

STRUCTURAL CALCULATION



M O D U L A R

MODULAR HANDRAIL TYPE – 1 & TYPE -2 DESIGN CALCULATION

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION**

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STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****I. Introduction**

This design calculation consists of structural calculation for Frame System. SAP software was used for this analysis and design.

II. Design codes

Codes used for the structural calculation

- BS 5950 part-1:2000 : Structural use of steel work in Building.
- BS 6180:2011 : Barriers in and about buildings.

III. Material Specification**Steel:**

Steel Density = 78 KN/m^3

Design Strength of Steel SS400 = 245 N/mm^2

Concrete: (C20/25)

Concrete Density = 24 KN/m^3

Compressive Strength of Concrete = 20 N/mm^2

IV. Design Loadings

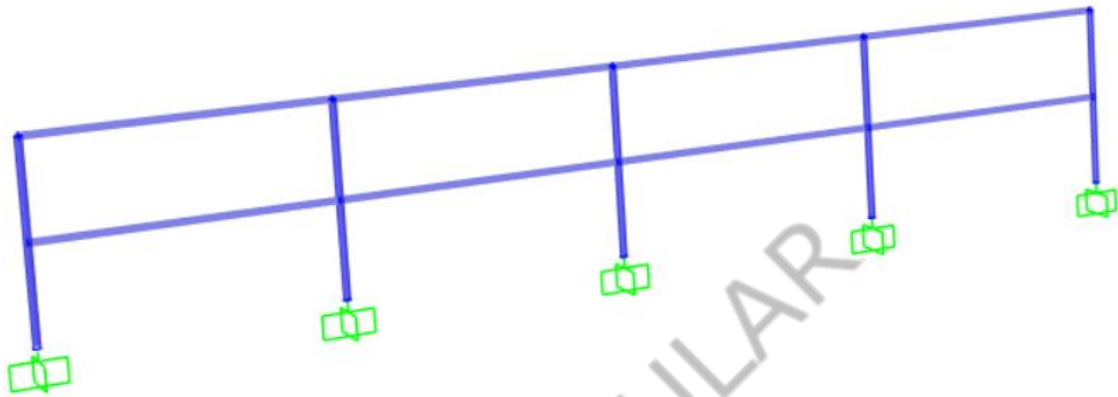
(Refer in calculation)

V. Structural Analysis

Program : SAP2000

VI. Load Combination

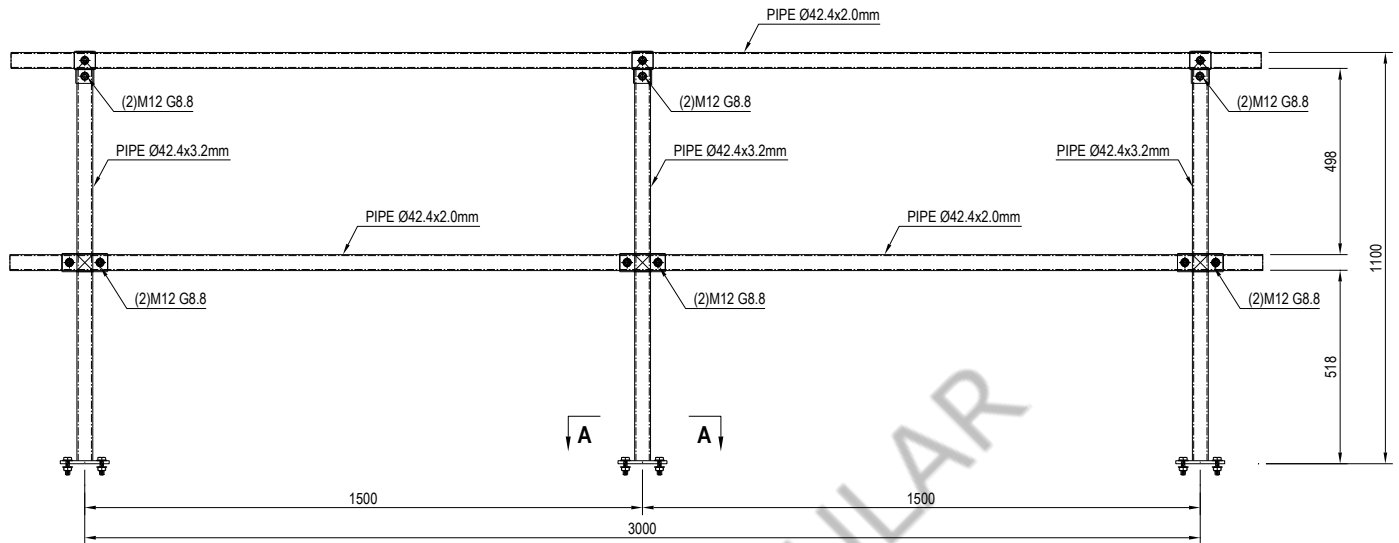
- 1.4 SDL
- 1.4 SDL + 1.6LL

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****VII. HANDRAIL – TYPE 1 (COLUMN SPACING 1500MM)****3D Sap Modal**

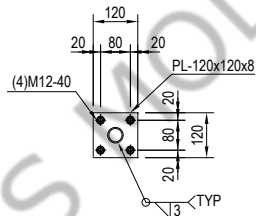
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1. Structural Drawing

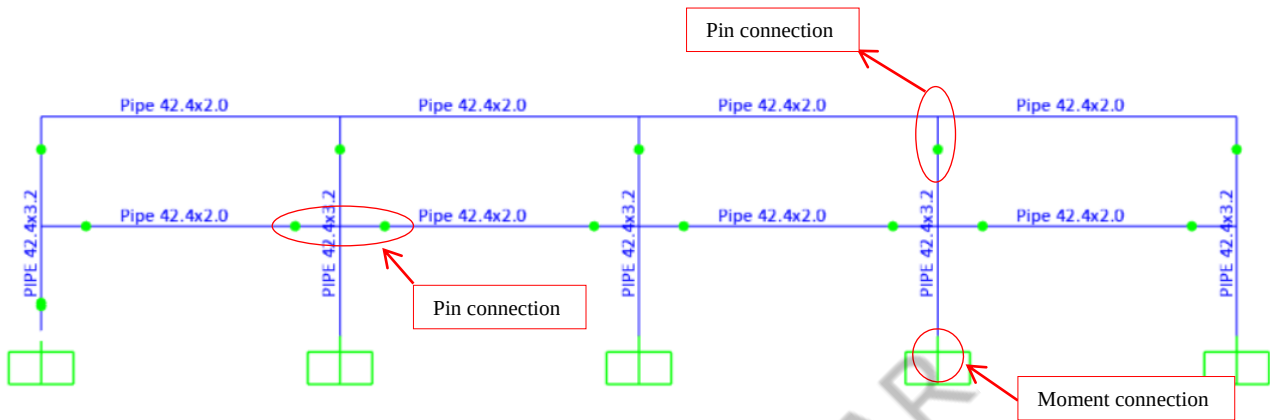


DETAL HANDRAIL



SECTION A-A

Typical Handrail

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****2. Design Calculation****MAIN FRAME****Design Load :****❖ Deal Load:**

- Self-weight of Handrail : Sap2000 program automatically calculate.

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❖ Live load:

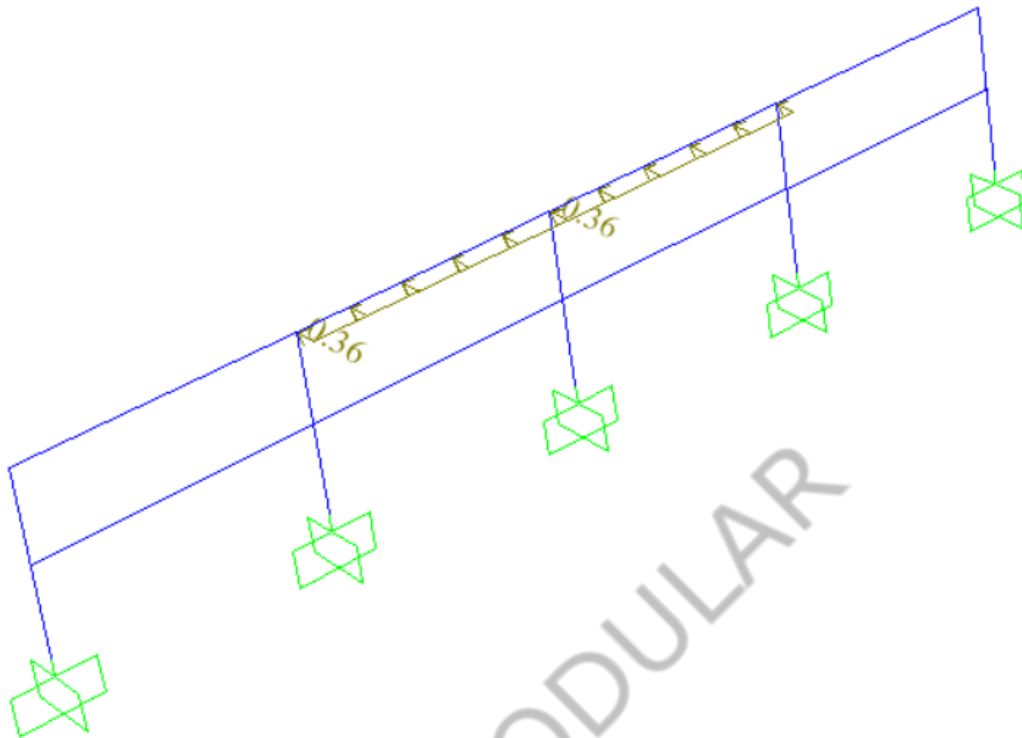
Table 2 of BS 6180:2011

Table 2 Minimum horizontal imposed loads for parapets, barriers and balustrades

Type of occupancy for part of the building or structure	Examples of specific use	Horizontal uniformly distributed line load (kN/m)	Uniformly distributed load applied to the infill (kN/m ²)	A point load applied to part of the infill (kN)
Domestic and residential activities	(i) All areas within or serving exclusively one single family dwelling including stairs, landings, etc. but excluding external balconies and edges of roofs	0.36	0.5	0.25
	(ii) Other residential, i.e. houses of multiple occupancy and balconies, including Juliette balconies and edges of roofs in single family dwellings	0.74	1.0	0.5
Offices and work areas not included elsewhere, including storage areas	(iii) Light access stairs and gangways not more than 600 mm wide	0.22	—	—
	(iv) Light pedestrian traffic routes in industrial and storage buildings except designated escape routes	0.36	0.5	0.25
	(v) Areas not susceptible to overcrowding in office and institutional buildings, also industrial and storage buildings except as given above	0.74	1.0	0.5
Areas where people might congregate	(vi) Areas having fixed seating within 530 mm of the barrier, balustrade or parapet	1.5	1.5	1.5
Areas with tables or fixed seatings	(vii) Restaurants and bars	1.5	1.5	1.5
Areas without obstacles for moving people and not susceptible to overcrowding	(viii) Stairs, landings, corridors, ramps	0.74	1.0	0.5
	(ix) External balconies including Juliette balconies and edges of roofs. Footways and pavements within building curtilage adjacent to basement/sunken areas	0.74	1.0	0.5
Areas susceptible to overcrowding	(x) Footways or pavements less than 3 m wide adjacent to sunken areas	1.5	1.5	1.5
	(xi) Theatres, cinemas, discotheques, bars, auditoria, shopping malls, assembly areas, studio. Footways or pavements greater than 3 m wide adjacent to sunken areas.	3.0	1.5	1.5
	(xii) Grandstands and stadia ^{A)}			
Retail areas	(xiii) All retail areas including public areas of banks/building societies or betting shops	1.5	1.5	1.5
Vehicular	(xiv) Pedestrian areas in car parks, including stairs, landings, ramps, edges or internal floors, footways, edges of roofs	1.5	1.5	1.5
	(xv) Horizontal loads imposed by vehicles ^{B)}			

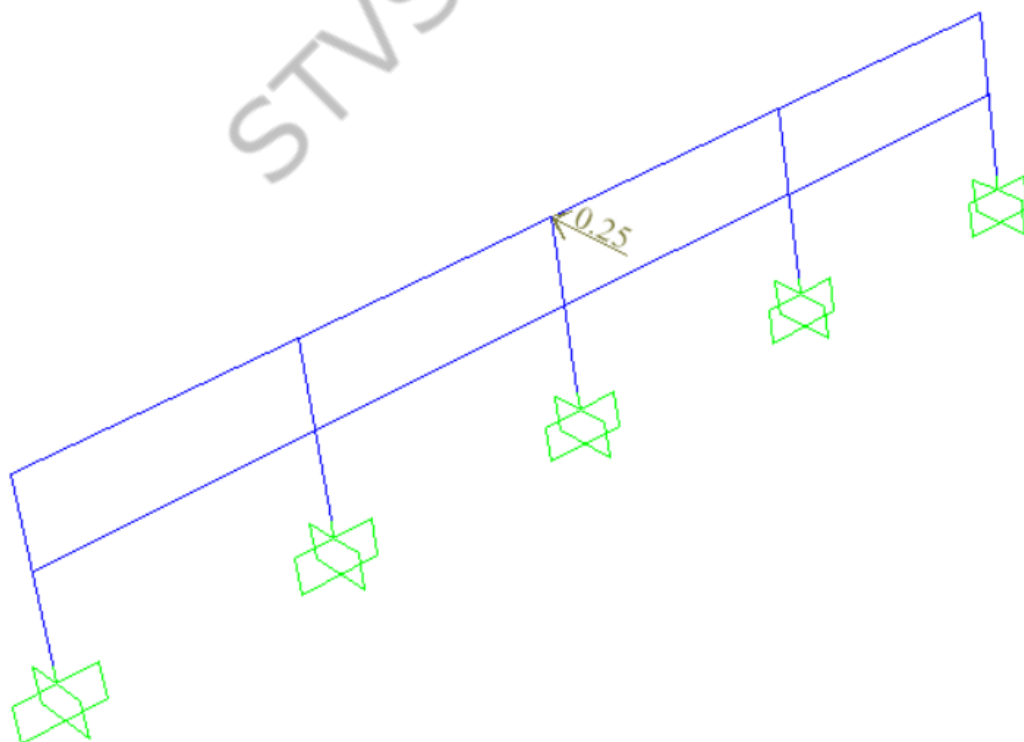
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Live Load 1- Uniform Load : $LL_1 = 0.36 \text{ kN/m}$

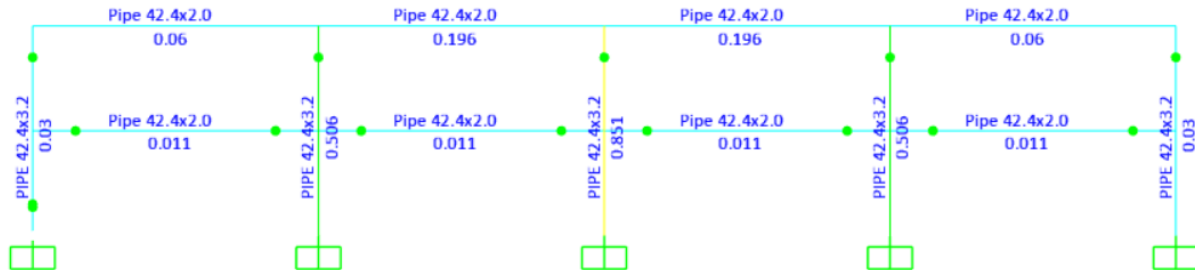


LIVE LOAD: LL1 (KN/m)

Live Load 2- point Load : $LL_2 = 0.25 \text{ kN}$



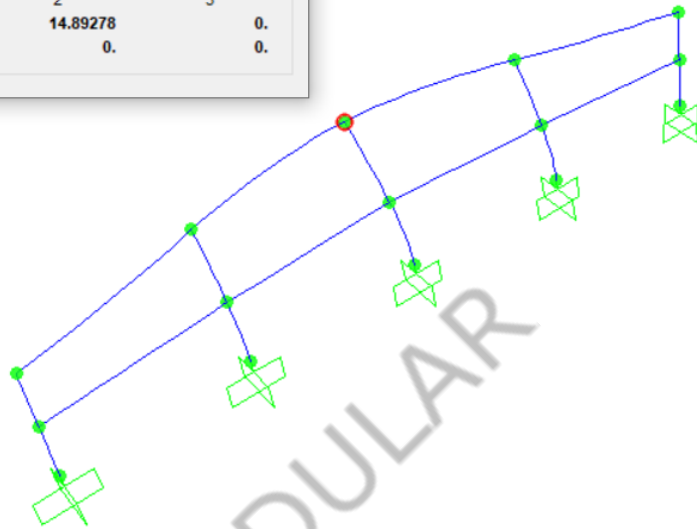
LIVE LOAD: LL2 (KN/m)

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****a) Sap Output****Design Strength unity check****STRENGTH UNITY CHECK**

Conclusion : The strength unity check ratio of all steel members are smaller than 1.0 ($UC < 1.0$).
Hence : All steel members are passed the design strength checking

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Deflection :**

Joint Displacements					
Joint	Object	6	Joint Element	6	
		1	2	3	
Trans		0.	14.89278	0.	
Rotn		0.	0.	0.	

