khusus[m]	2½	1¼	2½	10	10	10	10	10
4. Rangka beton bertulang pemikul momen menengah	1½	1¼	1½	10	10	TI	TI	TI
5. Rangka beton bertulang pemikul momen biasa	1	1¼	1	10	TI	TI	TI	TI
6. Rangka kayu	1½	1½	1½	10	10	10	TI	TI
H. Sistem baja tidak didetail secara khusus untuk ketahanan seismik, tidak termasuk sistem kolom kantilever	3	3	3	TB	TB	TI	TI	TI

DESIGN CALCULATION cont..





OUTPUT DATA

TABLE 16-D—MAXIMUM ALLOWABLE DEFLECTION FOR STRUCTURAL MEMBERS[1]

TYPE OF MEMBER	MEMBER LOADED WITH LIVE LOAD ONLY (L)	MEMBER LOADED WITH LIVE LOAD PLUS DEAD LOAD (L + K.D.)
Roof member supporting plaster or floor member	l/360	l/240

[1]Sufficient slope or camber shall be provided for flat roofs in accordance with Section 1611.7.

L.—live load.

D.—dead load.

K.—factor as determined by Table 16-E.

l—length of member in same units as deflection.

1997 UNIFORM BUILDING CODE

DEFLECTIONS

ANSI/AISC 360-16
An American National Standard

Excessive vertical deflections and misalignment arise primarily from three sources: (a) gravity loads, such as dead, live and snow loads; (b) effects of temperature, creep and differential settlement; and (c) construction tolerances and errors. Such deformations may be visually objectionable; cause separation, cracking or leakage of exterior cladding, doors, windows and seals; and cause damage to interior components and finishes. Appropriate limiting values of deformations depend on the type of structure, detailing and intended use (Galambos and Ellingwood, 1986). Historically, common deflection limits for horizontal members have been 1/360 of the span for floors subjected to reduced live load and 1/240 of the span for roof members. Deflections of about 1/300 of the span (for cantilevers, 1/150 of the length) are visible and may lead to general architectural damage or cladding leakage. Deflections greater than 1/200 of the span may impair operation of moveable components such as doors, windows and sliding partitions.

Deflection

Vertical Deflection

The limiting permissible vertical deflection for structural steel members shall be as specified below unless specified in vendor's requirement.

- Grating/ Checkered Plate : kL/200 or ¼″ whichever is minimum.
- Purlin supporting any type of roofing material under (Dead load + live load) or (dead load + wind load) conditions :kL/200
- Other structures/ structural components : As specified in relevant AISC Codes

OUTPUT DATA cont..

- Based on the given condition in the structural analysis, steel structure of pipe rack and foundation are considered adequate in meeting the design criteria.
- Steel structure dimension and UC ratio of pipe racks are :

Sym.	Dimension	Material	Max UC Ratio	Remarks
C1	WH 200 x 200 x 8 x 12	Structural Steel A-36	0.829	Main Column
1B1/2B1	SH 300 x 150 x 6.5 x 9	Structural Steel A-36	0.712	Transv'l. Main Beam
1B2/2B2	SH 250 x 125 x 6 x 9	Structural Steel A-36	0.811	Bottom Longitudinal Beam & Transv' Sec. Beam
2B1	SH 300 x 150 x 6.5 x 9	Structural Steel A-36	0.635	Upper Longitudinal Beam
C2	SH 200 x 100 x 5.5 x 8	Structural Steel A-36	0.484	Upper Platform Column
1B3/3B3/3BR2	C 150 x 75 x 6.5 x 10	Structural Steel A-36	0.700	Platform Beam
1BR1/2BR1/3BR1	CT 150 x 150 x 6.5 x 9	Structural Steel A-36	0.722	Vert'l & Hor'l Bracing

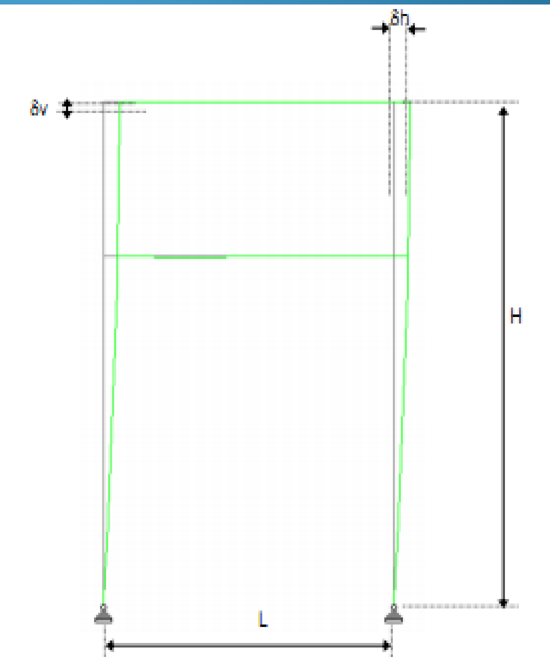
- Based on design and calculation, maximum displacement of structure :

Vertical displacement = 8.8 mm $< \delta_{al} = 20.00$ mm.... OK

Horizontal displacement = 9.79 mm $< \delta_{al} = 27.5$ mm.... OK

- Based on the structural analysis, the single pile axial and lateral capacity check:

Maximum axial force = 110.48 kN < 641.35 kN...OK
Maximum horizontal force = 25.87 kN < 58.74 kN...OK



δv	Vertical deflection (LC 109)	=	8.80	mm	STD Pro Output
L	Length of structure	=	4.00	m	
δv-all	Vertical allowable deflection = L / 200	=	20.00	mm	δv-all > δv, OK
δh	Horizontal deflection (LC 125)	=	9.79	mm	STD Pro Output
H	Height of structure	=	5.20	m	
δh-all	Horizontal allowable deflection = H / 200	=	26.00	mm	δh-all > δh, OK

OUTPUT DATA cont..

Support Reaction

The following unfactored support reactions are maximum value from STAAD Pro Output.

Node	Load Combination	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN
2	125 (D + EO + PO + AF) + 1/1.4EQX-	5.36	45.15	-4.96
11	124 (D + EO + PO + AF) + 1/1.4EQX+	-5.24	54.22	-5.74
10	135 (D + EO + PO + AF) + 0.75(L + 1/1.4EQZ-)	0.06	95.11	20.99
420	129 0.9(D + EO + PO + AF) + 1/1.4EQX-	1.09	-1.83	0.04
10	127 (D + EO + PO + AF) + 1/1.4EQZ-	0.05	83.88	25.87
11	126 (D + EO + PO + AF) + 1/1.4EQZ+	-0.70	74.65	-24.75
1	100 (D + EE + PE) + WX+	-0.99	10.13	0.01
1	100 (D + EE + PE) + WX+	-0.99	10.13	0.01
1	100 (D + EE + PE) + WX+	-0.99	10.13	0.01
1	100 (D + EE + PE) + WX+	-0.99	10.13	0.01
1	100 (D + EE + PE) + WX+	-0.99	10.13	0.01
1	100 (D + EE + PE) + WX+	-0.99	10.13	0.01

The following factored support reactions are maximum value from STAAD Pro Output.