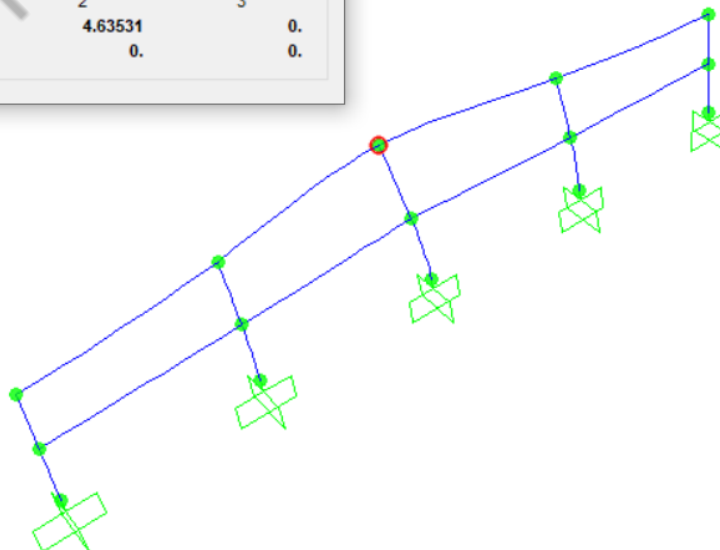


HORIZONTAL DEFLECTION $d = 14.9 \text{ mm}$
(LIVE 1)

Maximum Horizontal deflection limit at top column = $\text{Span}/65$ or $25\text{mm} = 1100/65$ or $25\text{mm} = 16.9 \text{ mm}$

Horizontal deflection at top column = $14.9 \text{ mm} < 16.9 \text{ mm} \rightarrow \text{OK}$

Joint Displacements					
Joint	Object	6	Joint Element	6	
		1	2	3	
Trans		0.	4.63531	0.	
Rotn		0.	0.	0.	



HORIZONTAL DEFLECTION $d = 4.6 \text{ mm}$
(LIVE 2)

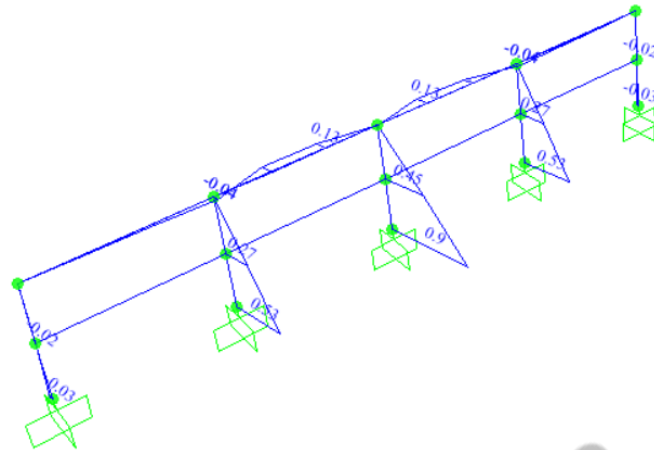
Maximum Horizontal deflection limit at top column = $\text{Span}/65$ or $25\text{mm} = 1100/65$ or $25\text{mm} = 16.9 \text{ mm}$

Horizontal deflection at top column = $4.6 \text{ mm} < 16.9 \text{ mm} \rightarrow \text{OK}$

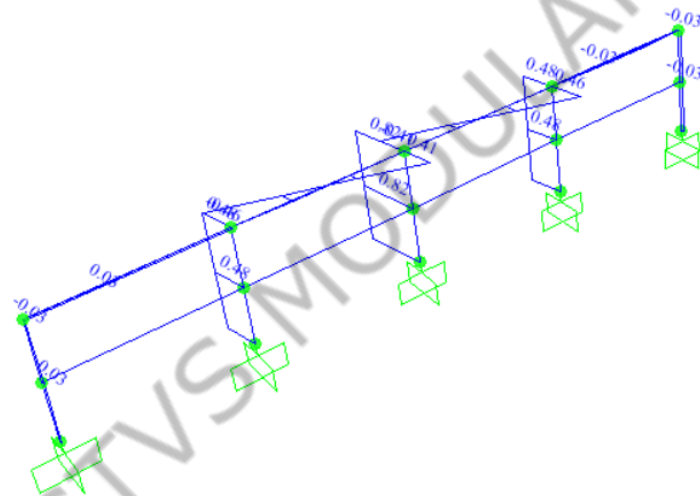
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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

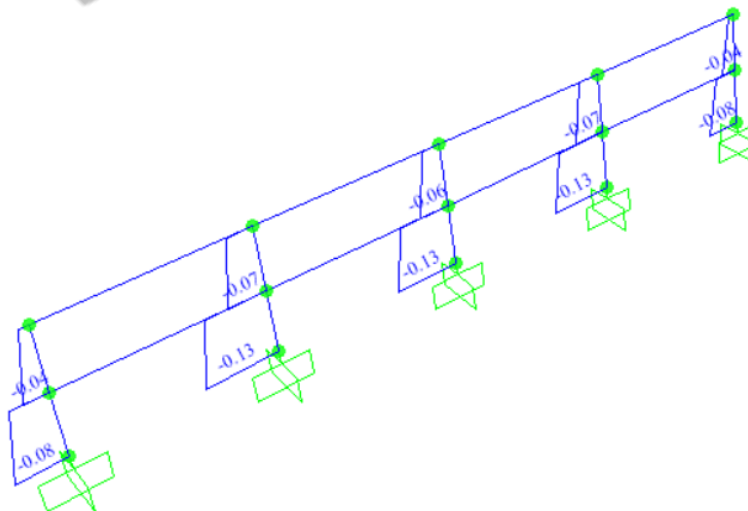
- 1.4D+1.6L1



MOMENT (KNM)



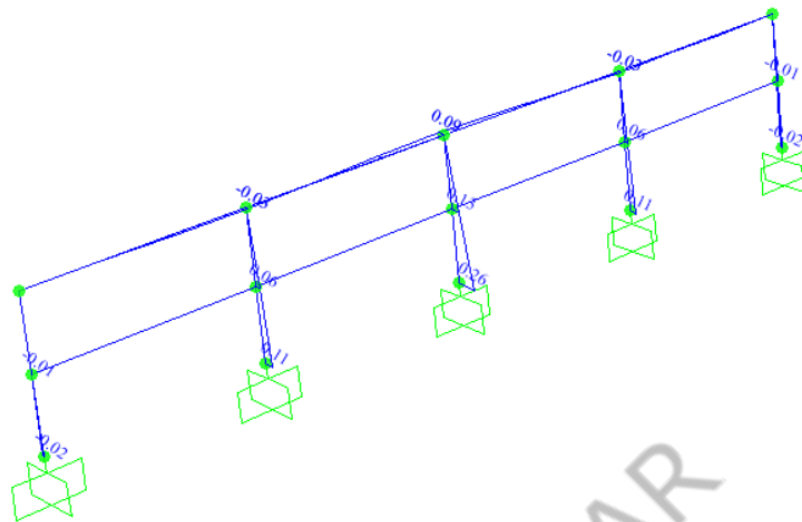
SHEAR (KN)



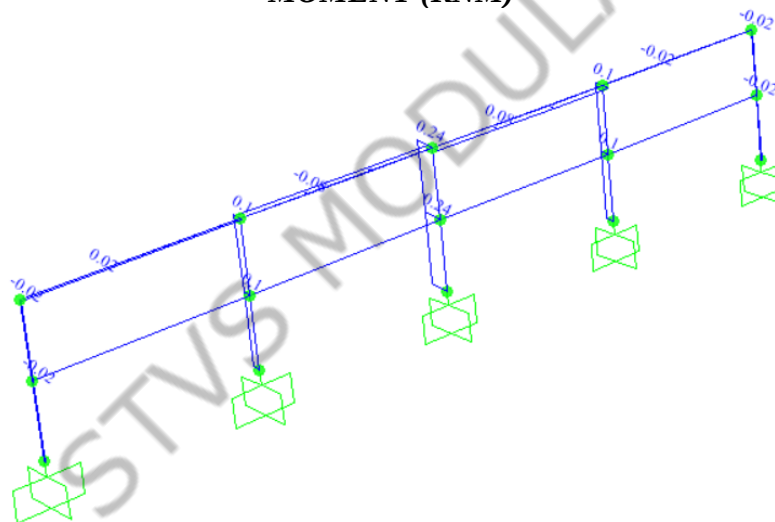
AXIAL (KN)

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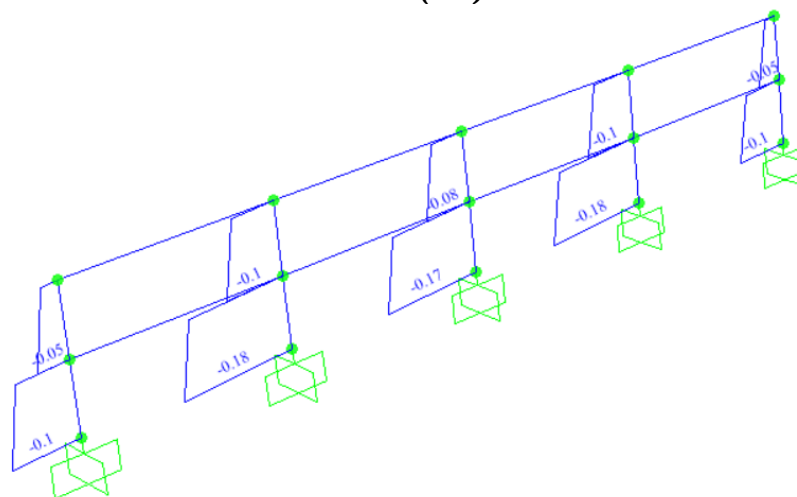
- 1.4D+1.6L2



MOMENT (KNM)



SHEAR (KN)



AXIAL (KN)

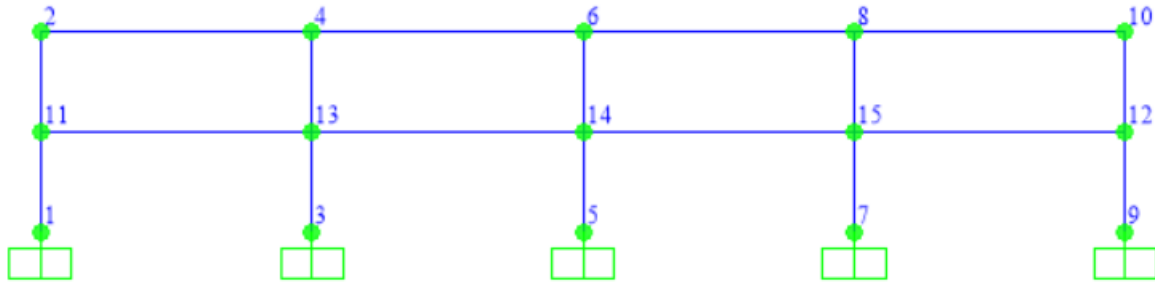
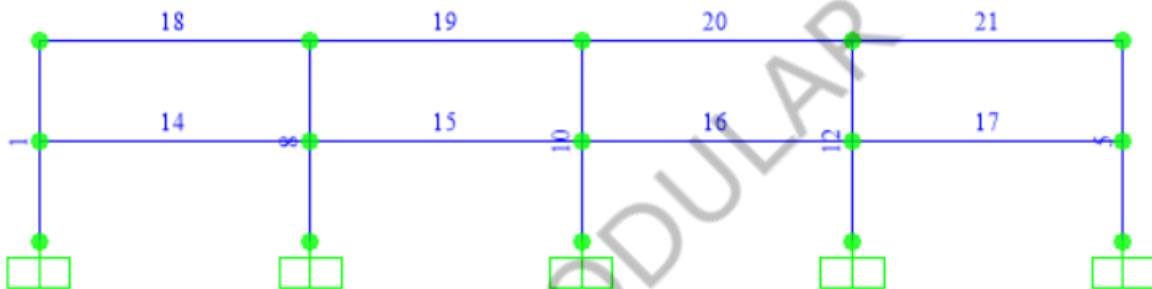
STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****b) Sap Input****JOINTS LABEL****FRAME LABEL****Table: Case - Static 1 - Load Assignments**

Table: Case - Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
DL	Load pattern	DL	1
LIVE 1	Load pattern	LIVE 1	1
LIVE 2	Load pattern	LIVE 2	1

Table: Combination Definitions, Part 1 of 3

Table: Combination Definitions, Part 1 of 3

ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
1.4DL	Linear Add	No	NonLin Static	DL	1.4	Strength
1.4DL+1.6LIVE 1	Linear Add	No	NonLin Static	DL	1.4	Strength
1.4DL+1.6LIVE 1			NonLin Static	LIVE 1	1.6	
DL+LIVE 1	Linear Add	No	NonLin Static	DL	1	Strength
DL+LIVE 1			NonLin Static	LIVE 1	1	
1.4DL+1.6LIVE 2	Linear Add	No	NonLin Static	DL	1.4	Strength
1.4DL+1.6LIVE 2			NonLin Static	LIVE 2	1.6	
DL+LIVE 2	Linear Add	No	NonLin Static	DL	1	Strength
DL+LIVE 2			NonLin Static	LIVE 2	1	

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Table: Combination Definitions, Part 2 of 3****Table: Combination Definitions, Part 2 of 3**

ComboName	CaseName	ConcDesign	AlumDesign	ColdDesign
1.4DL	DL	None	None	None
1.4DL+1.6LIVE 1	DL	None	None	None
1.4DL+1.6LIVE 1	LIVE 1			
DL+LIVE 1	DL	None	None	None
DL+LIVE 1	LIVE 1			
1.4DL+1.6LIVE 2	DL	None	None	None
1.4DL+1.6LIVE 2	LIVE 2			
DL+LIVE 2	DL	None	None	None
DL+LIVE 2	LIVE 2			

Table: Combination Definitions, Part 3 of 3**Table: Combination Definitions, Part 3 of 3**

ComboName	CaseName	GUID	Notes
1.4DL	DL		
1.4DL+1.6LIVE 1	DL		
1.4DL+1.6LIVE 1	LIVE 1		
DL+LIVE 1	DL		
DL+LIVE 1	LIVE 1		
1.4DL+1.6LIVE 2	DL		
1.4DL+1.6LIVE 2	LIVE 2		
DL+LIVE 2	DL		
DL+LIVE 2	LIVE 2		

Table: Frame Design Procedures**Table: Frame Design Procedures**

Frame	DesignProc
1	From Material
5	From Material
8	From Material
10	From Material
12	From Material
14	From Material
15	From Material
16	From Material
17	From Material
18	From Material
19	From Material
20	From Material
21	From Material

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Frame Loads - Distributed, Part 1 of 3

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
19	LIVE 1	GLOBAL	Force	Y	RelDist	0
20	LIVE 1	GLOBAL	Force	Y	RelDist	0

Table: Frame Loads - Distributed, Part 2 of 3

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA	AbsDistB	FOverLA	FOverLB
			m	m	KN/m	KN/m
19	LIVE 1	1	0	1.5	0.36	0.36
20	LIVE 1	1	0	1.5	0.36	0.36

Table: Frame Loads - Distributed, Part 3 of 3

Table: Frame Loads - Distributed, Part 3 of 3

Frame	LoadPat	GUID
19	LIVE 1	
20	LIVE 1	

Table: Frame Section Assignments

Table: Frame Section Assignments

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
1	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
5	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
8	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
10	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
12	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
14	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
15	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
16	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
17	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
18	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
19	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
20	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
21	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default

Table: Frame Section Properties 01 - General, Part 1 of 6

Table: Frame Section Properties 01 - General, Part 1 of 6

SectionName	Material	Shape	t3	tw	Area	TorsConst
			m	m	m2	m4
Pipe 42.4x2.0	Steel 245	Pipe	0.0424	0.002	0.000254	1.038E-07
PIPE 42.4x3.2	Steel 245	Pipe	0.0424	0.0032	0.000394	1.524E-07

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Frame Section Properties 01 - General, Part 2 of 6

Table: Frame Section Properties 01 - General, Part 2 of 6

SectionName	I33 m4	I22 m4	I23 m4	AS2 m2	AS3 m2	S33 m3	S22 m3
Pipe 42.4x2.0	5.192E-08	5.192E-08	0	0.000127	0.000127	2.449E-06	2.449E-06
PIPE 42.4x3.2	7.62E-08	7.62E-08	0	0.000198	0.000198	3.594E-06	3.594E-06

Table: Frame Section Properties 01 - General, Part 3 of 6

Table: Frame Section Properties 01 - General, Part 3 of 6

SectionName	Z33 m3	Z22 m3	R33 m	R22 m	ConcCol	ConcBeam	Color
Pipe 42.4x2.0	3.267E-06	3.267E-06	0.014301	0.014301	No	No	Red
PIPE 42.4x3.2	4.928E-06	4.928E-06	0.013905	0.013905	No	No	Red