Node	Load Combination	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN
2	229 1.2(D + EO + PO + AF) + L + EQX-	7.43	57.91	-6.14
11	228 1.2(D + EO + PO + AF) + L + EQX+	-7.23	71.01	-7.02
10	231 1.2(D + EO + PO + AF) + L + EQZ-	0.29	131.64	35.11
11	207 0.9(D + EE + PE) + EQZ-	0.10	-9.71	23.30
10	231 1.2(D + EO + PO + AF) + L + EQZ-	0.29	131.64	35.11
11	230 1.2(D + EO + PO + AF) + L + EQZ+	-0.87	99.62	-33.65
1	200 0.9(D + EE + PE) + 1.6WX+	-1.70	6.75	0.01
1	200 0.9(D + EE + PE) + 1.6WX+	-1.70	6.75	0.01
1	200 0.9(D + EE + PE) + 1.6WX+	-1.70	6.75	0.01
1	200 0.9(D + EE + PE) + 1.6WX+	-1.70	6.75	0.01
1	200 0.9(D + EE + PE) + 1.6WX+	-1.70	6.75	0.01
1	200 0.9(D + EE + PE) + 1.6WX+	-1.70	6.75	0.01

CONNECTION DETAIL

Connection Details

a. Connection Calc. for Beam H 400 x 200 x 8 x 13 to Column Flange H 300 x 300 x 10 x 15 (Type 2)

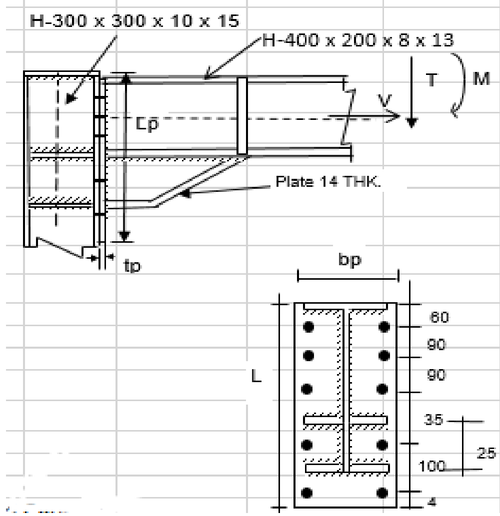


Plate :					
- t_p =	30	mm	- F_u =	4100	kg/cm^2
- F_y =	2531	kg/cm^2	- Lp =	735	mm
H 300 x 300 x 10 x 15 :			H 400 x 200 x 8 x 13 :		
- h_2 =	300	mm	- h_1 =	400	mm
- bf_2 =	300	mm	- b_{f1} =	200	mm
- t_{w2} =	10	mm	- t_{w1} =	8	mm
- t_{f2} =	15	mm	- t_{f1} =	13	mm
HSB Bolt A-325 :			Weld E70XX Electrode :		
- d_b =	24	mm	- w =	6	mm
- F_t =	3093.56	kg/cm^2	- F_u =	4914	kg/cm^2
- F_v =	1195.24	kg/cm^2	- F_v =	1400	kg/cm^2
- n =	10	(M24)			

CONNECTION DETAIL cont..

BASE PLATE DESIGN

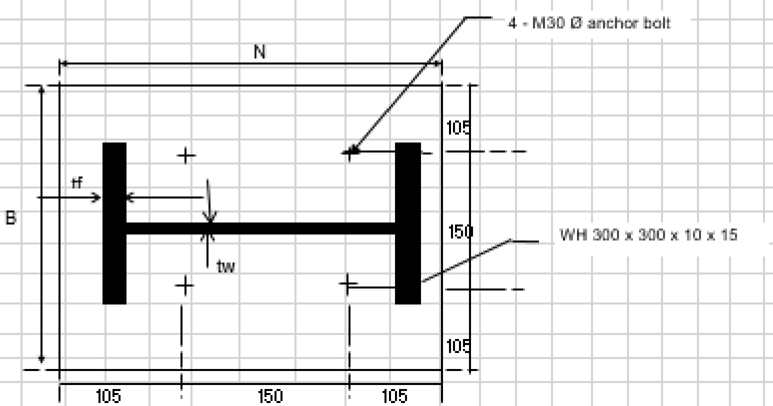
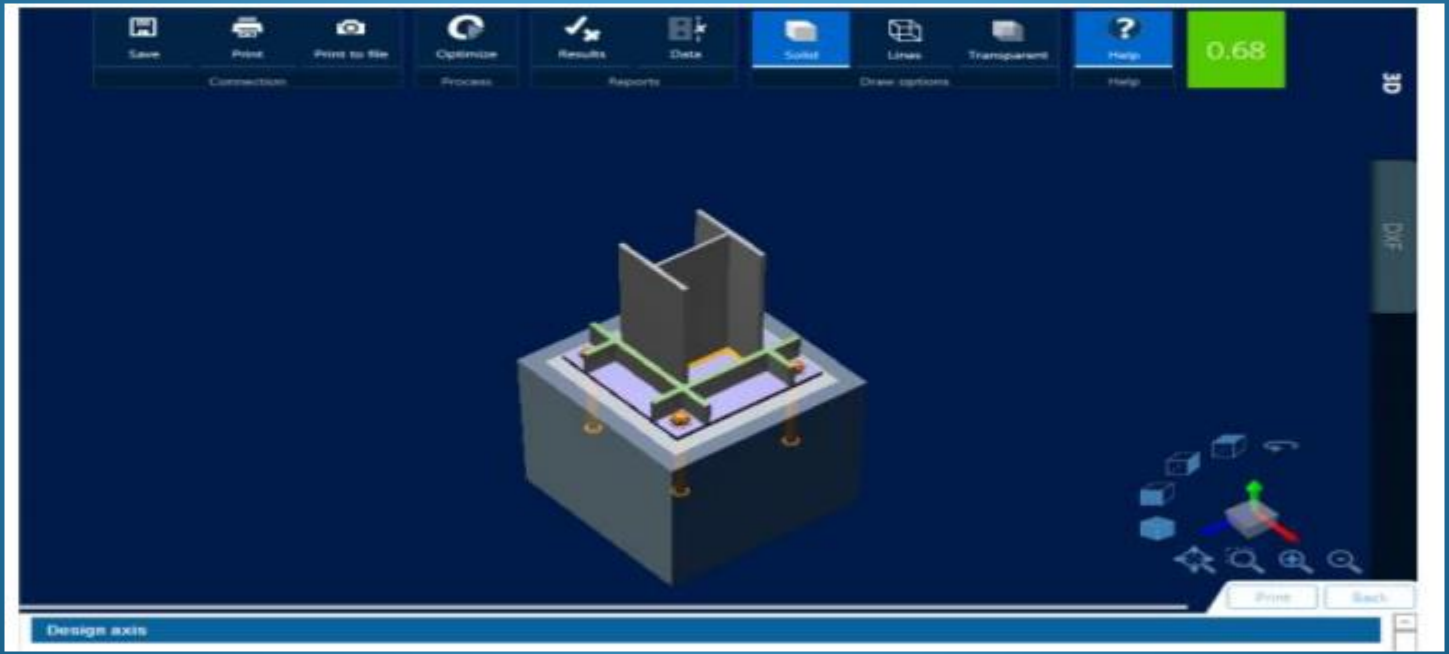


Plate :						
1 ksi =		1.00	kip/inch^2 =	6.895	Mpa or N/mm^2	
Steel ASTM A 36 =		36.00	kip/inch^2 =	248.21	Mpa or N/mm^2	
- t_p =	32	mm				
- B =	360	mm				
- N =	360	mm				
- F_y =	2400	kg/cm^2	=	235.36	Mpa or N/mm^2	(Steel JIS G3101 Grade SS400)
- F_u =	4078	kg/cm^2				
Base plate weight =		0.033	T			