Table: Frame Section Properties 01 - General, Part 4 of 6

Table: Frame Section Properties 01 - General, Part 4 of 6

SectionName	TotalWt KN	TotalMass KN-s2/m	FromFile	AMod	A2Mod	A3Mod	JMod
Pipe 42.4x2.0	0.391	0.03985	No	1	1	1	1
PIPE 42.4x3.2	0.318	0.03248	No	1	1	1	1

Table: Frame Section Properties 01 - General, Part 5 of 6

Table: Frame Section Properties 01 - General, Part 5 of 6

SectionName	I2Mod	I3Mod	MMod	WMod	GUID
Pipe 42.4x2.0	1	1	1	1	
PIPE 42.4x3.2	1	1	1	1	

Table: Frame Section Properties 01 - General, Part 6 of 6

Table: Frame Section Properties 01 - General, Part 6 of 6

SectionName	Notes
Pipe 42.4x2.0	Added 12/16/2022 10:25:19 PM
PIPE 42.4x3.2	Added 12/8/2022 8:40:52 PM

Table: Joint Loads - Force, Part 1 of 2

Table: Joint Loads - Force, Part 1 of 2

Joint	LoadPat	CoordSys	F1 KN	F2 KN	F3 KN	M1 KN-m	M2 KN-m
6	LIVE 2	GLOBAL	0	0.25	0	0	0

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Joint Loads - Force, Part 2 of 2

Table: Joint Loads - Force, Part 2 of 2

Joint	LoadPat	M3 KN-m	GUID
6	LIVE 2	0	

Table: Joint Pattern Definitions

Table: Joint
Pattern Definitions

Pattern
DEFAULT

Table: Joint Restraint Assignments

Table: Joint Restraint Assignments

Joint	U1	U2	U3	R1	R2	R3
1	Yes	Yes	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes	Yes	Yes	Yes

Table: Load Case Definitions, Part 1 of 3

Table: Load Case Definitions, Part 1 of 3

Case	Type	InitialCond	ModalCase	BaseCase	MassSource	DesTypeOpt	DesignType
DL	NonStatic	Zero				Prog Det	Dead
LIVE 1	NonStatic	Zero				Prog Det	Live
LIVE 2	NonStatic	Zero				Prog Det	Live

Table: Load Case Definitions, Part 2 of 3

Table: Load Case Definitions, Part 2 of 3

Case	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus	GUID
DL	Prog Det	Non-Composite	None	Yes	Finished	
LIVE 1	Prog Det	Short-Term Composite	None	Yes	Finished	
LIVE 2	Prog Det	Short-Term Composite	None	Yes	Finished	

Table: Load Case Definitions, Part 3 of 3

Table: Load Case Definitions, Part 3 of 3

Case	Notes
DL	
LIVE 1	
LIVE 2	

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Load Pattern Definitions

Table: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
DL	Dead	1			
LIVE 1	Live	0			
LIVE 2	Live	0			Added 12/8/2022 8:49:55 PM

Table: Material Properties 01 - General, Part 1 of 2

Table: Material Properties 01 - General, Part 1 of 2

Material	Type	Grade	SymType	TempDepen d	Color	GUID
Steel 245	Steel		Isotropic	No	Yellow	

Table: Material Properties 01 - General, Part 2 of 2

Table: Material Properties 01 - General, Part 2 of 2

Material	Notes
Steel 245	ASTM A36 added 6/11/2008 9:51:3

Table: Material Properties 03a - Steel Data

Table: Material Properties 03a - Steel Data

Material	Fy KN/m2	Fu KN/m2	EffFy KN/m2	EffFu KN/m2	SSCurveOpt	SSHysType
Steel 245	245000	400000	379500	528000	User Defined	Elastic

Table: Overwrites - Steel Design - BS5950 2000, Part 1 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 1 of 5

Frame	DesignSect	FrameType	Fy KN/m2	RLLF	AreaRatio	XLMajor
1	Program Determined	Program Determined	0	0	0	0
5	Program Determined	Program Determined	0	0	0	0
8	Program Determined	Program Determined	0	0	0	0
10	Program Determined	Program Determined	0	0	0	0
12	Program Determined	Program Determined	0	0	0	0
14	Program Determined	Program Determined	0	0	0	0
15	Program Determined	Program Determined	0	0	0	0
16	Program Determined	Program Determined	0	0	0	0
17	Program Determined	Program Determined	0	0	0	0
18	Program Determined	Program Determined	0	0	0	0
19	Program Determined	Program Determined	0	0	0	0
20	Program Determined	Program Determined	0	0	0	0
21	Program Determined	Program Determined	0	0	0	0

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Table: Overwrites - Steel Design - BS5950 2000, Part 2 of 5**

Table: Overwrites - Steel Design - BS5950 2000, Part 2 of 5

Frame	XLMinor	XKMajor	XKMinor	MMajor	MMinor	MLT	Pc KN
1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0

Table: Overwrites - Steel Design - BS5950 2000, Part 3 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 3 of 5

Frame	Pt KN	Mc3 KN-m	Mc2 KN-m	Mb KN-m	Pv2 KN	Pv3 KN	CheckDefl
1	0	0	0	0	0	0	Program Determined
5	0	0	0	0	0	0	Program Determined
8	0	0	0	0	0	0	Program Determined
10	0	0	0	0	0	0	Program Determined
12	0	0	0	0	0	0	Program Determined
14	0	0	0	0	0	0	Program Determined
15	0	0	0	0	0	0	Program Determined
16	0	0	0	0	0	0	Program Determined
17	0	0	0	0	0	0	Program Determined
18	0	0	0	0	0	0	Program Determined
19	0	0	0	0	0	0	Program Determined
20	0	0	0	0	0	0	Program Determined
21	0	0	0	0	0	0	Program Determined

Table: Overwrites - Steel Design - BS5950 2000, Part 4 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 4 of 5

Frame	DeflType	DLRat	SDLAndLLR at	LLRat	TotalRat	NetRat	DLAbs m
1	Program Determined	0	0	0	0	0	0
5	Program Determined	0	0	0	0	0	0
8	Program Determined	0	0	0	0	0	0
10	Program Determined	0	0	0	0	0	0
12	Program Determined	0	0	0	0	0	0
14	Program Determined	0	0	0	0	0	0
15	Program Determined	0	0	0	0	0	0
16	Program Determined	0	0	0	0	0	0
17	Program Determined	0	0	0	0	0	0
18	Program Determined	0	0	0	0	0	0

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Table: Overwrites - Steel Design - BS5950 2000, Part 4 of 5

Frame	DeflType	DLRat	SDLAndLLR at	LLRat	TotalRat	NetRat	DLAbs m
19	Program Determined	0	0	0	0	0	0
20	Program Determined	0	0	0	0	0	0
21	Program Determined	0	0	0	0	0	0

Table: Overwrites - Steel Design - BS5950 2000, Part 5 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 5 of 5

Frame	SDLAndLLA bs m	LLAbs m	TotalAbs m	NetAbs m	SpecCambe r m
1	0	0	0	0	0
5	0	0	0	0	0
8	0	0	0	0	0
10	0	0	0	0	0
12	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0

Table: Preferences - Dimensional, Part 1 of 2

Table: Preferences - Dimensional, Part 1 of 2

MergeTol m	FineGrid m	Nudge m	SelectTol	SnapTol	SLineThick	PLineThick	MaxFont	MinFont
0.001	0.25	0.25	3	12	1	4	7	7

Table: Preferences - Dimensional, Part 2 of 2

Table: Preferences - Dimensional, Part 2
of 2

AutoZoom	ShrinkFact	TextFileLen
5	70	240

Table: Preferences - Steel Design - BS5950 2000, Part 1 of 2

Table: Preferences - Steel Design - BS5950 2000, Part 1 of 2

THDesign	FrameType	PatLLF	SRatioLimit	MaxIter	CheckDefl	DLRat	SDLAndLLR at	LLRat
Envelopes		0.75	1	1	No	120	120	360

Table: Preferences - Steel Design - BS5950 2000, Part 2 of 2

Table: Preferences - Steel Design - BS5950 2000, Part 2 of
2

TotalRat	NetRat
240	240

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

c) Sap Output

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 1 of 2

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 1 of 2

Frame	DesignSect	DesignType	Status	Ratio	RatioType
1	PIPE 42.4x3.2	Column	No Messages	0.03047	PMM
5	PIPE 42.4x3.2	Column	No Messages	0.03047	PMM
8	PIPE 42.4x3.2	Column	No Messages	0.505636	PMM
10	PIPE 42.4x3.2	Column	No Messages	0.85079	PMM
12	PIPE 42.4x3.2	Column	No Messages	0.505636	PMM
14	Pipe 42.4x2.0	Beam	No Messages	0.010828	PMM
15	Pipe 42.4x2.0	Beam	No Messages	0.010828	PMM
16	Pipe 42.4x2.0	Beam	No Messages	0.010828	PMM
17	Pipe 42.4x2.0	Beam	No Messages	0.010828	PMM
18	Pipe 42.4x2.0	Beam	No Messages	0.059958	PMM
19	Pipe 42.4x2.0	Beam	No Messages	0.196256	PMM
20	Pipe 42.4x2.0	Beam	No Messages	0.196256	PMM
21	Pipe 42.4x2.0	Beam	No Messages	0.059958	PMM

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 2 of 2

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 2 of 2

Frame	Combo	Location m	ErrMsg	WarnMsg
1	1.4DL+1.6LIVE 1	0	No Messages	No Messages
5	1.4DL+1.6LIVE 1	0	No Messages	No Messages
8	1.4DL+1.6LIVE 1	0	No Messages	No Messages
10	1.4DL+1.6LIVE 1	0	No Messages	No Messages
12	1.4DL+1.6LIVE 1	0	No Messages	No Messages
14	1.4DL	1	No Messages	No Messages
15	1.4DL	1	No Messages	No Messages
16	1.4DL	1	No Messages	No Messages
17	1.4DL	1	No Messages	No Messages
18	1.4DL+1.6LIVE 1	1.5	No Messages	No Messages
19	1.4DL+1.6LIVE 1	1	No Messages	No Messages
20	1.4DL+1.6LIVE 1	0.5	No Messages	No Messages
21	1.4DL+1.6LIVE 1	0	No Messages	No Messages

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 1 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 1 of 7

Frame	DesignSect	DesignType	Status	Combo	Location m	Pu KN
1	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.083
5	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.083
8	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.135
10	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.126
12	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.135
14	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1	2.925E-18
15	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1	2.136E-18

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 1 of 7

Frame	DesignSect	DesignType	Status	Combo	Location m	Pu KN
16	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1	1.398E-18
17	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1	6.91E-19
18	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 1	1.5	3.237E-18
19	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 1	1	2.442E-18
20	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 1	0.5	1.635E-18
21	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 1	0	8.197E-19

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 2 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 2 of 7

Frame	MuMajor KN-m	MuMinor KN-m	VuMajor KN	VuMinor KN	Tu KN-m	Equation	TotalRatio
1	5.169E-18	-0.0313	6.161E-18	-0.028	0	(4.8.3.2)	0.03047
5	3.812E-18	-0.0313	-1.511E-18	-0.028	0	(4.8.3.2)	0.03047
8	3.786E-18	0.5328	-1.583E-18	0.484	0	(4.8.3.2)	0.505636
10	3.799E-18	0.8977	-1.546E-18	0.816	0	(4.8.3.2)	0.85079
12	3.807E-18	0.5328	-1.522E-18	0.484	0	(4.8.3.2)	0.505636
14	0.0068	0	0.006838	0	0	(4.8.3.3.1-1)	0.010828
15	0.0068	0	0.006838	0	0	(4.8.3.3.1-1)	0.010828
16	0.0068	0	0.006838	0	0	(4.8.3.3.1-1)	0.010828
17	0.0068	0	0.006838	0	0	(4.8.3.3.1-1)	0.010828
18	-0.0066	-0.0427	0.025	0.028	0	(4.8.2.2)	0.059958
19	0.0017	0.1253	0.00539	0.12	0	(4.8.3.3.1-2)	0.196256
20	0.0017	0.1253	-0.00539	-0.12	0	(4.8.3.3.1-2)	0.196256
21	-0.0066	-0.0427	-0.025	-0.028	0	(4.8.2.2)	0.059958

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 3 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 3 of 7

Frame	PRatio	MMajRatio	MMinRatio	SRLimit	FtOrFcDsgn KN	Pc KN	Pt KN
1	0.000863	0	0.029607	1	-0.083	69.575	96.55
5	0.000863	0	0.029607	1	-0.083	69.575	96.55
8	0.001394	0	0.504242	1	-0.135	69.575	96.55
10	0.001304	0	0.849487	1	-0.126	69.575	96.55
12	0.001394	0	0.504242	1	-0.135	69.575	96.55
14	0	0.010828	0	1	2.925E-18	33.991	62.191
15	0	0.010828	0	1	2.136E-18	33.991	62.191
16	0	0.010828	0	1	1.398E-18	33.991	62.191
17	0	0.010828	0	1	6.91E-19	33.991	62.191
18	0	0.00914	0.059258	1	3.237E-18	33.991	62.191
19	0	0.002132	0.196244	1	2.442E-18	33.991	62.191
20	0	0.002132	0.196244	1	1.635E-18	33.991	62.191
21	0	0.00914	0.059258	1	8.197E-19	33.991	62.191

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Table: Steel Design 2 - PMM Details - BS5950 2000, Part 4 of 7**

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 4 of 7

Frame	PcMajor KN	PcMinor KN	MfMajDsgn KN-m	McMajor KN-m	Mb	XKMajor	XLMajor
1	71.694	69.575	5.169E-18	1.0567	1207401.813	1.902939	0.5
5	71.694	69.575	3.812E-18	1.0567	1207401.813	1.902939	0.5
8	71.694	69.575	3.786E-18	1.0567	1207401.813	1.902939	0.5
10	71.694	69.575	3.799E-18	1.0567	1207401.813	1.902939	0.5
12	71.694	69.575	3.807E-18	1.0567	1207401.813	1.902939	0.5
14	33.991	33.991	0.0068	0.72	800411.733	1	1
15	33.991	33.991	0.0068	0.72	800411.733	1	1
16	33.991	33.991	0.0068	0.72	800411.733	1	1
17	33.991	33.991	0.0068	0.72	800411.733	1	1
18	33.991	33.991	-0.0066	0.72	800411.733	1	1
19	33.991	33.991	0.0017	0.8004	800411.733	1	1
20	33.991	33.991	0.0017	0.8004	800411.733	1	1
21	33.991	33.991	-0.0066	0.72	800411.733	1	1

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 5 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 5 of 7

Frame	mMajor	mLT	MfMinDsgn KN-m	McMinor KN-m	XKMinor	XLMinor	mMinor
1	1	1	-0.0313	1.0567	1	1	0.6
5	1	1	-0.0313	1.0567	1	1	0.6
8	1	1	0.5328	1.0567	1	1	0.6
10	1	1	0.8977	1.0567	1	1	0.6
12	1	1	0.5328	1.0567	1	1	0.6
14	0.95	1	0	0.72	1	1	1
15	0.95	1	0	0.72	1	1	1
16	0.95	1	0	0.72	1	1	1
17	0.95	1	0	0.72	1	1	1
18	0.579424	1	-0.0427	0.72	1	1	0.6
19	0.339088	1	0.1253	0.8004	1	1	0.939653
20	0.339088	1	0.1253	0.8004	1	1	0.939653
21	0.579424	1	-0.0427	0.72	1	1	0.6

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 6 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 6 of 7

Frame	Fy KN/m2	E KN/m2	Length m	MajAxisAng Degrees	RLLF	SectClass
1	245000	199900000	1.1		1	Class 1
5	245000	199900000	1.1		1	Class 1
8	245000	199900000	1.1		1	Class 1
10	245000	199900000	1.1		1	Class 1
12	245000	199900000	1.1		1	Class 1
14	245000	199900000	1.5		1	Class 1
15	245000	199900000	1.5		1	Class 1
16	245000	199900000	1.5		1	Class 1
17	245000	199900000	1.5		1	Class 1
18	245000	199900000	1.5		1	Class 1
19	245000	199900000	1.5		1	Class 1

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 6 of 7

Frame	Fy KN/m2	E KN/m2	Length m	MajAxisAng Degrees	RLLF	SectClass
20	245000	199900000	1.5		1	Class 1
21	245000	199900000	1.5		1	Class 1

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 7 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 7 of 7

Frame	FramingType	ErrMsg	WarnMsg
1	Eccentrically Braced Frame	No Messages	No Messages
5	Eccentrically Braced Frame	No Messages	No Messages
8	Eccentrically Braced Frame	No Messages	No Messages
10	Eccentrically Braced Frame	No Messages	No Messages
12	Eccentrically Braced Frame	No Messages	No Messages
14	Eccentrically Braced Frame	No Messages	No Messages
15	Eccentrically Braced Frame	No Messages	No Messages
16	Eccentrically Braced Frame	No Messages	No Messages
17	Eccentrically Braced Frame	No Messages	No Messages
18	Eccentrically Braced Frame	No Messages	No Messages
19	Eccentrically Braced Frame	No Messages	No Messages
20	Eccentrically Braced Frame	No Messages	No Messages
21	Eccentrically Braced Frame	No Messages	No Messages

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 1 of 4

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 1 of 4

Frame	DesignSect	DesignType	Status	VMajorCombo	VMajorLoc m	VMajorRatio
1	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
5	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
8	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
10	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
12	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
14	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000916
15	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000916
16	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000916
17	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000916
18	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1.5	0.001112
19	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000981
20	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1.5	0.000981
21	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.001112

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 2 of 4

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 2 of 4

Frame	FvMajDsgn KN	PvMajor KN	TuMajor KN-m	VMinorCombo	VMinorLoc m	VMinorRatio	FvMinDsgn KN
1	6.161E-18	34.758	0	1.4DL+1.6LIVE 1	0.55	0.000818	6.161E-18
5	1.511E-18	34.758	0	1.4DL+1.6LIVE 1	0.55	0.000818	1.511E-18
8	1.583E-18	34.758	0	1.4DL+1.6LIVE 1	0.55	0.013937	1.583E-18
10	1.546E-18	34.758	0	1.4DL+1.6LIVE 1	0.55	0.023479	1.546E-18

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 2 of 4

Frame	FvMajDsgn KN	PvMajor KN	TuMajor KN-m	VMinorCombo	VMinorLoc m	VMinorRatio	FvMinDsgn KN
12	1.522E-18	34.758	0	1.4DL+1.6LIVE 1	0.55	0.013937	1.522E-18
14	0.021	22.389	0	1.4DL	0	0	0.021
15	0.021	22.389	0	1.4DL	0	0	0.021
16	0.021	22.389	0	1.4DL	0	0	0.021
17	0.021	22.389	0	1.4DL	0	0	0.021
18	0.025	22.389	0	1.4DL+1.6LIVE 1	0	0.00127	0.025
19	0.022	22.389	0	1.4DL+1.6LIVE 1	0	0.020366	0.022
20	0.022	22.389	0	1.4DL+1.6LIVE 1	1.5	0.020366	0.022
21	0.025	22.389	0	1.4DL+1.6LIVE 1	0	0.00127	0.025

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 3 of 4

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 3 of 4

Frame	PvMinor KN	TuMinor KN-m	SRLimit	RLLF	FramingType
1	34.758	0	1	1	Eccentrically Braced Frame
5	34.758	0	1	1	Eccentrically Braced Frame
8	34.758	0	1	1	Eccentrically Braced Frame
10	34.758	0	1	1	Eccentrically Braced Frame
12	34.758	0	1	1	Eccentrically Braced Frame
14	22.389	0	1	1	Eccentrically Braced Frame
15	22.389	0	1	1	Eccentrically Braced Frame
16	22.389	0	1	1	Eccentrically Braced Frame
17	22.389	0	1	1	Eccentrically Braced Frame
18	22.389	0	1	1	Eccentrically Braced Frame
19	22.389	0	1	1	Eccentrically Braced Frame
20	22.389	0	1	1	Eccentrically Braced Frame
21	22.389	0	1	1	Eccentrically Braced Frame

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 4 of 4

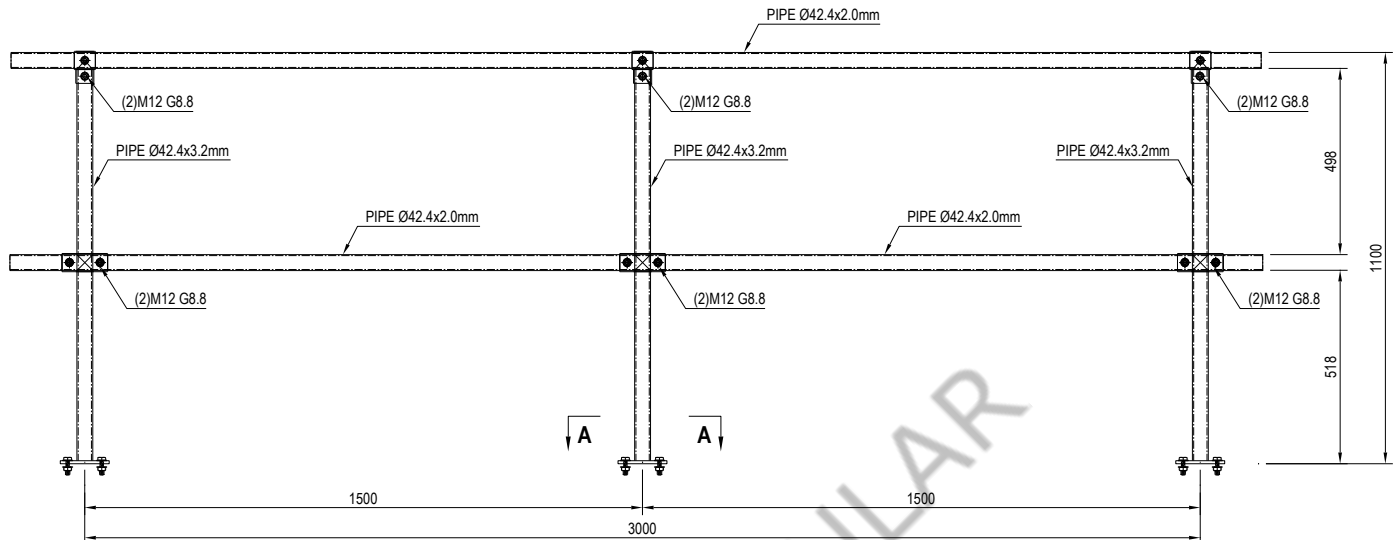
Table: Steel Design 3 - Shear Details - BS5950 2000, Part 4 of 4

Frame	ErrMsg	WarnMsg
1	No Messages	No Messages
5	No Messages	No Messages
8	No Messages	No Messages
10	No Messages	No Messages
12	No Messages	No Messages
14	No Messages	No Messages
15	No Messages	No Messages
16	No Messages	No Messages
17	No Messages	No Messages
18	No Messages	No Messages
19	No Messages	No Messages
20	No Messages	No Messages
21	No Messages	No Messages

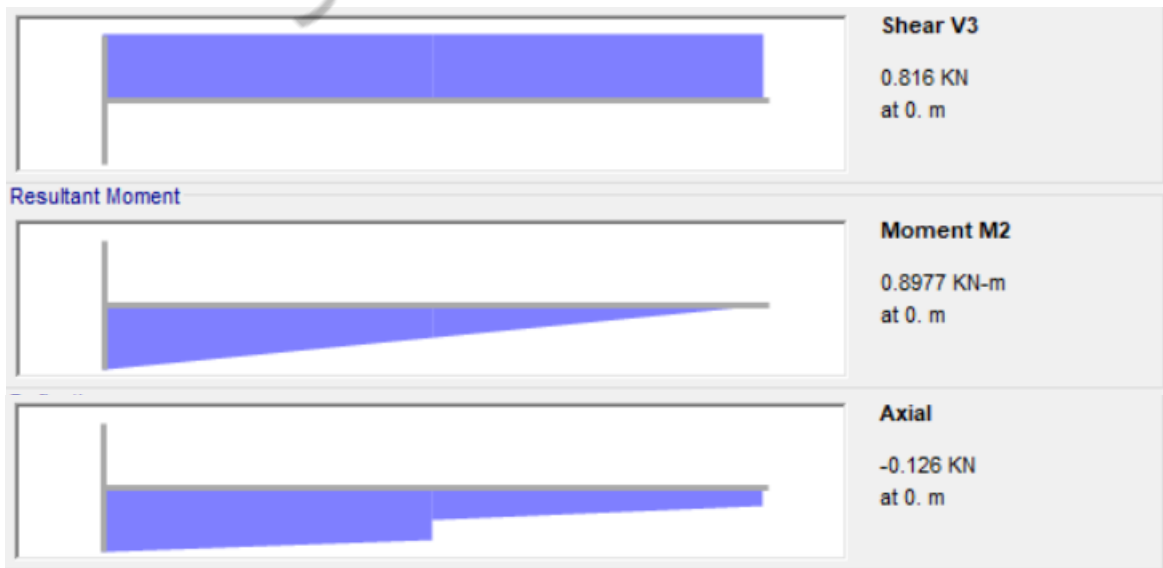
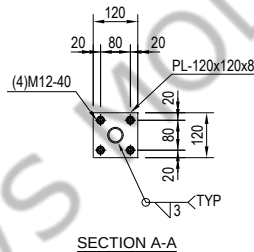
STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

3. Connection Calculation



DETAL HANDRAIL



STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

❖ Check Bolt

Quy cách	Mã hiệu	Đường kính lỗ khoan độ [mm]	Chiều dài tác kê l [mm]	Chiều sâu lỗ khoan tối thiểu h ₁ [mm]	Chiều sâu neo hiệu quả h _{ef} [mm]	Đường kính ty ren M [mm]	Lực nhổ đề nghị N _{rec} [kN]	Lực cắt đề nghị V _{rec} [kN]	Số lượng mỗi hộp cái
EA II M 6	048264	8	30	32	30	M 6	3.9	2.9	100
EA II M 8	048284	10	30	33	30	M 8	3.9	4.0	100
EA II M 8 x 40	048323	10	40	43	40	M 8	6.1	3.9	50
EA II M 10 x 30	048332	12	30	33	30	M 10	3.9	4.0	50
EA II M 10	048339	12	40	43	40	M 10	6.1	5.0	50
EA II M 12	048406	15	50	54	50	M 12	8.5	8.5	25
EA II M 16	048408	20	65	70	65	M 16	12.6	18.3	20
EA II M 20	048409	24	80	85	80	M 20	17.2	29.1	10

Chú ý:

- Tất cả giá trị của lực ở trên áp dụng cho bê tông chịu nén C20/25, không chịu ảnh hưởng bởi khoảng cách mép nền và khoảng cách trục giữa 2 bulong.
- Lực đề nghị: Đã bao gồm hệ số an toàn vật liệu và hệ số an toàn tải trọng là 1.4

Connection Calculation**1) Maximum ultimate reaction**

Moment, M =	0.9	KNm
Axial load, P =	-0.1	KN
Shear force, V =	0.82	KN

2) Bolt Type

Bolt tye and size =	M12	
Tension capacity, T _c =	8.5	KN
Shear capacity, V _c =	8.5	KN

3) No. of bolt

Distance from the last row

No. of bolt in 1st row - N1 =	2	d1 =	80	mm
No. of bolt in 1st row - N2 =	2	d2 =	0	mm
No. of bolt in 1st row - N3 =	0	d3 =	0	mm
No. of bolt in 1st row - N4 =	0	d4 =	0	mm
No. of bolt in 1st row - N5 =	0	d5 =	0	mm
No. of bolt in 1st row - N6 =	0	d6 =	0	mm
No. of bolt in 1st row - N7 =	0	d7 =	0	mm
No. of bolt in 1st row - N8 =	0	d8 =	0	mm

4) Check the bolt

Maximum tension force on the bolt due to moment

$T_m = (M \times d_1) / (\sum N_i \times d_i^2) =$	5.63	KN
Tension force on bolt due to axial load, T _a =	-0.03	KN
Shear force on bolt due to shear, V =	0.21	KN

So total tension on bolt, T =	5.60	KN
T	<=	T _c OK

Total shear on bolt, V =	0.21	KN
V	<=	V _c OK

Combined action

T/T _c + V/V _c =	0.68	
T/T _c + V/V _c =	<=	1.4 OK

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION**

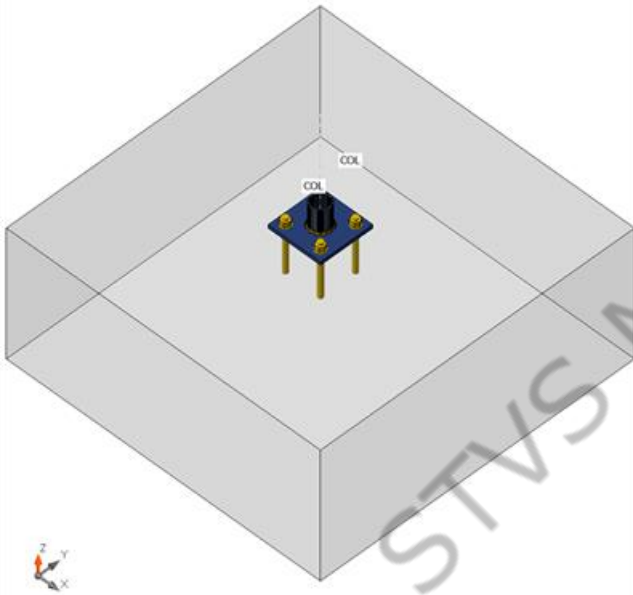
❖ Check base plate and welds by Idea Statica Software

Material

Steel S 245, S 345
Concrete C20/25

Beams and columns

Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
COL	2 - PiPE 42.4x3.2	0.0	-90.0	0.0	0	0	0	Node

**Cross-sections**

Name	Material
2 - PiPE 42.4x3.2	S 245

Anchors

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M12 8.8	M12 8.8	12	800.0	113

Load effects (equilibrium not required)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	COL	-0.1	0.8	0.0	0.0	0.0	0.9

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Check****Summary**

Name	Value	Status
Analysis	100.0%	OK
Plates	0.0 < 5.0%	OK
Welds	84.4 < 100%	OK

Plates

Name	Material	Thickness [mm]	Loads	σ_{Ed} [MPa]	ϵ_{PI} [%]	σ_{CEd} [MPa]	Status
COL	S 245	3.2	LE1	245.0	0.0	0.0	OK
BP1	S 345	8.0	LE1	256.0	0.0	0.0	OK

Design data

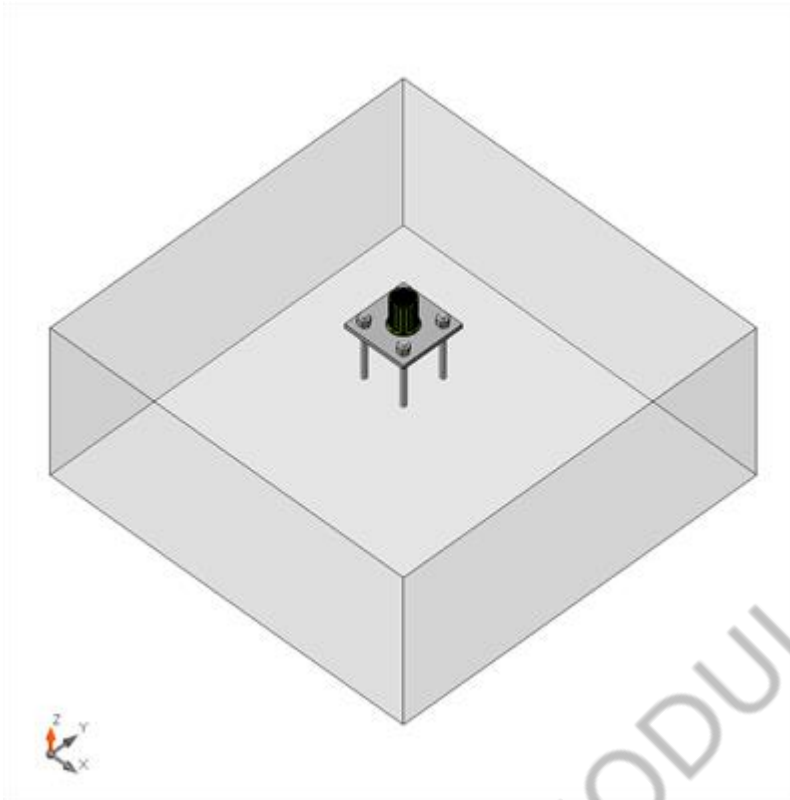
Material	f_y [MPa]	ϵ_{lim} [%]
S 245	245.0	5.0
S 345	345.0	5.0

Symbol explanation

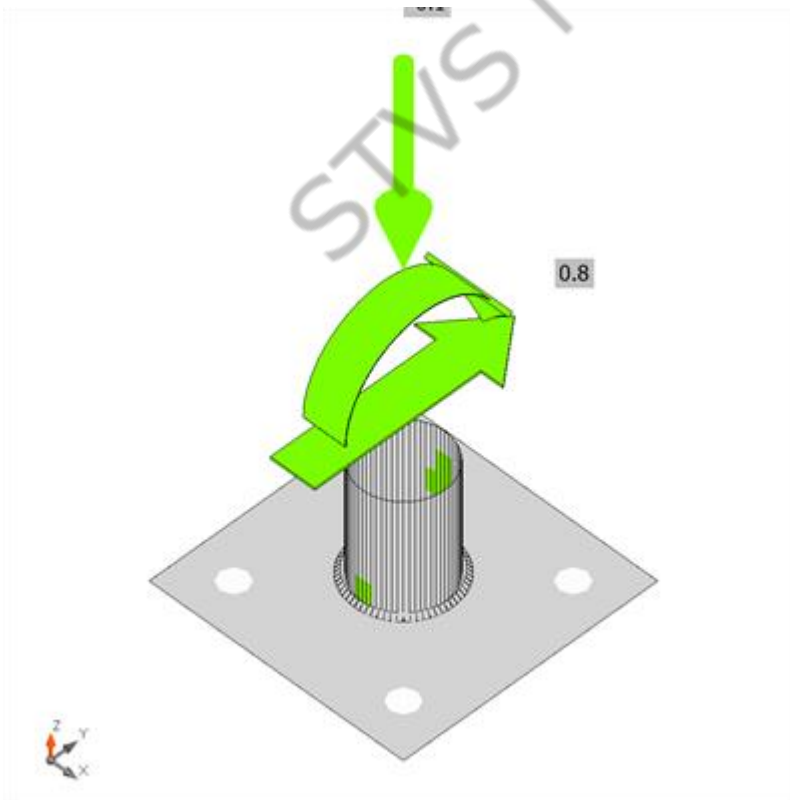
ϵ_{PI}	Strain
σ_{Ed}	Eq. stress
σ_{CEd}	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