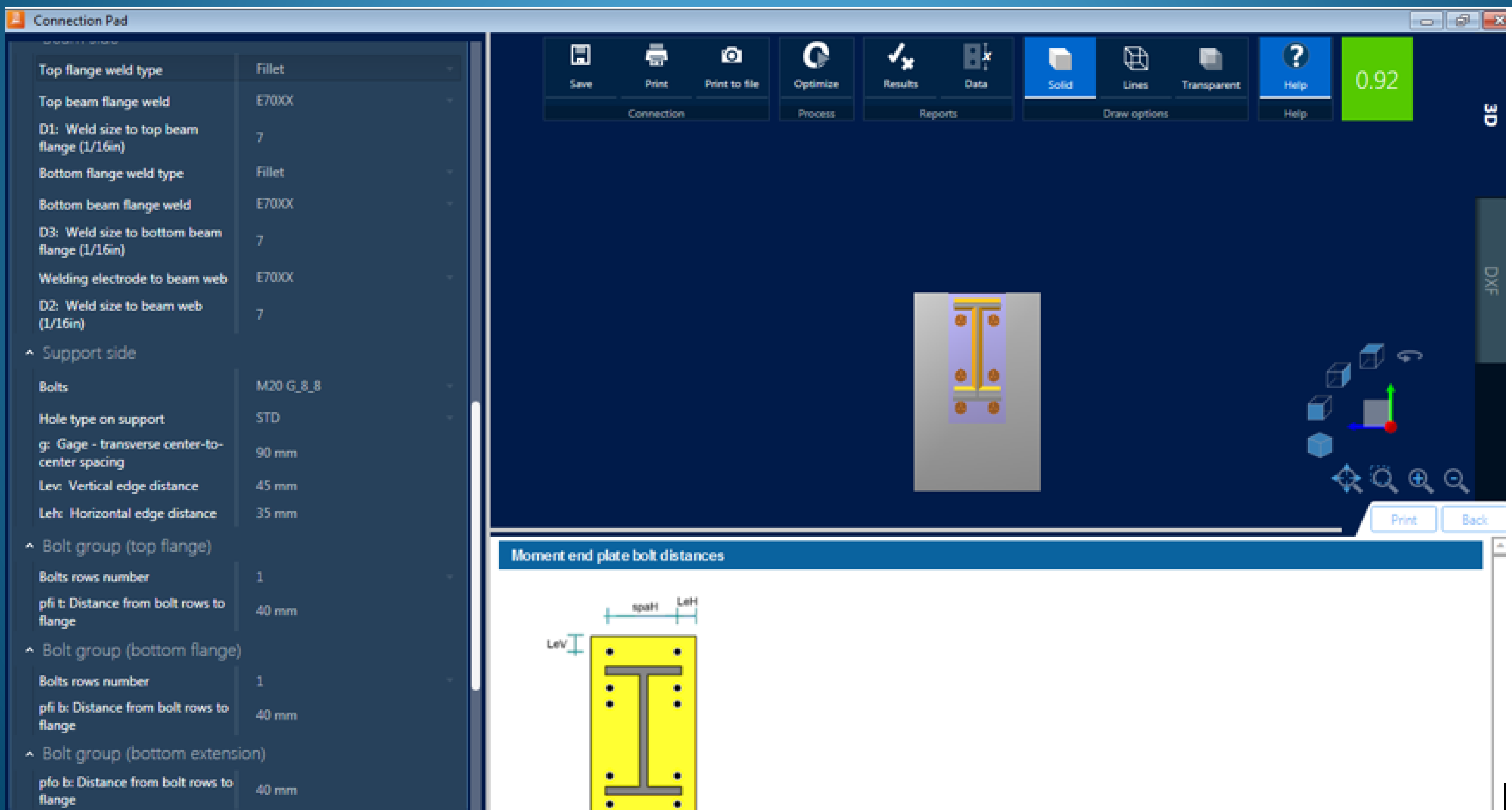
Structure column dimension:						
WH 300x300x10x15			Concrete Pedestal :			
- H =	300	mm	-Section area =	450.00	x	450.00
- b_f =	300	mm	=	202500	mm^2	
- t_w =	10	mm	- f'_c =	240.00	kg/cm^2	
- t_f =	15	mm	- cover =	65.00	mm	

Weld E60XX Electrode :			Anchor Bolt A-36 :			
- w1 =	6	mm	- d_b =	30	mm	(1 1/4")
- w2 =	6	mm	- F_t =	19.14	ksi	(0.33 Fu ----> AISC ASD)
- w3 =	6	mm	=	1345.68	kg/cm^2	
- w4 =	6	mm	- F_v =	9.86	ksi	(0.17 Fu ----> AISC ASD)
- F_u =	60.00	ksi	=	693.23	kg/cm^2	
=	4218.42	kg/cm^2	- n =	4		
- F_v =	19.60	ksi				
=	1378.02	kg/cm^2				
- F_t =	1378.02	kg/cm^2				

CONNECTION DETAIL cont..



CONNECTION DETAIL cont..



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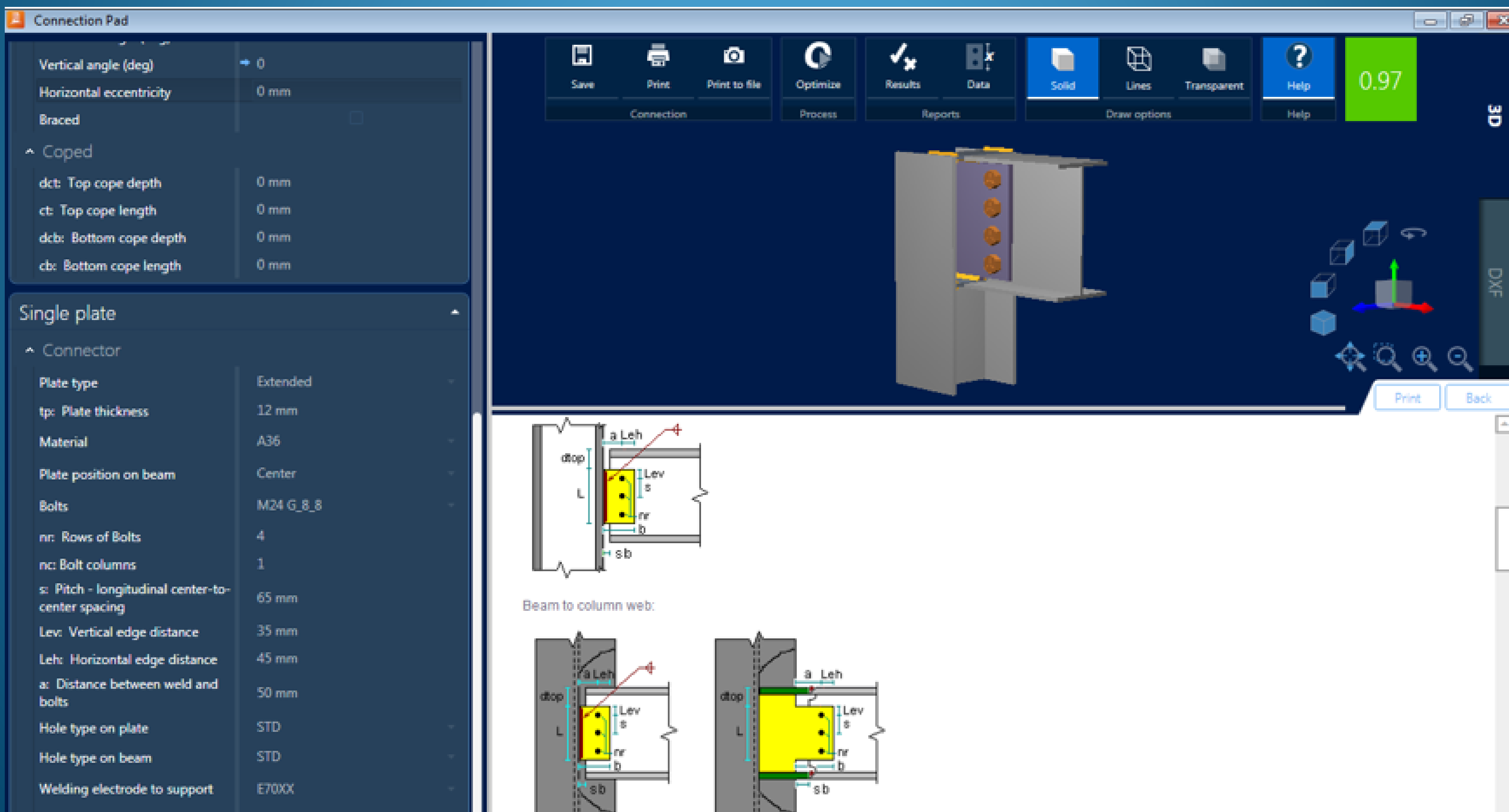

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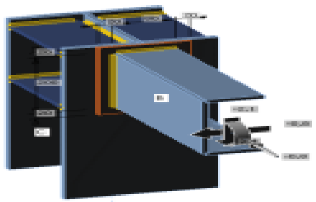
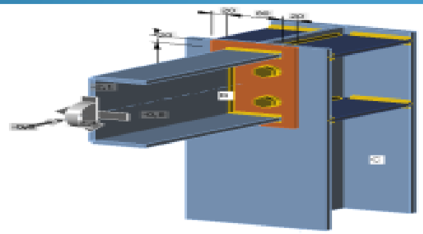




Project:
Project no:
Author:

IDEA StatiCa

Project data

Project name	
Project number	
Author	
Description	
Date	04/09/2020
Design code	AISC 360-16

Material

Steel	A36

Project:
Project no:
Author:

IDEA StatiCa

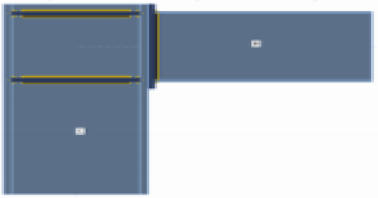
Project item CON4

Design

Name	CON4
Description	
Analysis	Stress, strain/ simplified loading
Design code	AISC – ASD

Beams and columns

Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
C	10 – H 200x200x8	0,0	90,0	0,0	0	15	0	Node
B	3 – U 200x80x7,5	0,0	0,0	0,0	0	0	0	Node



Cross-sections

Name	Material
10 - H 200x200x8	A36
3 - U 200x80x7,5	A36

Bolts

Name	Bolt assembly	Diameter [mm]	fu [MPa]	Gro
5/8 A325	5/8 A325	16	825,0	

CONNECTION DETAIL cont..

Load effects (equilibrium not required)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	B	-0,8	-0,8	-2,1	0,0	2,4	0,0

Check

Summary

Name	Value	Check status
Analysis	100,0%	OK
Plates	0,1 < 5%	OK
Bolts	36,0 < 100%	OK
Welds	54,9 < 100%	OK
Buckling	Not calculated	

Plates

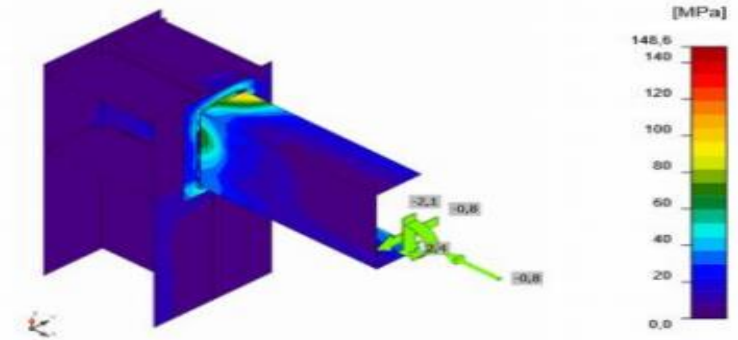
Name	F_y [MPa]	Thickness [mm]	Loads	σ_{Ed} [MPa]	ε_{Pl} [%]	Check status
C-bfl 1	248,2	12,0	LE1	8,6	0,0	OK
C-tfl 1	248,2	12,0	LE1	88,5	0,0	OK
C-w 1	248,2	8,0	LE1	38,5	0,0	OK
B-bfl 1	248,2	11,0	LE1	84,1	0,0	OK
B-tfl 1	248,2	11,0	LE1	97,7	0,0	OK
B-w 1	248,2	7,5	LE1	72,6	0,0	OK
STIFF1a	248,2	10,0	LE1	21,6	0,0	OK
STIFF1b	248,2	10,0	LE1	8,9	0,0	OK
STIFF1c	248,2	10,0	LE1	23,0	0,0	OK
STIFF1d	248,2	10,0	LE1	5,0	0,0	OK
EP1	248,2	8,0	LE1	148,8	0,1	OK

Design data

Material	fy [MPa]	ε_{lim} [%]
A36	248,2	5,0

Symbol explanation

ε_{Pl}	Plastic strain
σ_{Ed}	Eq. stress
fy	Yield strength
ε_{lim}	Limit of plastic strain



Equivalent stress, LE1

Bolts

Shape	Item	Grade	Loads	F_t [kN]	V [kN]	$Rn/\Omega_{Bearing}$ [kN]	Ut_t [%]	Ut_s [%]	Ut_{ts} [%]	Status
	B7	5/8 A325 - 1	LE1	22,1	1,5	61,0	36,0	4,2	-	OK
	B8	5/8 A325 - 1	LE1	4,8	1,4	61,0	7,8	3,9	-	OK

Design data

Grade	$Rn/\Omega_{Tension}$ [kN]	Rn/Ω_{Shear} [kN]
5/8 A325 - 1	61,4	36,8

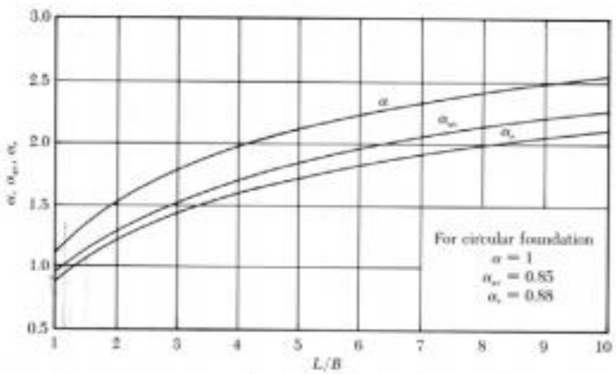
Symbol explanation

F_t	Tension force		
V	Resultant of shear forces Vy, Vz in bolt	$Rn/\Omega_{Tension}$	Bolt tension resistance AISC 360-16 J3.6
$Rn/\Omega_{Bearing}$	Bolt bearing resistance	Rn/Ω_{Shear}	Bolt shear resistance AISC 360-16 – J3.8
Ut_t	Utilization in tension		
Ut_s	Utilization in shear		
Ut_{ts}	Utilization in tension and shear		

FOUNDATION DESIGN

MOSES INSTITUTE

1. Immediate Settlement (Se)



Assumed settlement occurred uniformly at the bottom of square foundation:

$$S_e = \frac{Bq_o}{E_s}(1-\mu_s^2)\alpha_r = \text{(rigid foundation)}$$

L/B	=	1		Test Condition Load V =	659.15 kN (Staad Pro Static Result)
α_r	=	0.77		Ope Condition Load V =	659.15 kN (Staad Pro Static Result)
V	=	(W_{found} + E(T)			
	=	12.37+2.99+659.15			
	=	674.5 kN			
Width	=	800 mm	=	0.8 m	
Lengtł	=	800 mm	=	0.8 m	
Af	=	Width x Length	=	0.64 m^2	
q_o	=	V / Af	=	1053.9 kN/m^2	
E_s	=	Modulus of elasticity of soil			
		for elastic settlement, take the smallest Es from Soil Report			
	=	54 kg/cm^2			
	=	5296 kN/m^2			
µs	=	0.45	(for most clay soils)		