STVS MODULAR

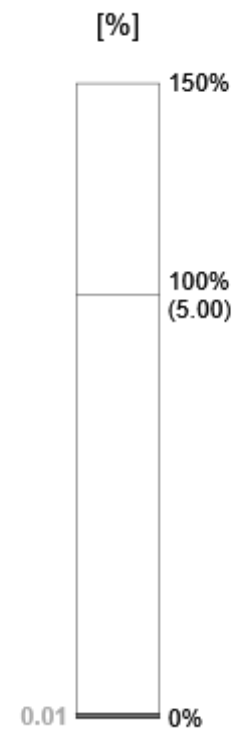
MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION



Overall check, LE1

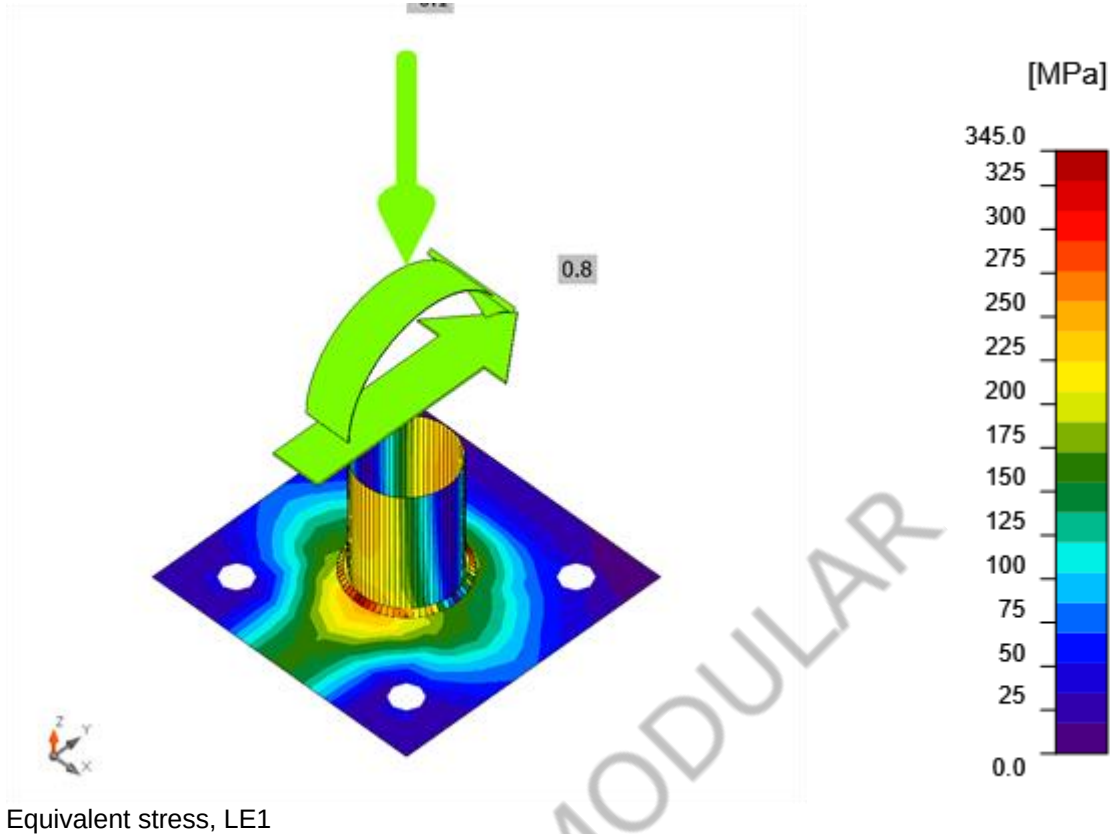


Strain check, LE1



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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION



Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{PI} [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	Ut [%]	Ut _c [%]	Status
BP1	COL	3.0	123	LE1	367.4	0.0	-216.0	30.5	168.9	84.4	53.0	OK

Design data

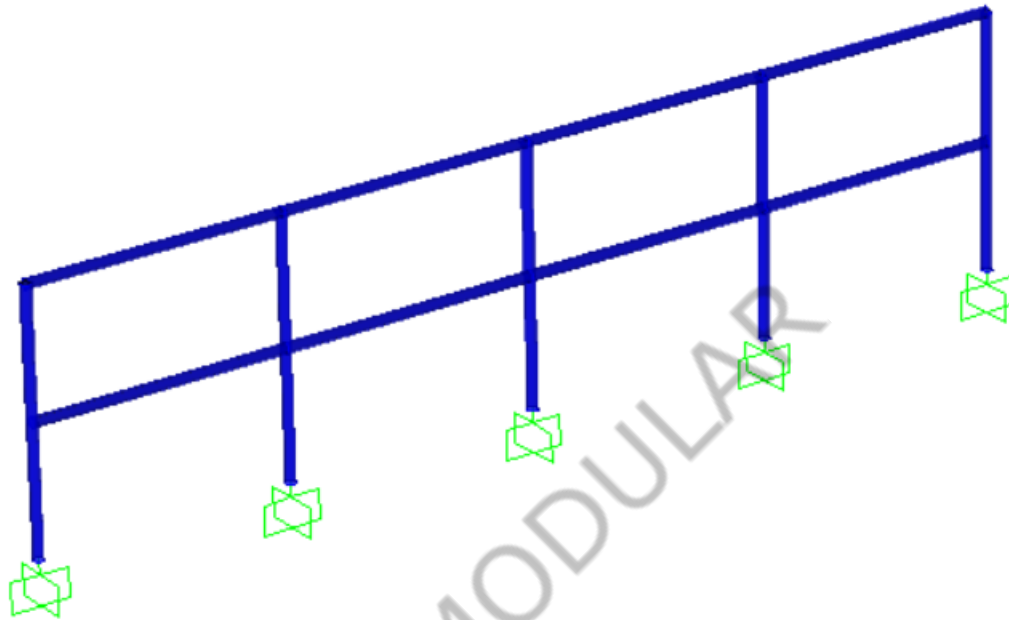
	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9σ [MPa]
S 345	0.90	435.6	352.8

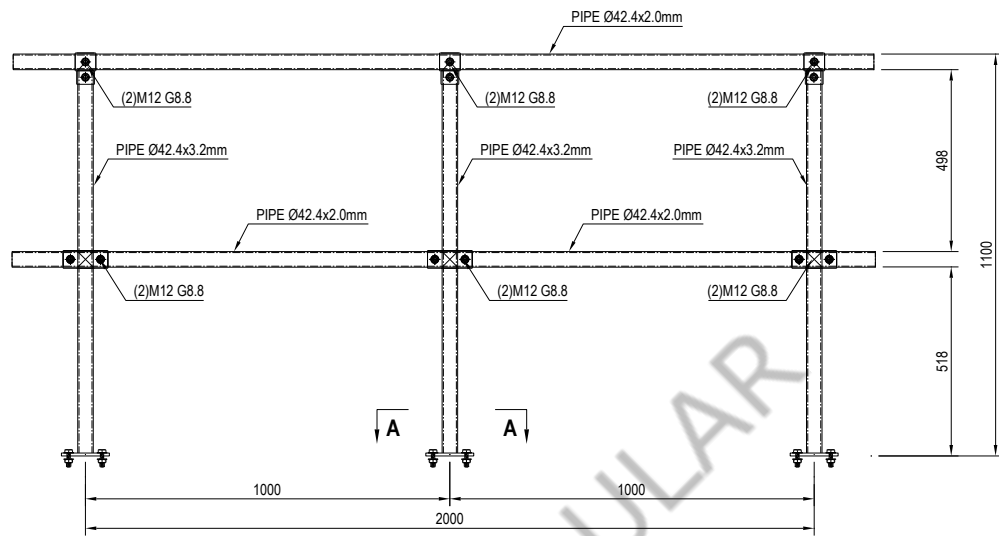
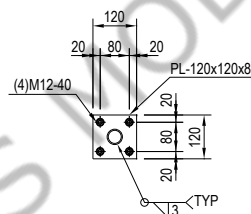
Symbol explanation

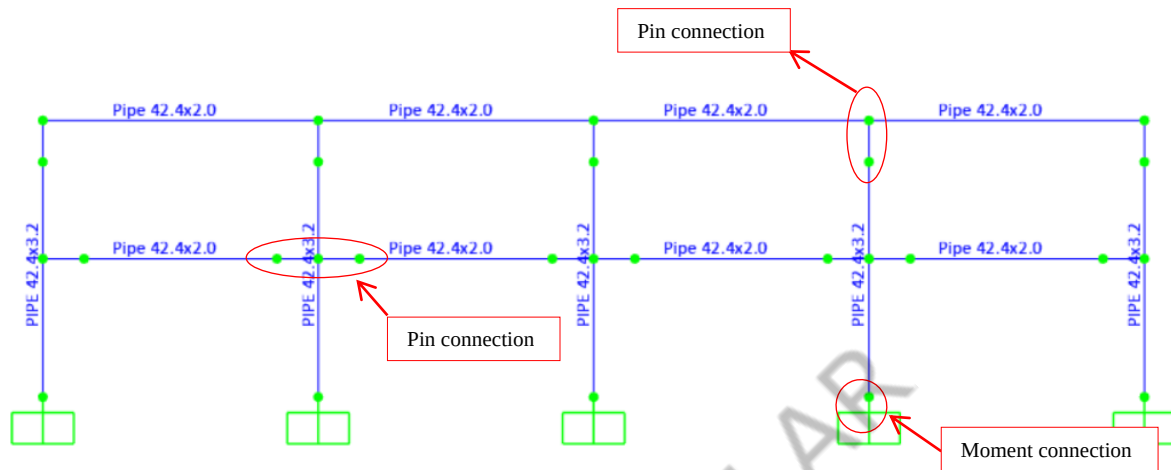
ϵ_{PI}	Strain
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
$\sigma_{\perp}$	Perpendicular stress
$\tau_{\parallel}$	Shear stress parallel to weld axis
$\tau_{\perp}$	Shear stress perpendicular to weld axis
0.9σ	Perpendicular stress resistance - $0.9 \cdot f_u / \gamma_{M2}$
β_w	Corelation factor EN 1993-1-8 tab. 4.1
Ut	Utilization
Ut _c	Weld capacity utilization

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Code settings**

Item	Value	Unit	Reference
γ_{M0}	1.00	-	EN 1993-1-1: 6.1
γ_{M1}	1.00	-	EN 1993-1-1: 6.1
γ_{M2}	1.25	-	EN 1993-1-1: 6.1
γ_{M3}	1.25	-	EN 1993-1-8: 2.2
γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	0.67	-	EN 1993-1-8: 6.2.5
Effective area - influence of mesh size	0.10	-	
Friction coefficient - concrete	0.25	-	EN 1993-1-8
Friction coefficient in slip-resistance	0.30	-	EN 1993-1-8 tab 3.7
Limit plastic strain	0.05	-	EN 1993-1-5
Weld stress evaluation	Plastic redistribution		
Detailing	Yes		
Distance between bolts [d]	2.20	-	EN 1993-1-8: tab 3.3
Distance between bolts and edge [d]	1.20	-	EN 1993-1-8: tab 3.3
Concrete breakout resistance check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated α_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****VIII. HANDRAIL - TYPE 2 (COLUMN SPACING 1000MM)****3D Sap Modal**

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****1. Structural Drawing****DETAL HANDRAIL****Typical Handrail**

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****2. Design Calculation****MAIN FRAME****Design Load :**

❖ Deal Load:

- Self-weight of Handrail : Sap2000 program automatically calculate.

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

❖ Live load:

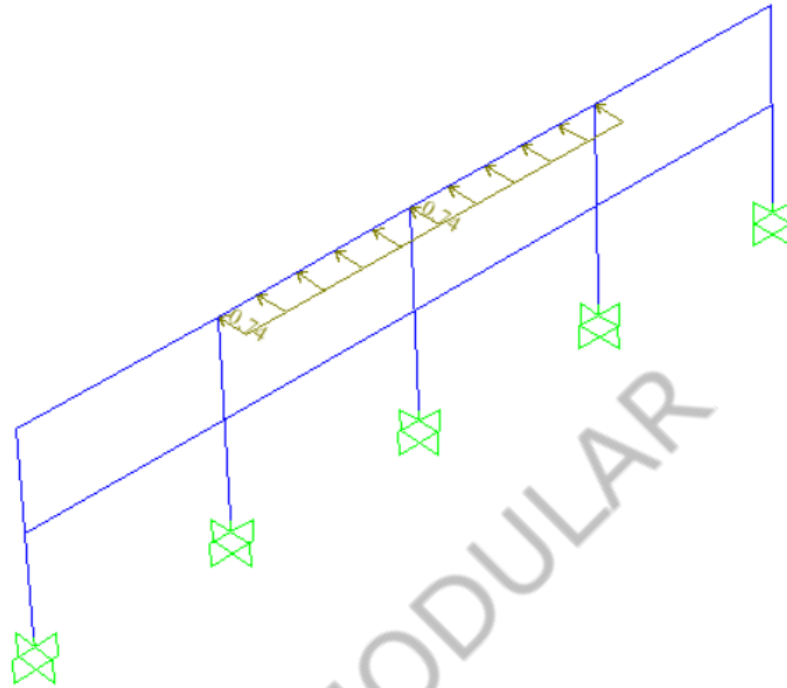
Table 2 of BS 6180:2011

Table 2 Minimum horizontal imposed loads for parapets, barriers and balustrades

Type of occupancy for part of the building or structure	Examples of specific use	Horizontal uniformly distributed line load (kN/m)	Uniformly distributed load applied to the infill (kN/m ²)	A point load applied to part of the infill (kN)
Domestic and residential activities	(i) All areas within or serving exclusively one single family dwelling including stairs, landings, etc. but excluding external balconies and edges of roofs	0.36	0.5	0.25
	(ii) Other residential, i.e. houses of multiple occupancy and balconies, including Juliette balconies and edges of roofs in single family dwellings	0.74	1.0	0.5
Offices and work areas not included elsewhere, including storage areas	(iii) Light access stairs and gangways not more than 600 mm wide	0.22	—	—
	(iv) Light pedestrian traffic routes in industrial and storage buildings except designated escape routes	0.36	0.5	0.25
	(v) Areas not susceptible to overcrowding in office and institutional buildings, also industrial and storage buildings except as given above	0.74	1.0	0.5
Areas where people might congregate	(vi) Areas having fixed seating within 530 mm of the barrier, balustrade or parapet	1.5	1.5	1.5
Areas with tables or fixed seatings	(vii) Restaurants and bars	1.5	1.5	1.5
Areas without obstacles for moving people and not susceptible to overcrowding	(viii) Stairs, landings, corridors, ramps	0.74	1.0	0.5
	(ix) External balconies including Juliette balconies and edges of roofs. Footways and pavements within building curtilage adjacent to basement/sunken areas	0.74	1.0	0.5
Areas susceptible to overcrowding	(x) Footways or pavements less than 3 m wide adjacent to sunken areas	1.5	1.5	1.5
	(xi) Theatres, cinemas, discotheques, bars, auditoria, shopping malls, assembly areas, studio. Footways or pavements greater than 3 m wide adjacent to sunken areas.	3.0	1.5	1.5
	(xii) Grandstands and stadia ^{A)}			
Retail areas	(xiii) All retail areas including public areas of banks/building societies or betting shops	1.5	1.5	1.5
Vehicular	(xiv) Pedestrian areas in car parks, including stairs, landings, ramps, edges or internal floors, footways, edges of roofs	1.5	1.5	1.5
	(xv) Horizontal loads imposed by vehicles ^{B)}			