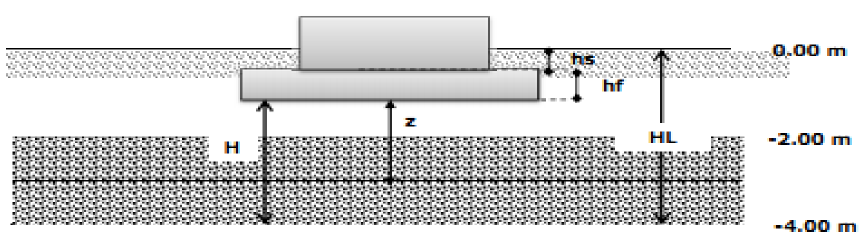
μ	Soil type
0.4–0.5	Most clay soils
0.45–0.50	Saturated clay soils
0.3–0.4	Cohesionless—medium and dense
0.2–0.35	Cohesionless—loose to medium

Table is taken from Foundation analysis and Design Book fifth Edition, by J Bowles

The elastic settlement is as below:

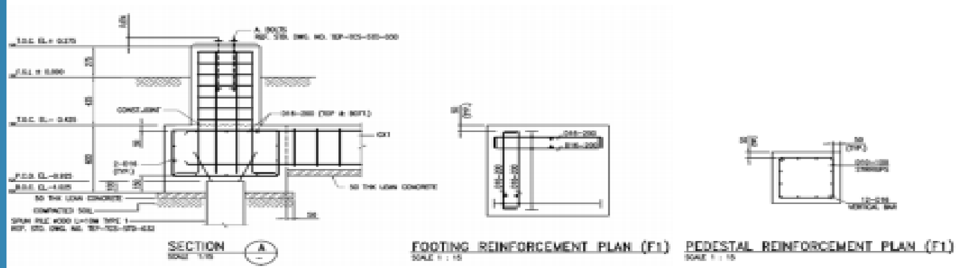
Se	=	0.8 * 1053.93/5295.591 * (1 - 0.45^2)*0.77
	=	0.098 m
	=	97.77 mm

2) Consolidation Settlement (Sc)



FOUNDATION DESIGN Cont..

Plan Foundation



General Data

Concrete

γ_c	Unit weight for structural concrete	=	23.54	kN/m^3
γ_{pc}	Unit weight for leveling concrete	=	21.6	kN/m^3
γ_s	Unit weight for Soil	=	16.09	kN/m^3

Pile Capacity Data

Single pile net. capacity for BH-4 Pile dia 300mm : (see Attachment C)

Allowable Capacity	Q_{comp} (kN)	Q_{lat} (kN)
Permanent	641.4	58.74
Temporary, increase 33%	853.00	78.12

Pilecap Dimension	bwx	=	0.80	m
	bwz	=	0.80	m
	h_f	=	0.60	m

Pedestal Dimension	hp	Height of pedestal	=	0.700	m
	Lp	Length of pedestal	=	0.450	m
	Bp	Width of pedestal	=	0.450	m

Dimension Pile :

Dia.	=	0.30	m
h_p	=	10.00	m
n pile	=	1.00	ea

Vertical Load

Foundation Total Weight and Pile Cap + Pedestal + Soil

Volume of Pile Cap	=	0.384	m^3
Volume of Pedestal	=	0.14	m^3
Volume of Soil	=	0.19	m^3
Weight of Foundation	=	15.37	kN

FOUNDATION DESIGN Cont..

Foundation Settlement Check

The settlement of pile group with average depth of 10 m was analyzed using elastic half-space theory proposed by Timoshenko and Goodier (1951) and Poulos and Davis (1980) as shown below. Imaginary raft at the depth of 2/3 the length of pile was assumed with load spreading of 4v : 1h. The settlement were estimated below.

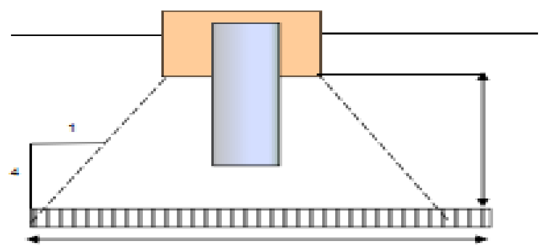
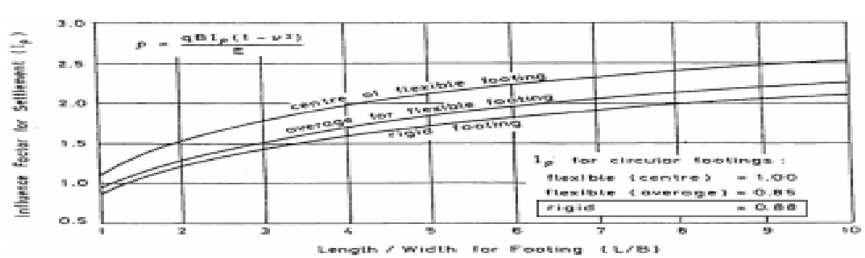


Figure B.11.1 Scheme of load distribution

Check Settlement

where,

Vu_s	Maximum unfactored load combination	110.48	kN
Lp	Length of pile	10	m
N	The value of blow SPT at the pile tip (L = 10m)	47.25	
2/3 Lp		6.67	m
B raft	Width of imagi = 2 x 6.67/4 + 2 x 1 + 0.3	5.63	m
Ar	Area of Imaginary raft	31.73	m^2
p	Load per unit area p = V/Ar	3.48	kPa
μ	Poisson ratio	0.3	
Es	Young Modulus : *Es = 10* (N + 15)* (kg/cm^2)	6225	kPa
Ip	Influence Factor	0.88	



FOUNDATION DESIGN Cont..

Immediate Settlement

Si Elastic Settlement,

$$\boxed{S_i = p.B.\frac{1-\mu^2}{Es}Ip}$$

Si = 0.0025 m
2.5228 mm < 25.4 mm ...OK

Dengan menggunakan data Boring (SPT) atau nilai N. Modulus elastisitas dihitung menggunakan rumus :

E = 6 (N + 5)	kg/cm^2	(untuk pasir berlempung/ lempung)
E = 10 (N + 15)	kg/cm2	(untuk pasir)

Based on Soil Investigation Data

Nomor Titik Bor	Kedalaman (m) Muka Tanah	Muka Air		N	N'
BOR 4	6,00	2,8 - 3		5	7,5
BLOK	8,00			18	22,5
PANDAN	10,00			61	47,25
	12,00			66	52,5
	14,00		>	60	60,25
	16,00		>	60	61,5
	18,00			70	65
	20,00		>	60	60

Nilai Perkiraan Angka Poisson Tanah (sumber Bowles, 1997)

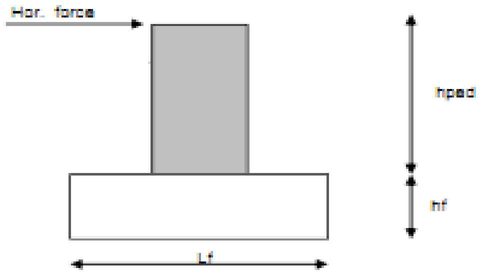
Macam Tanah		$E (Kg/cm^2)$ μ
LEMPUNG		
	Jenuh	0,40 - 0,50
	Tak Jenuh	0,10 - 0,30
	Berpasir	0,20 - 0,30
PASIR		
	Padat	0,20 - 0,40
	Kasar	0,15
	Halus	0,25
LANAU		0,30 - 0,35
LOESS		0,10 - 0,40
CADAS / BATU		0,10 - 0,30

Rasio Poisson sering dianggap sebesar 0,2 - 0,4 dalam pekerjaan-pekerjaan mekanika tanah. Nilai sebesar 0,5 biasanya dipakai untuk tanah jenuh dan nilai 0 sering dipakai untuk tanah kering.