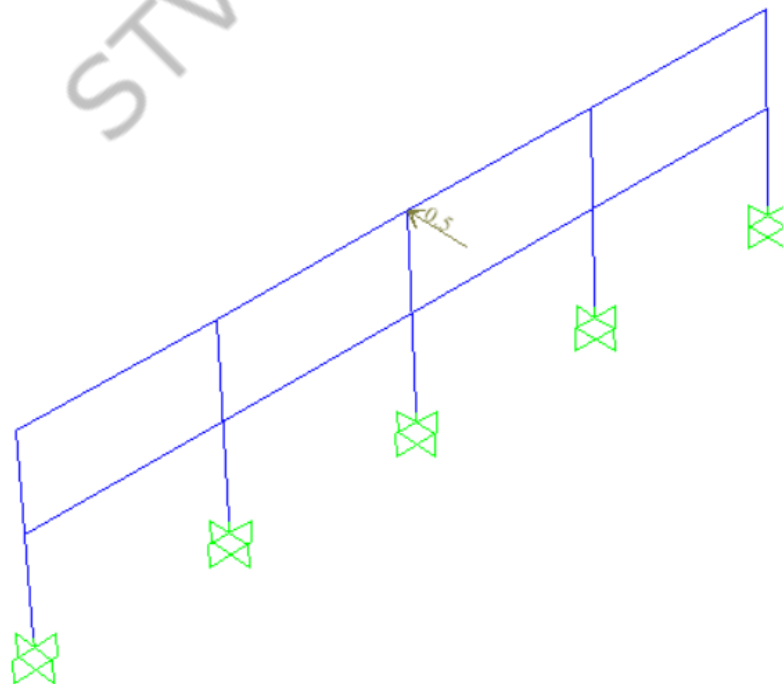
STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION**

Live Load 1- Uniform Load : $LL_1 = 0.74 \text{ kN/m}$



LIVE LOAD: LL_1 (KN/m)

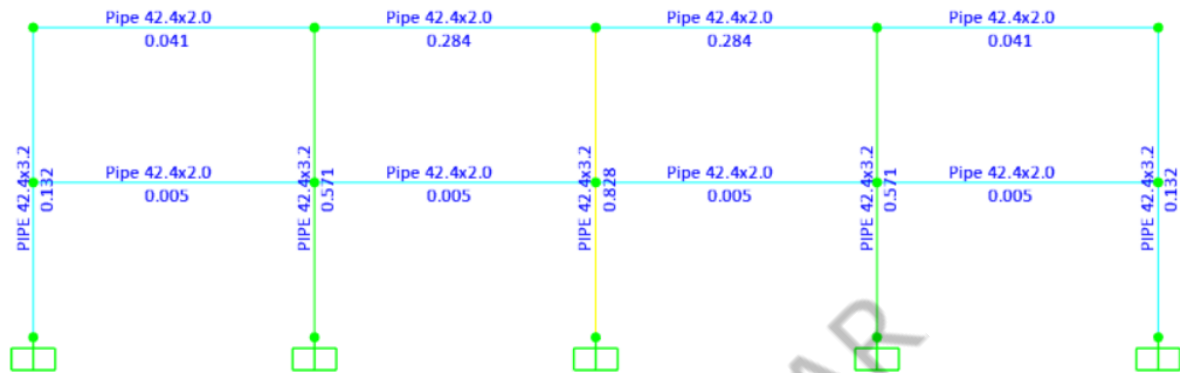
Live Load 2- point Load : $LL_2 = 0.5 \text{ kN}$



LIVE LOAD: LL_2 (KN/m)

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****d) Sap Output**

Design Strength unity check

**STRENGTH UNITY CHECK**

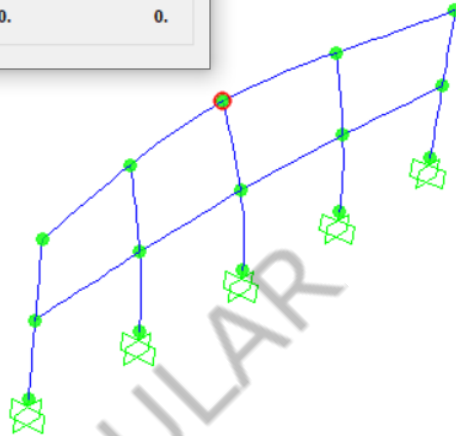
Conclusion : The strength unity check ratio of all steel members are smaller than 1.0 ($UC < 1.0$).
 Hence : All steel members are passed the design strength checking

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Deflection :

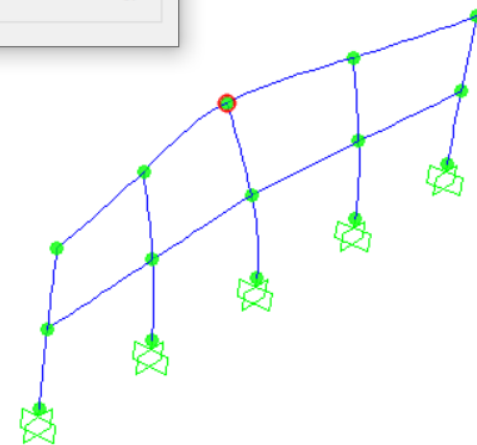
Joint Displacements				
Joint	Object	49	Joint Element	49
	1		2	3
Trans	0.		13.99386	0.
Rotn	0.		0.	0.



HORIZONTAL DEFLECTION $d = 14.0 \text{ mm}$
(LIVE 1)

Maximum Horizontal deflection limit at top column = $\text{Span}/65$ or $25\text{mm} = 1100/65$ or $25\text{mm} = 16.9 \text{ mm}$
Horizontal deflection at top column = $14.0 \text{ mm} < 16.9 \text{ mm} \rightarrow \text{OK}$

Joint Displacements				
Joint	Object	49	Joint Element	49
	1		2	3
Trans	0.		5.85376	0.
Rotn	0.		0.	0.



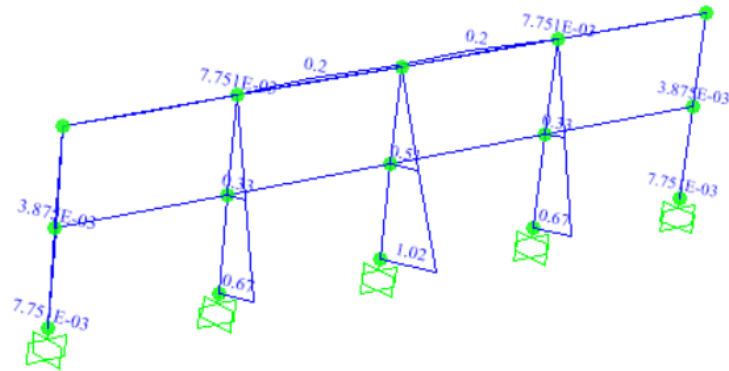
HORIZONTAL DEFLECTION $d = 5.9 \text{ mm}$
(LIVE 2)

Maximum Horizontal deflection limit at top column = $\text{Span}/65$ or $25\text{mm} = 1100/65$ or $25\text{mm} = 16.9 \text{ mm}$
Horizontal deflection at top column = $5.9 \text{ mm} < 16.9 \text{ mm} \rightarrow \text{OK}$

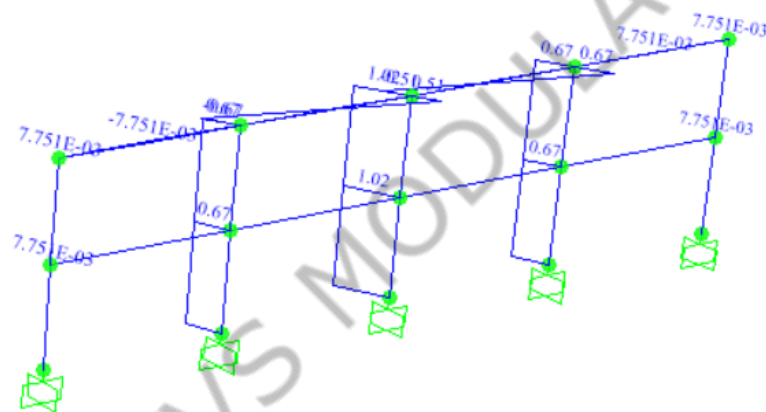
STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

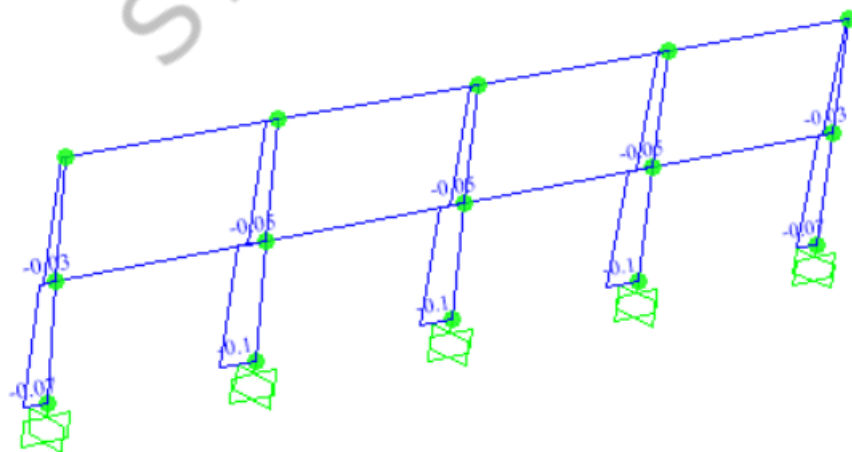
- 1.4D+1.6L1



MOMENT (KNM)



SHEAR (KN)

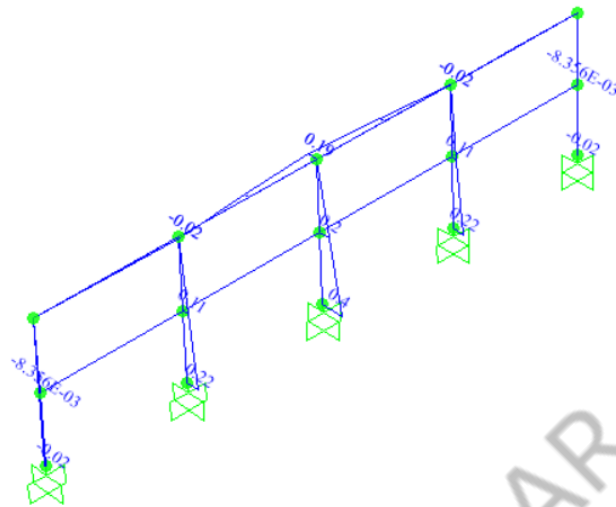


AXIAL (KN)

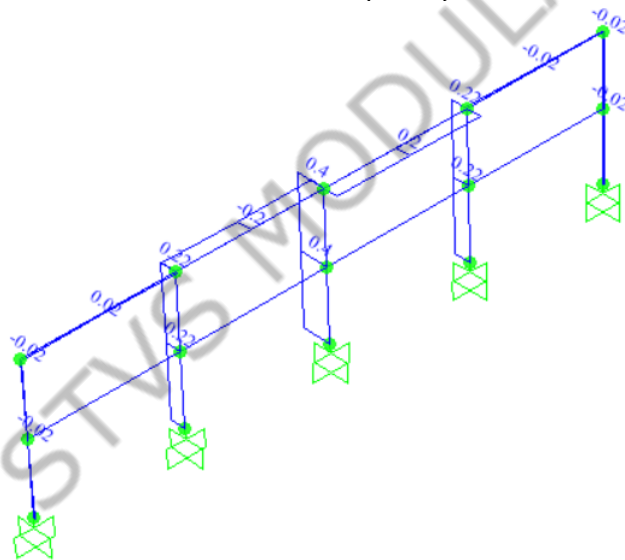
STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

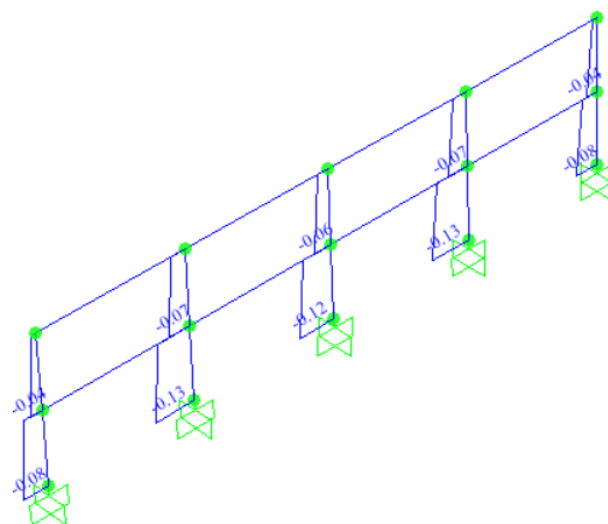
- 1.4D+1.6L2



MOMENT (KNM)



SHEAR (KN)



AXIAL (KN)

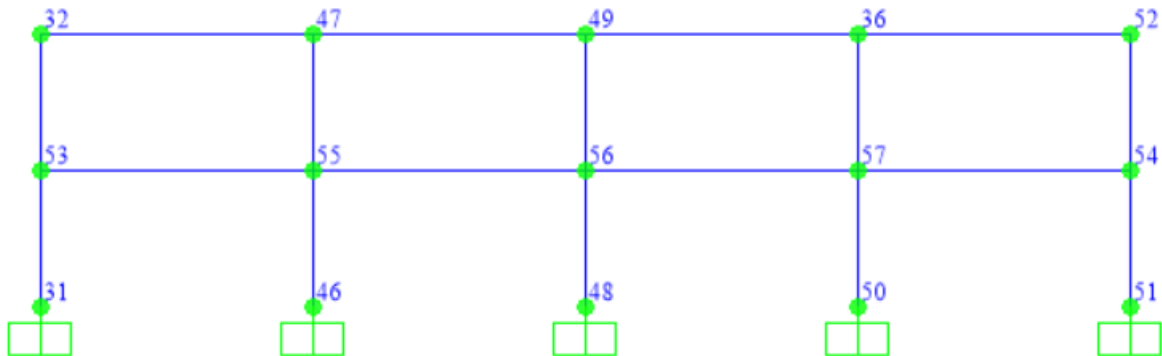
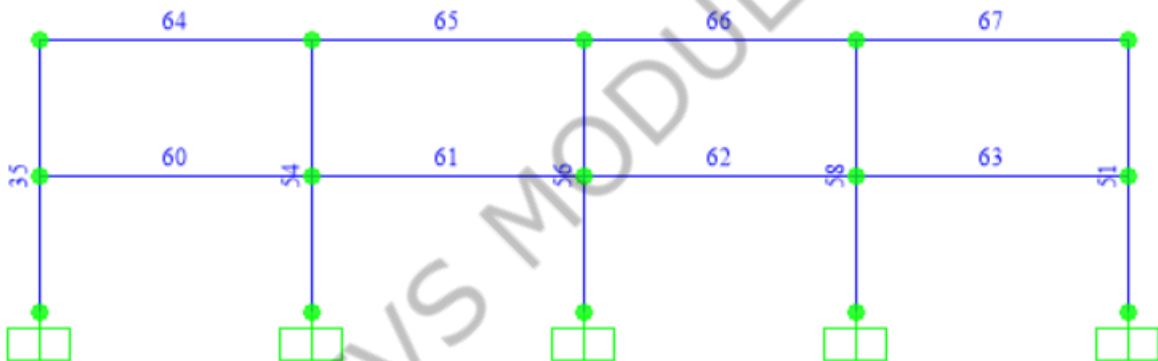
STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****e) Sap Input****JOINTS LABEL****FRAME LABEL****Table: Case - Static 1 - Load Assignments**

Table: Case - Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
DL	Load pattern	DL	1
LIVE 1	Load pattern	LIVE 1	1
LIVE 2	Load pattern	LIVE 2	1

Table: Combination Definitions, Part 1 of 3

Table: Combination Definitions, Part 1 of 3

ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
1.4DL	Linear Add	No	NonLin Static	DL	1.4	Strength
1.4DL+1.6LIVE 1	Linear Add	No	NonLin Static	DL	1.4	Strength
1.4DL+1.6LIVE 1	Linear Add	No	NonLin Static	LIVE 1	1.6	Strength
DL+LIVE 1	Linear Add	No	NonLin Static	DL	1	Strength
DL+LIVE 1	Linear Add	No	NonLin Static	LIVE 1	1	Strength
1.4DL+1.6LIVE 2	Linear Add	No	NonLin Static	DL	1.4	Strength

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Table: Combination Definitions, Part 1 of 3**

ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
1.4DL+1.6LIVE 2			NonLin Static	LIVE 2	1.6	
DL+LIVE 2	Linear Add	No	NonLin Static	DL	1	Strength
DL+LIVE 2			NonLin Static	LIVE 2	1	

Table: Combination Definitions, Part 2 of 3**Table: Combination Definitions, Part 2 of 3**

ComboName	CaseName	ConcDesign	AlumDesign	ColdDesign
1.4DL	DL	None	None	None
1.4DL+1.6LIVE 1	DL	None	None	None
1.4DL+1.6LIVE 1	LIVE 1			
DL+LIVE 1	DL	None	None	None
DL+LIVE 1	LIVE 1			
1.4DL+1.6LIVE 2	DL	None	None	None
1.4DL+1.6LIVE 2	LIVE 2			
DL+LIVE 2	DL	None	None	None
DL+LIVE 2	LIVE 2			

Table: Combination Definitions, Part 3 of 3**Table: Combination Definitions, Part 3 of 3**

ComboName	CaseName	GUID	Notes
1.4DL	DL		
1.4DL+1.6LIVE 1	DL		
1.4DL+1.6LIVE 1	LIVE 1		
DL+LIVE 1	DL		
DL+LIVE 1	LIVE 1		
1.4DL+1.6LIVE 2	DL		
1.4DL+1.6LIVE 2	LIVE 2		
DL+LIVE 2	DL		
DL+LIVE 2	LIVE 2		

Table: Frame Design Procedures**Table: Frame Design Procedures**

Frame	DesignProc
35	From Material
51	From Material
54	From Material
56	From Material
58	From Material
60	From Material
61	From Material
62	From Material
63	From Material
64	From Material
65	From Material
66	From Material

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Frame Design Procedures

Frame	DesignProc
67	From Material

Table: Frame Section Assignments

Table: Frame Section Assignments

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
35	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
51	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
54	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
56	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
58	Pipe	N.A.	PIPE 42.4x3.2	PIPE 42.4x3.2	Default
60	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
61	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
62	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
63	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
64	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
65	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
66	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default
67	Pipe	N.A.	Pipe 42.4x2.0	Pipe 42.4x2.0	Default

Table: Frame Section Properties 01 - General, Part 1 of 6

Table: Frame Section Properties 01 - General, Part 1 of 6

SectionName	Material	Shape	t3 m	tw m	Area m2	TorsConst m4
Pipe 42.4x2.0	Steel 245	Pipe	0.0424	0.002	0.000254	1.038E-07
PIPE 42.4x3.2	Steel 245	Pipe	0.0424	0.0032	0.000394	1.524E-07

Table: Frame Section Properties 01 - General, Part 2 of 6

Table: Frame Section Properties 01 - General, Part 2 of 6

SectionName	I33 m4	I22 m4	I23 m4	AS2 m2	AS3 m2	S33 m3	S22 m3
Pipe 42.4x2.0	5.192E-08	5.192E-08	0	0.000127	0.000127	2.449E-06	2.449E-06
PIPE 42.4x3.2	7.62E-08	7.62E-08	0	0.000198	0.000198	3.594E-06	3.594E-06

Table: Frame Section Properties 01 - General, Part 3 of 6

Table: Frame Section Properties 01 - General, Part 3 of 6

SectionName	Z33 m3	Z22 m3	R33 m	R22 m	ConcCol	ConcBeam	Color
Pipe 42.4x2.0	3.267E-06	3.267E-06	0.014301	0.014301	No	No	Red
PIPE 42.4x3.2	4.928E-06	4.928E-06	0.013905	0.013905	No	No	Red

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Frame Section Properties 01 - General, Part 4 of 6

Table: Frame Section Properties 01 - General, Part 4 of 6

SectionName	TotalWt KN	TotalMass KN-s2/m	FromFile	AMod	A2Mod	A3Mod	JMod
Pipe 42.4x2.0	0.391	0.03985	No	1	1	1	1
PIPE 42.4x3.2	0.318	0.03248	No	1	1	1	1

Table: Frame Section Properties 01 - General, Part 5 of 6

Table: Frame Section Properties 01 - General, Part 5 of 6

SectionName	I2Mod	I3Mod	MMod	WMod	GUID
Pipe 42.4x2.0	1	1	1	1	
PIPE 42.4x3.2	1	1	1	1	

Table: Frame Section Properties 01 - General, Part 6 of 6

Table: Frame Section Properties 01 - General, Part 6 of 6

SectionName	Notes
Pipe 42.4x2.0	Added 12/16/2022 10:25:19 PM
PIPE 42.4x3.2	Added 12/8/2022 8:40:52 PM

Table: Material Properties 01 - General, Part 1 of 2

Table: Material Properties 01 - General, Part 1 of 2

Material	Type	Grade	SymType	TempDepen d	Color	GUID
Steel 245	Steel		Isotropic	No	Yellow	

Table: Material Properties 01 - General, Part 2 of 2

Table: Material Properties 01 - General, Part 2 of 2

Material	Notes
Steel 245	ASTM A36 added 6/11/2008 9:51:33 AM

Table: Material Properties 03a - Steel Data

Table: Material Properties 03a - Steel Data

Material	Fy KN/m2	Fu KN/m2	EffFy KN/m2	EffFu KN/m2	SSCurveOpt	SSHysType
Steel 245	245000	400000	379500	528000	User Defined	Elastic

Table: Frame Loads - Distributed, Part 1 of 3

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
65	LIVE 1	GLOBAL	Force	Y	RelDist	0

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
66	LIVE 1	GLOBAL	Force	Y	RelDist	0

Table: Frame Loads - Distributed, Part 2 of 3

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA	AbsDistB	FOverLA	FOverLB
			m	m	KN/m	KN/m
65	LIVE 1	1	0	1	0.74	0.74
66	LIVE 1	1	0	1	0.74	0.74

Table: Frame Loads - Distributed, Part 3 of 3

Table: Frame Loads - Distributed, Part 3 of 3

Frame	LoadPat	GUID
65	LIVE 1	
66	LIVE 1	

Table: Joint Loads - Force, Part 1 of 2

Table: Joint Loads - Force, Part 1 of 2

Joint	LoadPat	CoordSys	F1	F2	F3	M1	M2
			KN	KN	KN	KN-m	KN-m
49	LIVE 2	GLOBAL	0	0.5	0	0	0

Table: Joint Loads - Force, Part 2 of 2

Table: Joint Loads - Force, Part 2 of 2

Joint	LoadPat	M3	GUID
		KN-m	
49	LIVE 2	0	

Table: Joint Restraint Assignments

Table: Joint Restraint Assignments

Joint	U1	U2	U3	R1	R2	R3
31	Yes	Yes	Yes	Yes	Yes	Yes
46	Yes	Yes	Yes	Yes	Yes	Yes
48	Yes	Yes	Yes	Yes	Yes	Yes
50	Yes	Yes	Yes	Yes	Yes	Yes
51	Yes	Yes	Yes	Yes	Yes	Yes

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Table: Joint Pattern Definitions**Table: Joint
Pattern Definitions

Pattern
DEFAULT

Table: Load Case Definitions, Part 1 of 3

Table: Load Case Definitions, Part 1 of 3

Case	Type	InitialCond	ModalCase	BaseCase	MassSource	DesTypeOpt	DesignType
DL	NonStatic	Zero				Prog Det	Dead
LIVE 1	NonStatic	Zero				Prog Det	Live
LIVE 2	NonStatic	Zero				Prog Det	Live

Table: Load Case Definitions, Part 2 of 3

Table: Load Case Definitions, Part 2 of 3

Case	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus	GUID
DL	Prog Det	Non-Composite	None	Yes	Finished	
LIVE 1	Prog Det	Short-Term Composite	None	Yes	Finished	
LIVE 2	Prog Det	Short-Term Composite	None	Yes	Finished	

Table: Load Case Definitions, Part 3 of 3

Table: Load Case Definitions, Part 3 of 3

Case	Notes
DL	
LIVE 1	
LIVE 2	

Table: Load Pattern Definitions

Table: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
DL	Dead	1			
LIVE 1	Live	0			
LIVE 2	Live	0			Added 12/8/2022 8:49:55 PM

Table: Overwrites - Steel Design - BS5950 2000, Part 1 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 1 of 5

Frame	DesignSect	FrameType	Fy KN/m2	RLLF	AreaRatio	XLMajor
35	Program Determined	Program Determined	0	0	0	0
35	Program Determined	Program Determined	0	0	0	0
51	Program Determined	Program Determined	0	0	0	0
51	Program Determined	Program Determined	0	0	0	0
54	Program Determined	Program Determined	0	0	0	0
56	Program Determined	Program Determined	0	0	0	0
58	Program Determined	Program Determined	0	0	0	0

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Table: Overwrites - Steel Design - BS5950 2000, Part 1 of 5**

Frame	DesignSect	FrameType	Fy KN/m2	RLLF	AreaRatio	XLMajor
60	Program Determined	Program Determined	0	0	0	0
61	Program Determined	Program Determined	0	0	0	0
62	Program Determined	Program Determined	0	0	0	0
63	Program Determined	Program Determined	0	0	0	0
64	Program Determined	Program Determined	0	0	0	0
65	Program Determined	Program Determined	0	0	0	0
66	Program Determined	Program Determined	0	0	0	0
67	Program Determined	Program Determined	0	0	0	0

Table: Overwrites - Steel Design - BS5950 2000, Part 2 of 5**Table: Overwrites - Steel Design - BS5950 2000, Part 2 of 5**

Frame	XLMinor	XKMajor	XKMinor	MMajor	MMinor	MLT	Pc KN
35	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0

Table: Overwrites - Steel Design - BS5950 2000, Part 3 of 5**Table: Overwrites - Steel Design - BS5950 2000, Part 3 of 5**

Frame	Pt KN	Mc3 KN-m	Mc2 KN-m	Mb KN-m	Pv2 KN	Pv3 KN	CheckDefl
35	0	0	0	0	0	0	Program Determined
35	0	0	0	0	0	0	Program Determined
51	0	0	0	0	0	0	Program Determined
51	0	0	0	0	0	0	Program Determined
54	0	0	0	0	0	0	Program Determined
56	0	0	0	0	0	0	Program Determined
58	0	0	0	0	0	0	Program Determined
60	0	0	0	0	0	0	Program Determined
61	0	0	0	0	0	0	Program Determined
62	0	0	0	0	0	0	Program Determined
63	0	0	0	0	0	0	Program Determined
64	0	0	0	0	0	0	Program Determined
65	0	0	0	0	0	0	Program Determined
66	0	0	0	0	0	0	Program Determined
67	0	0	0	0	0	0	Program Determined

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Overwrites - Steel Design - BS5950 2000, Part 4 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 4 of 5

Frame	DeflType	DLRat	SDLAndLLR at	LLRat	TotalRat	NetRat	DLAbs m
35	Program Determined	0	0	0	0	0	0
35	Program Determined	0	0	0	0	0	0
51	Program Determined	0	0	0	0	0	0
51	Program Determined	0	0	0	0	0	0
54	Program Determined	0	0	0	0	0	0
56	Program Determined	0	0	0	0	0	0
58	Program Determined	0	0	0	0	0	0
60	Program Determined	0	0	0	0	0	0
61	Program Determined	0	0	0	0	0	0
62	Program Determined	0	0	0	0	0	0
63	Program Determined	0	0	0	0	0	0
64	Program Determined	0	0	0	0	0	0
65	Program Determined	0	0	0	0	0	0
66	Program Determined	0	0	0	0	0	0
67	Program Determined	0	0	0	0	0	0

Table: Overwrites - Steel Design - BS5950 2000, Part 5 of 5

Table: Overwrites - Steel Design - BS5950 2000, Part 5 of 5

Frame	SDLAndLLA bs m	LLAbs m	TotalAbs m	NetAbs m	SpecCambe r m
35	0	0	0	0	0
35	0	0	0	0	0
51	0	0	0	0	0
51	0	0	0	0	0
54	0	0	0	0	0
56	0	0	0	0	0
58	0	0	0	0	0
60	0	0	0	0	0
61	0	0	0	0	0
62	0	0	0	0	0
63	0	0	0	0	0
64	0	0	0	0	0
65	0	0	0	0	0
66	0	0	0	0	0
67	0	0	0	0	0

Table: Preferences - Steel Design - BS5950 2000, Part 1 of 2

Table: Preferences - Steel Design - BS5950 2000, Part 1 of 2

THDesign	FrameType	PatLLF	SRatioLimit	MaxIter	CheckDefl	DLRat	SDLAndLLR at	LLRat
Envelopes		0.75	1	1	No	120	120	360

Table: Preferences - Steel Design - BS5950 2000, Part 2 of 2

Table: Preferences - Steel Design - BS5950 2000, Part 2 of 2

TotalRat	NetRat
240	240

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

f) Sap Output

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 1 of 2

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 1 of 2

Frame	DesignSect	DesignType	Status	Ratio	RatioType
35	PIPE 42.4x3.2	Column	No Messages	0.131964	PMM
51	PIPE 42.4x3.2	Column	No Messages	0.131964	PMM
54	PIPE 42.4x3.2	Column	No Messages	0.571111	PMM
56	PIPE 42.4x3.2	Column	No Messages	0.828219	PMM
58	PIPE 42.4x3.2	Column	No Messages	0.571111	PMM
60	Pipe 42.4x2.0	Beam	No Messages	0.005129	PMM
61	Pipe 42.4x2.0	Beam	No Messages	0.005129	PMM
62	Pipe 42.4x2.0	Beam	No Messages	0.005129	PMM
63	Pipe 42.4x2.0	Beam	No Messages	0.005129	PMM
64	Pipe 42.4x2.0	Beam	No Messages	0.040596	PMM
65	Pipe 42.4x2.0	Beam	No Messages	0.283723	PMM
66	Pipe 42.4x2.0	Beam	No Messages	0.283723	PMM
67	Pipe 42.4x2.0	Beam	No Messages	0.040596	PMM

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 2 of 2

Table: Steel Design 1 - Summary Data - BS5950 2000, Part 2 of 2

Frame	Combo	Location m	ErrMsg	WarnMsg
35	1.4DL+1.6LIVE 1	1.1	No Messages	No Messages
51	1.4DL+1.6LIVE 1	1.1	No Messages	No Messages
54	1.4DL+1.6LIVE 1	0	No Messages	No Messages
56	1.4DL+1.6LIVE 1	0	No Messages	No Messages
58	1.4DL+1.6LIVE 1	0	No Messages	No Messages
60	1.4DL	0.5	No Messages	No Messages
61	1.4DL	0.5	No Messages	No Messages
62	1.4DL	0.5	No Messages	No Messages
63	1.4DL	0.5	No Messages	No Messages
64	1.4DL+1.6LIVE 2	1	No Messages	No Messages
65	1.4DL+1.6LIVE 1	0.5	No Messages	No Messages
66	1.4DL+1.6LIVE 1	0.5	No Messages	No Messages
67	1.4DL+1.6LIVE 2	0	No Messages	No Messages

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 1 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 1 of 7

Frame	DesignSect	DesignType	Status	Combo	Location m	Pu KN
35	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	1.1	-0.011
51	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	1.1	-0.011
54	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.105
56	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.1
58	PIPE 42.4x3.2	Column	No Messages	1.4DL+1.6LIVE 1	0	-0.105
60	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0.5	0
61	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0.5	0
62	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0.5	0

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 1 of 7

Frame	DesignSect	DesignType	Status	Combo	Location m	Pu KN
63	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0.5	0
64	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 2	1	0
65	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 1	0.5	0
66	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 1	0.5	0
67	Pipe 42.4x2.0	Beam	No Messages	1.4DL+1.6LIVE 2	0	0

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 2 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 2 of 7

Frame	MuMajor KN-m	MuMinor KN-m	VuMajor KN	VuMinor KN	Tu KN-m	Equation	TotalRatio
35	0	0.1169	0	-0.001956	0	(4.8.3.3.1-2)	0.131964
51	0	0.1169	0	-0.001956	0	(4.8.3.3.1-2)	0.131964
54	0	0.6882	0	0.672	0	(4.8.3.2)	0.571111
56	0	0.9987	0	1.028	0	(4.8.3.2)	0.828219
58	0	0.6882	0	0.672	0	(4.8.3.2)	0.571111
60	0.0034	0	5.634E-19	0	0	(4.8.3.3.1-1)	0.005129
61	0.0034	0	5.634E-19	0	0	(4.8.3.3.1-1)	0.005129
62	0.0034	0	5.634E-19	0	0	(4.8.3.3.1-1)	0.005129
63	0.0034	0	5.634E-19	0	0	(4.8.3.3.1-1)	0.005129
64	-0.0029	-0.0291	0.017	0.029	-0.0446	(4.8.3.2)	0.040596
65	0.0009784	0.185	-0.0009462	-0.078	-0.0661	(4.8.3.3.1-2)	0.283723
66	0.0009784	0.185	0.0009462	0.078	0.0661	(4.8.3.3.1-2)	0.283723
67	-0.0029	-0.0291	-0.017	-0.029	0.0446	(4.8.3.2)	0.040596

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 3 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 3 of 7

Frame	PRatio	MMajRatio	MMinRatio	SRLimit	FtOrFcDsgn KN	Pc KN	Pt KN
35	0.000155	0	0.131809	1	-0.011	69.575	96.55
51	0.000155	0	0.131809	1	-0.011	69.575	96.55
54	0.00109	0	0.570021	1	-0.105	69.575	96.55
56	0.001031	0	0.827188	1	-0.1	69.575	96.55
58	0.00109	0	0.570021	1	-0.105	69.575	96.55
60	0	0.005129	0	1	0	47.901	62.191
61	0	0.005129	0	1	0	47.901	62.191
62	0	0.005129	0	1	0	47.901	62.191
63	0	0.005129	0	1	0	47.901	62.191
64	0	0.004047	0.040394	1	0	47.901	62.191
65	0	0.001222	0.283721	1	0	47.901	62.191
66	0	0.001222	0.283721	1	0	47.901	62.191
67	0	0.004047	0.040394	1	0	47.901	62.191