FOUNDATION DESIGN Cont..

Hor.x	=	7.23 kN		(due to earthquake load)
hp	=	0.70 m		
Mz	=	5.06 kN.m	==>	**Mu**
Axial	=	131.64 kN	==>	**Pu**
Pedestal condition		OK !		by inspection of interaction diagram

Use : **12 D 16**



Shear Reinforcement

Bp Pedestal width		=	0.450 m
Vu Ultimate shear forces		=	7.2 kN
Leg of shear reinforcement		=	2
bar diameter		=	10 mm
area section of shear reinforcement	(Av)	=	157.08 mm2
Ø Shear capacity reduction factor		=	0.75

$$Vc = (1 + \frac{Nu}{14\,Ag})\frac{\sqrt{fc'}}{6} * bw * d \quad = \quad 137.39 \text{ kN}$$

Dimension requirement

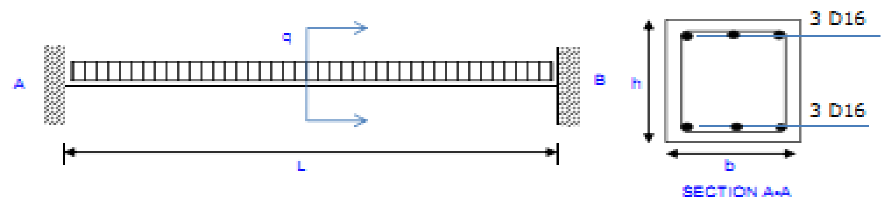
$V_u < 0.5 * Øs * V_c$	No reinforcement required
$0{,}5 * Øs * V_c < V_u < Øs * V_c$	use minimum reinforcement
$(V_u - Øs * V_c) < 0.67 * b_w * d * \sqrt{f_c'}$	pedestal dimension ok, if not, dimension need to be made larger

0.5 ØsVc		Vu		ØsVc
51.520	>	7.23		

==> No Reinforcement required
will use min. shear reiforcement

FOUNDATION DESIGN Cont..

Tie Beam Reinforcement

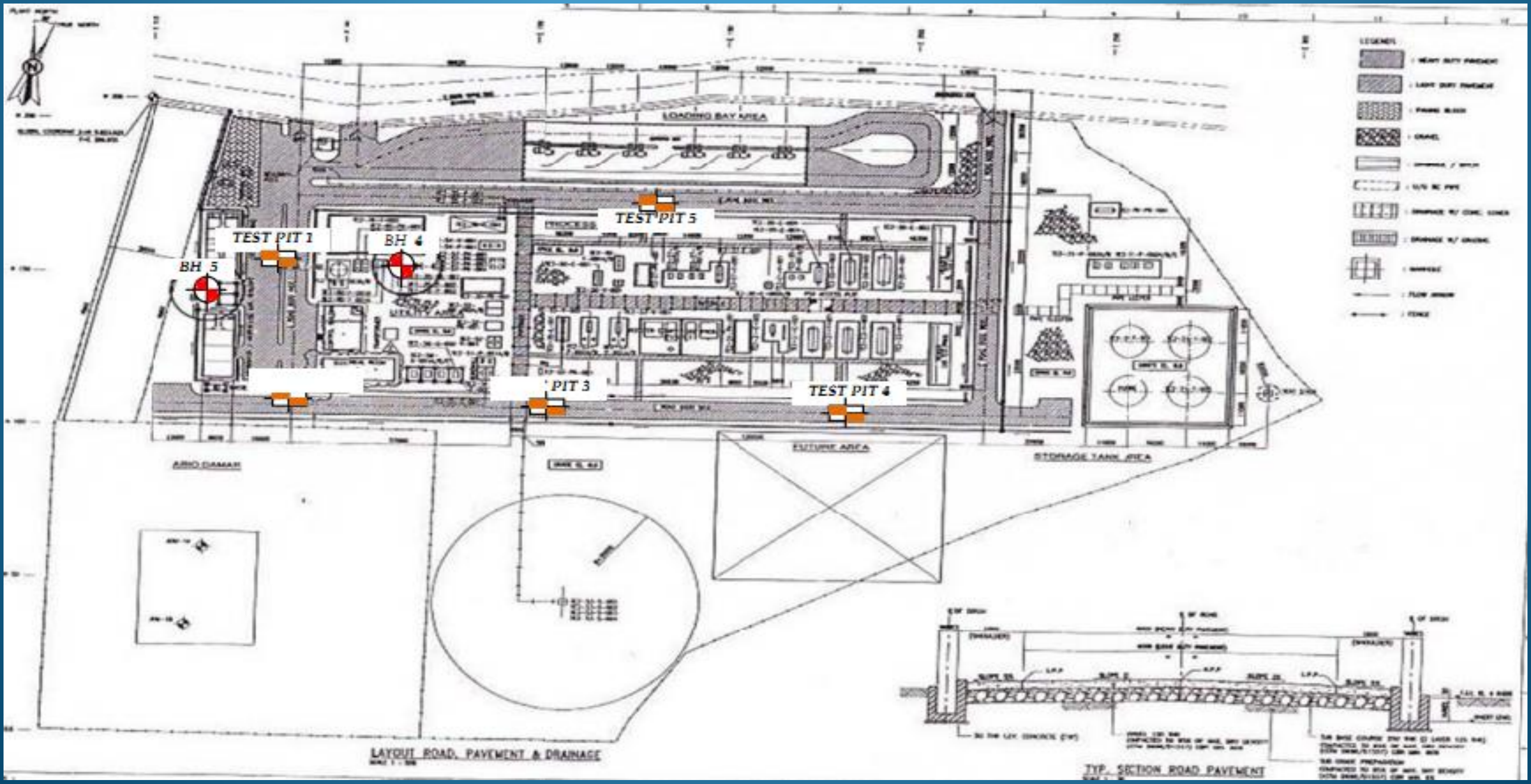


Tie Beam Flexural Reinforcement

L	Tie beam length	=	6000.00	mm	
h	Tie beam depth	=	400.00	mm	
b	Tie beam width	=	350.00	mm	
qt	Tie beam uniform load = b * h * γc	=	3.30	kN/m	
Hx_{max}	Max horizontal force at X dir	=	35.11	kN	
Z	Pedestal height above ground level	=	400.00	mm	
ht	distance of top pedestal to tension rebar Z+b	=	800.00	mm	
Mu	Maximum critical actual moment due to deflection				
	$= 1/8 * qt * L^2 + Hx_{max} * ht$	=	42.92	kNm	
Mu_{design}	= 1.4 * Mu	=	60.08	kNm	
c	Concrete cover	=	50.00	mm	
$Ø_{rebar}$	Rebar diameter designed	=	16	mm	
d	Footing effective depth				
	= h - c - 0.5 * Ørebar	=	342.00	mm	
β1	Block stress depth factor	=	0.85		
Ru	Coefficient of resistance				
	$= Mu / (Ø * b * d^2)$	=	1.63	MPa	where Ø = 0.9
m	= Fy / (0.85 * fc')	=	22.41		fc' and Fy in MPa
ρ_{req}	Required reinforcement ratio				
	= (1/m) * [1 - √(1 - 2m * Ru / Fy)]	=	0.43	%	Fy in MPa
ρb	Balanced reinforcement ratio				
	= (β1 * 0.85 * fc' / Fy) * (600 / (600 + Fy))	=	2.28	%	fc' and Fy in MPa
ρ_{max}	Maximum reinforcement ratio				
	= 0.75 * ρb	=	1.71	%	
ρ_{min}	Minimum reinforcement ratio				
	= 1.4 / Fy	=	0.35	%	Fy in MPa

SOIL DATA

ATTACHMENT C
SOIL INVESTIGATION REPORT (PILE CAPACITY)



SOIL DATA cont..

Tabel 4.4.1B Daya Dukung Tanah berdasarkan "MAYERHOF" Lokasi Pandan Block Station (Desa Petunang)

Nomor Titik Bor	Kedalaman (m) Muka Tanah	Muka Air	N	N'	Ñ	Ap dia 30 cm	Ap dia 35 cm	Qp (ton) dia 30 cm	Qp (ton) dia 35 cm	As dia 30 cm	As dia 35 cm	Qs dia 30 cm	Qs dia 35 cm	Qult dia 30 cm	Qult dia 35 cm	Qall SF = 3 dia 30 cm	Qall SF = 3 dia 35 cm
BOR 4	6,00	2,8 - 3	5	7,5		0,07	0,10	21,21	28,86	5,65	6,60	21,21	24,74	42,41	53,60	14,14	17,87
BLOK	8,00		18	22,5		0,07	0,10	63,62	86,59	7,54	8,80	84,82	98,96	148,44	185,55	49,48	61,85
PANDAN	10,00		61	47,25		0,07	0,10	133,60	181,84	9,42	11,00	222,66	259,77	356,26	441,61	118,75	147,20
	12,00		66	52,5		0,07	0,10	148,44	202,04	11,31	13,19	242,45	282,86	390,89	484,90	130,30	161,63
	14,00		> 60	60,25		0,07	0,10	170,35	231,87	13,19	15,39	268,09	312,77	438,44	544,64	146,15	181,55
	16,00		> 60	61,5		0,07	0,10	173,89	236,68	15,08	17,59	292,22	340,92	466,10	577,60	155,37	192,53
	18,00		70	65		0,07	0,10	183,78	250,15	16,96	19,79	320,68	374,12	504,46	624,27	168,15	208,09
	20,00		> 60	60		0,07	0,10	169,65	230,91	18,85	21,99	335,76	391,72	505,40	622,62	168,47	207,54
BOR 5	6,00	2,9 - 3	6	5,5		0,07	0,10	15,55	21,17	5,65	6,60	15,55	18,14	31,10	39,31	10,37	13,10
BLOK	8,00		6	9,25		0,07	0,10	26,15	35,60	7,54	8,80	34,87	40,68	61,03	76,28	20,34	25,43
PANDAN	10,00		26	27,5		0,07	0,10	77,75	105,83	9,42	11,00	129,59	151,19	207,35	257,02	69,12	85,67
	12,00		> 60	46,5		0,07	0,10	131,48	178,95	11,31	13,19	262,95	306,78	394,43	485,73	131,48	161,91
	14,00		62	52,5		0,07	0,10	148,44	202,04	13,19	15,39	282,74	329,87	431,18	531,91	143,73	177,30
	16,00		60	60		0,07	0,10	169,65	230,91	15,08	17,59	308,19	359,56	477,84	590,46	159,28	196,82
	18,00		65	63		0,07	0,10	178,13	242,45	16,96	19,79	334,20	389,90	512,33	632,36	170,78	210,79
	20,00		> 60	60		0,07	0,10	169,65	230,91	18,85	21,99	353,43	412,33	523,08	643,24	174,36	214,41

Kesimpulan :

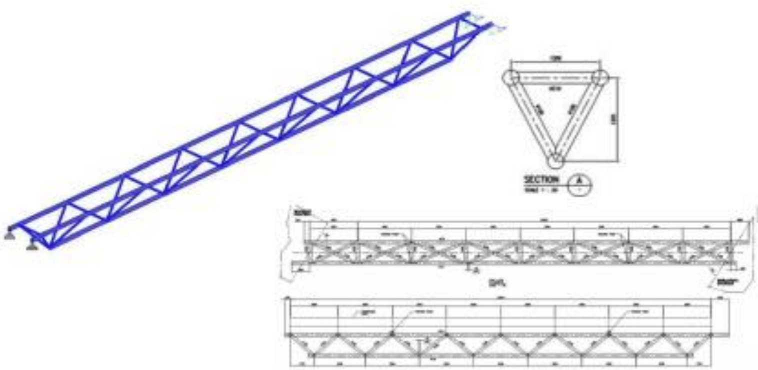
Diameter Tiang Pancang	D =	cm	30	35	40	50	60
Besar gaya Lateral	Ht =	ton	5.995	7.426	7.578	10.992	14.819
Defleksi maksimum							
Free Head Pile (Ujung Tiang Bebas)	Ymax =	cm	0,809	0,721	0,685	0,531	0,427
Fixed Head Pile (Ujung Tiang Terjepit)	Ymax =	cm	0,465	0,311	0,186	0,111	0,072

PROJECT REFERENCES

WALKWAY

Walkway adalah Struktur yang didesain berfungsi sebagai jembatan penghubung dari satu platform ke platform yang lainnya.

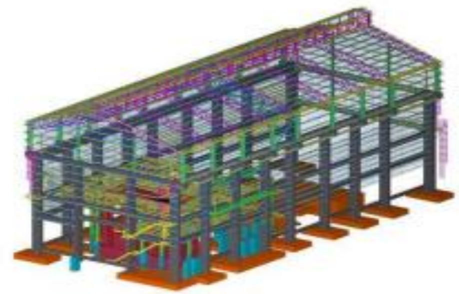
Komponen struktural dari Wakway untuk bentang panjang, agar memperoleh nilai inersia yang cukup tinggi maka menggunakan system truss dari pipa-pipa agar lebih mudah, murah dan efisien.



Gbr. Staad Pro Model for Walkway

SHELTER/ WAREHOUSE

Shelter adalah Struktur yang didesain berfungsi sebagai pelindung equipment-equipment seperti Genset, Compressor, Catalalyst, dan beberapa equpment lainnya yang biasa di gunakan untuk beberapa fasilitas oil gas & minning



Komponenen dari struktur ini biasanya didesain pada prinsipnya hampir sama dengan struktur baja lainnya.

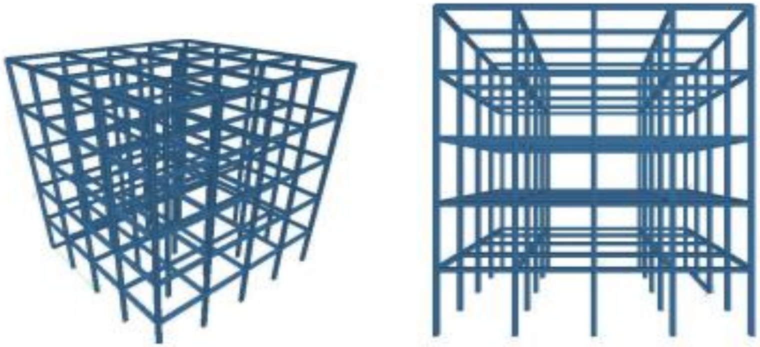
Gbr. Staad Pro Model for Shelter

PROJECT REFERENCES

PLATFORM

Platform adalah Struktur yang didesain berfungsi sebagai pelindung equipment-equipment seperti Genset, Compressor, Catalalyst, dan beberapa equpment lainnya yang biasa di gunakan untuk beberapa fasilitas oil gas & minning

Komponenen dari struktur ini biasanya didesain pada prinsipnya hampir sama dengan struktur baja lainnya.



Gbr. Staad Pro Model for Platform

BRIDGE

Jembatan adalah Struktur yang menghubungkan tempat yang berbeda yang terpisah oleh lautan, suangai taupun daratan yang butuh akses dibawahnya.

Komponenen dari struktur ini biasanya didesain pada prinsipnya hampir sama dengan struktur baja lainnya.

Gbr. Staad Pro Model for Platform

PROJECT REFERENCES

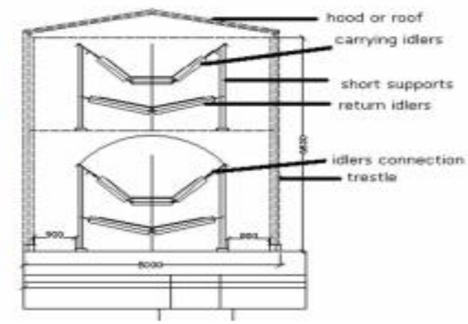
MENARA TEGANGAN LISTRIK & FLARE PIPE SUPPORT

Komponenen dari struktur ini biasanya didesain pada prinsipnya hampir sama dengan struktur baja lainnya

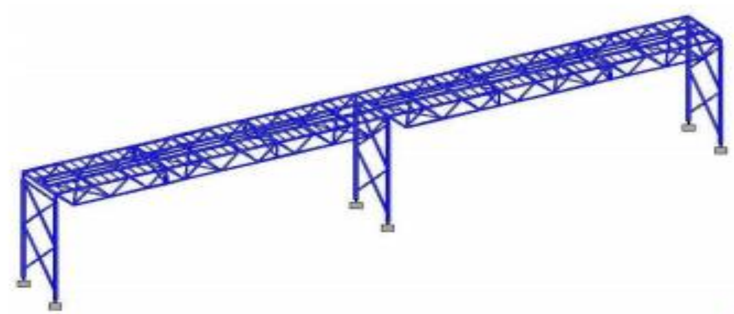
Gbr. Staad Pro Model for Platform

CONVEYOR

Conveyor adalah Struktur yang didesain berfungsi sebagai alat transportasi material seperti batu bara, nikel, dan lain2.



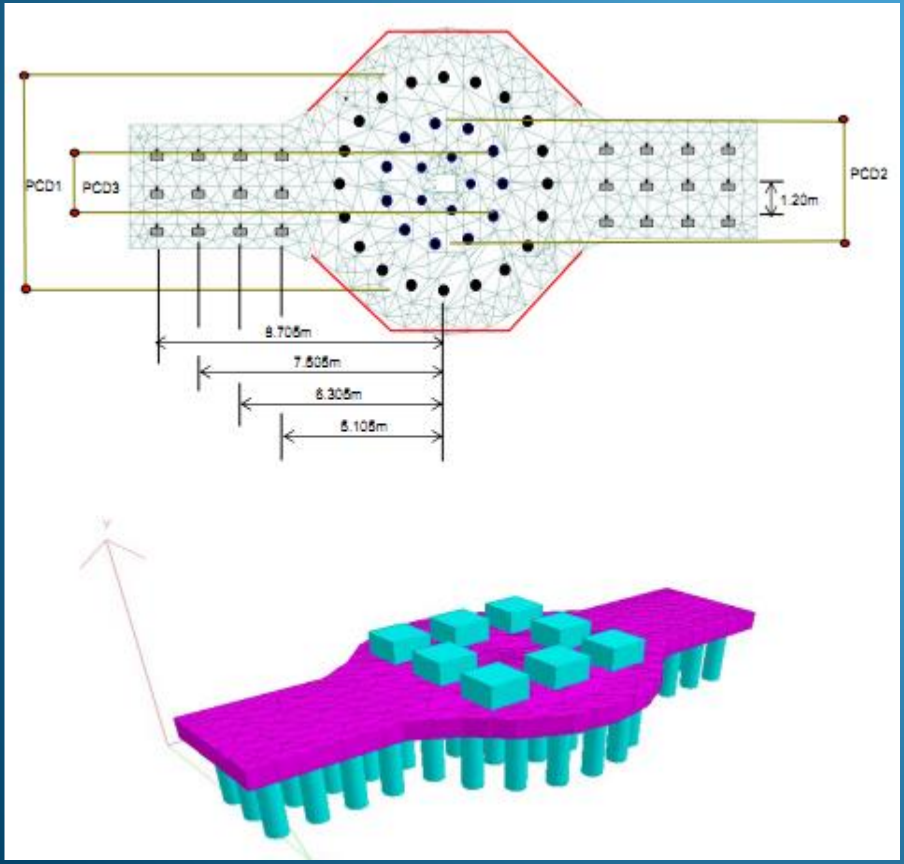
Komponenen dari struktur ini biasanya didesain pada prinsipnya hampir sama dengan struktur baja lainnya.



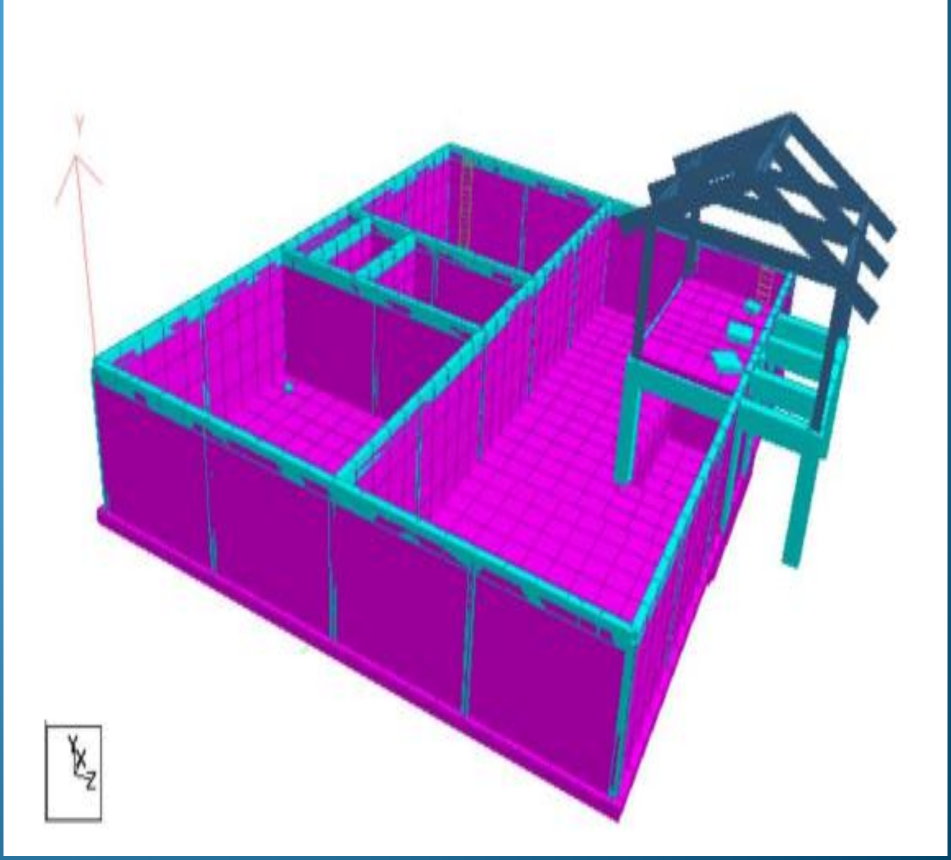
Gbr. Staad Pro Model for Platform

PROJECT REFERENCES

FURNACE FOUNDATION



COLLECTION BASIN ST01-BA009
STRUCTURE & FOUNDATION



THANK YOU

MOSES

INSTITUTE