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 4 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 4 of 7

Frame	PcMajor KN	PcMinor KN	MfMajDsgn KN-m	McMajor KN-m	Mb	XKMaj	XLMajor
35	71.694	69.575	0	1.0567	1207401.813	1.902939	0.5

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 4 of 7

Frame	PcMajor KN	PcMinor KN	MfMajDsgn KN-m	McMajor KN-m	Mb	XKMajor	XLMajor
51	71.694	69.575	0	1.0567	1207401.813	1.902939	0.5
54	71.694	69.575	0	1.0567	1207401.813	1.902939	0.5
56	71.694	69.575	0	1.0567	1207401.813	1.902939	0.5
58	71.694	69.575	0	1.0567	1207401.813	1.902939	0.5
60	47.901	47.901	0.0034	0.72	800411.733	1	1
61	47.901	47.901	0.0034	0.72	800411.733	1	1
62	47.901	47.901	0.0034	0.72	800411.733	1	1
63	47.901	47.901	0.0034	0.72	800411.733	1	1
64	47.901	47.901	-0.0029	0.72	800411.733	1	1
65	47.901	47.901	0.0009784	0.8004	800411.733	1	1
66	47.901	47.901	0.0009784	0.8004	800411.733	1	1
67	47.901	47.901	-0.0029	0.72	800411.733	1	1

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 5 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 5 of 7

Frame	mMajor	mLT	MfMinDsgn KN-m	McMinor KN-m	XKMinor	XLMinor	mMinor
35	1	1	0.1169	1.2074	1	1	0.992641
51	1	1	0.1169	1.2074	1	1	0.992641
54	1	1	0.6882	1.2074	1	1	0.58522
56	1	1	0.9987	1.2074	1	1	0.573538
58	1	1	0.6882	1.2074	1	1	0.58522
60	0.9	1	0	0.72	1	1	1
61	0.9	1	0	0.72	1	1	1
62	0.9	1	0	0.72	1	1	1
63	0.9	1	0	0.72	1	1	1
64	0.654038	1	-0.0291	0.72	1	1	0.6
65	0.451641	1	0.185	0.8004	1	1	0.92001
66	0.451641	1	0.185	0.8004	1	1	0.92001
67	0.654038	1	-0.0291	0.72	1	1	0.6

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 6 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 6 of 7

Frame	Fy KN/m2	E KN/m2	Length m	MajAxisAng Degrees	RLLF	SectClass
35	245000	199900000	1.1		1	Class 1
51	245000	199900000	1.1		1	Class 1
54	245000	199900000	1.1		1	Class 1
56	245000	199900000	1.1		1	Class 1
58	245000	199900000	1.1		1	Class 1
60	245000	199900000	1		1	Class 1
61	245000	199900000	1		1	Class 1
62	245000	199900000	1		1	Class 1
63	245000	199900000	1		1	Class 1
64	245000	199900000	1		1	Class 1
65	245000	199900000	1		1	Class 1
66	245000	199900000	1		1	Class 1
67	245000	199900000	1		1	Class 1

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 7 of 7

Table: Steel Design 2 - PMM Details - BS5950 2000, Part 7 of 7

Frame	FramingType	ErrMsg	WarnMsg
35	Eccentrically Braced Frame	No Messages	No Messages
51	Eccentrically Braced Frame	No Messages	No Messages
54	Eccentrically Braced Frame	No Messages	No Messages
56	Eccentrically Braced Frame	No Messages	No Messages
58	Eccentrically Braced Frame	No Messages	No Messages
60	Eccentrically Braced Frame	No Messages	No Messages
61	Eccentrically Braced Frame	No Messages	No Messages
62	Eccentrically Braced Frame	No Messages	No Messages
63	Eccentrically Braced Frame	No Messages	No Messages
64	Eccentrically Braced Frame	No Messages	No Messages
65	Eccentrically Braced Frame	No Messages	No Messages
66	Eccentrically Braced Frame	No Messages	No Messages
67	Eccentrically Braced Frame	No Messages	No Messages

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 1 of 4

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 1 of 4

Frame	DesignSect	DesignType	Status	VMajorCombo	VMajorLoc m	VMajorRatio
35	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
51	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
54	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
56	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
58	PIPE 42.4x3.2	Column	No Messages	1.4DL	0	0
60	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000611
61	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000611
62	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000611
63	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000611
64	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1	0.000741
65	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000653
66	Pipe 42.4x2.0	Beam	No Messages	1.4DL	1	0.000653
67	Pipe 42.4x2.0	Beam	No Messages	1.4DL	0	0.000741

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 2 of 4

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 2 of 4

Frame	FvMajDsgn KN	PvMajor KN	TuMajor KN-m	VMinorCombo	VMinorLoc m	VMinorRatio	FvMinDsgn KN
35	0	34.758	0	1.4DL+1.6LIVE 2	0	0.000837	0
51	0	34.758	0	1.4DL+1.6LIVE 2	0.55	0.000837	0
54	0	34.758	0	1.4DL+1.6LIVE 1	0	0.019331	0
56	0	34.758	0	1.4DL+1.6LIVE 1	0.55	0.029578	0
58	0	34.758	0	1.4DL+1.6LIVE 1	0	0.019331	0
60	0.014	22.389	0	1.4DL	0	0	0.014
61	0.014	22.389	0	1.4DL	0	0	0.014
62	0.014	22.389	0	1.4DL	0	0	0.014
63	0.014	22.389	0	1.4DL	0	0	0.014

STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 2 of 4

Frame	FvMajDsgn KN	PvMajor KN	TuMajor KN-m	VMinorCombo	VMinorLoc m	VMinorRatio	FvMinDsgn KN
64	0.017	22.389	0	1.4DL+1.6LIVE 2	0	0.001299	0.017
65	0.015	22.389	0	1.4DL+1.6LIVE 1	0	0.029924	0.015
66	0.015	22.389	0	1.4DL+1.6LIVE 1	1	0.029924	0.015
67	0.017	22.389	0	1.4DL+1.6LIVE 2	0	0.001299	0.017

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 3 of 4

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 3 of 4

Frame	PvMinor KN	TuMinor KN-m	SRLimit	RLLF	FramingType
35	34.758	0	1	1	Eccentrically Braced Frame
51	34.758	0	1	1	Eccentrically Braced Frame
54	34.758	0	1	1	Eccentrically Braced Frame
56	34.758	0	1	1	Eccentrically Braced Frame
58	34.758	0	1	1	Eccentrically Braced Frame
60	22.389	0	1	1	Eccentrically Braced Frame
61	22.389	0	1	1	Eccentrically Braced Frame
62	22.389	0	1	1	Eccentrically Braced Frame
63	22.389	0	1	1	Eccentrically Braced Frame
64	22.389	0	1	1	Eccentrically Braced Frame
65	22.389	0	1	1	Eccentrically Braced Frame
66	22.389	0	1	1	Eccentrically Braced Frame
67	22.389	0	1	1	Eccentrically Braced Frame

Table: Steel Design 3 - Shear Details - BS5950 2000, Part 4 of 4

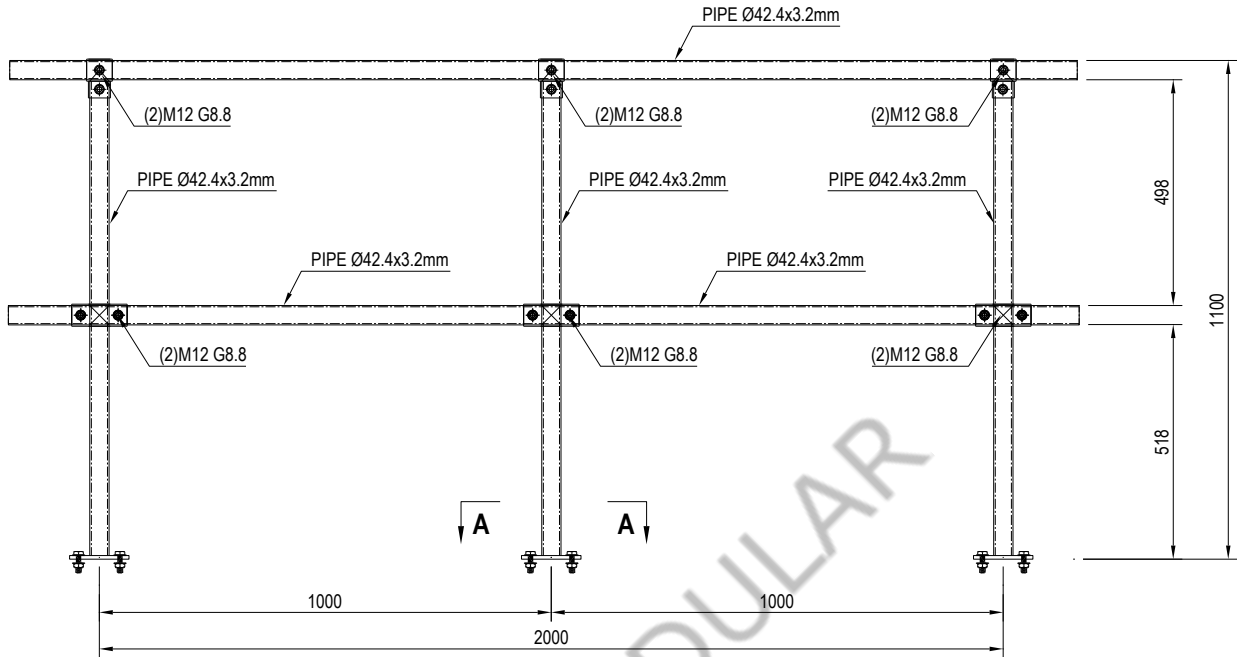
Table: Steel Design 3 - Shear Details - BS5950 2000, Part 4 of 4

Frame	ErrMsg	WarnMsg
35	No Messages	No Messages
51	No Messages	No Messages
54	No Messages	No Messages
56	No Messages	No Messages
58	No Messages	No Messages
60	No Messages	No Messages
61	No Messages	No Messages
62	No Messages	No Messages
63	No Messages	No Messages
64	No Messages	No Messages
65	No Messages	No Messages
66	No Messages	No Messages
67	No Messages	No Messages

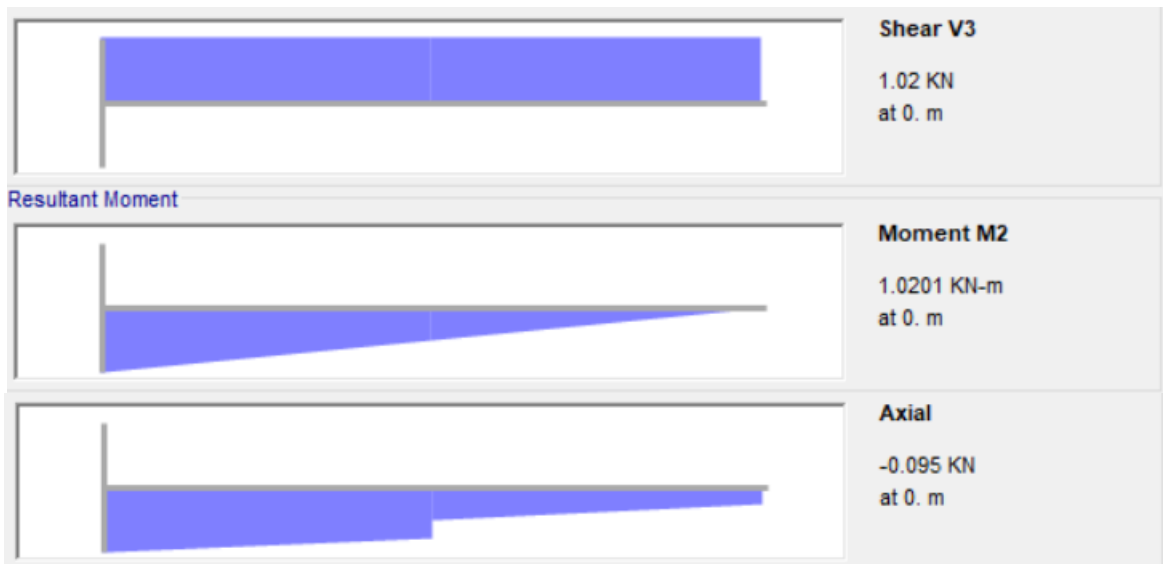
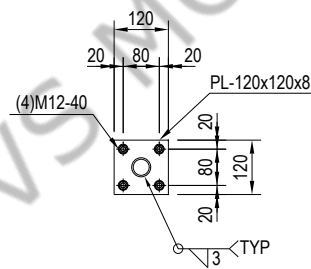
Description

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

3. Connection Calculation



DETAL HANDRAIL



STVS MODULAR

MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

❖ Check Bolt

Quy cách	Mã hiệu	Đường kính lỗ khoan độ [mm]	Chiều dài tắc kê l [mm]	Chiều sâu lỗ khoan tối thiểu h1 [mm]	Chiều sâu neo hiệu quả hef [mm]	Đường kính ty ren M [mm]	Lực nhô đề nghị Nrec [kN]	Lực cắt đề nghị Vrec [kN]	Số lượng mỗi hộp cái
EA II M 6	048264	8	30	32	30	M 6	3.9	2.9	100
EA II M 8	048284	10	30	33	30	M 8	3.9	4.0	100
EA II M 8 x 40	048323	10	40	43	40	M 8	6.1	3.9	50
EA II M 10 x 30	048332	12	30	33	30	M 10	3.9	4.0	50
EA II M 10	048339	12	40	43	40	M 10	6.1	5.0	50
EA II M 12	048406	15	50	54	50	M 12	8.5	8.5	25
EA II M 16	048408	20	65	70	65	M 16	12.6	18.3	20
EA II M 20	048409	24	80	85	80	M 20	17.2	29.1	10

Chú ý:

- Tất cả giá trị của lực ở trên áp dụng cho bê tông chịu nén C20/25, không chịu ảnh hưởng bởi khoảng cách mép nền và khoảng cách trục giữa 2 bulong.
- Lực đề nghị: Đã bao gồm hệ số an toàn vật liệu và hệ số an toàn tải trọng là 1.4

Connection Calculation**1) Maximum ultimate reaction**

Moment, M = 1.02 KNm
 Axial load, P = -0.1 KN
 Shear force, V = 1.02 KN

2) Bolt Type

Bolt type and size = M12
 Tension capacity, Tc = 8.5 KN
 Shear capacity, Vc = 8.5 KN

3) No. of bolt

Distance from the last row

No. of bolt in 1st row - N1 = 2 d1 = 80 mm
 No. of bolt in 1st row - N2 = 2 d2 = 0 mm
 No. of bolt in 1st row - N3 = 0 d3 = 0 mm
 No. of bolt in 1st row - N4 = 0 d4 = 0 mm
 No. of bolt in 1st row - N5 = 0 d5 = 0 mm
 No. of bolt in 1st row - N6 = 0 d6 = 0 mm
 No. of bolt in 1st row - N7 = 0 d7 = 0 mm
 No. of bolt in 1st row - N8 = 0 d8 = 0 mm

4) Check the bolt

Maximum tension force on the bolt due to moment

$$T_m = (M \times d_1) / (\sum N_i \times d_i^2) = 6.38 \text{ KN}$$

Tension force on bolt due to axial load, Ta = -0.03 KN

Shear force on bolt due to shear, V = 0.26 KN

So total tension on bolt, T = 6.35 KN

T ≤ Tc OK

Total shear on bolt, V = 0.26 KN

V ≤ Vc OK

Combined action

T/Tc + V/Vc = 0.78

T/Tc + V/Vc ≤ 1.4 OK

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION**

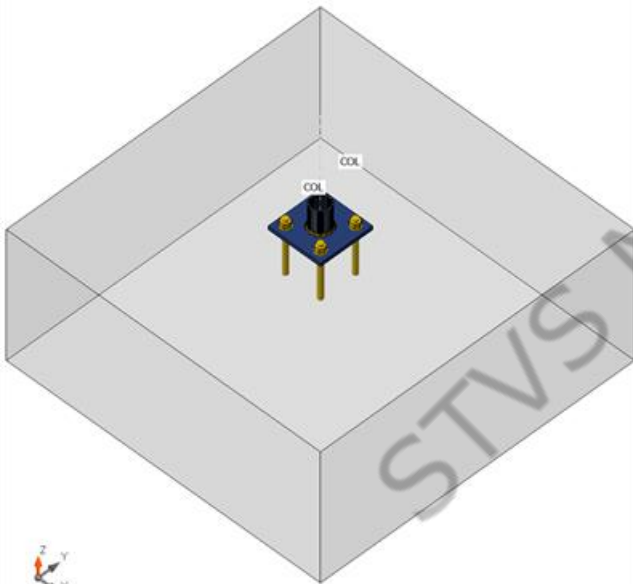
❖ Check base plate and welds by Idea Statica Software

Material

Steel S 245, S 345
Concrete C20/25

Beams and columns

Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
COL	2 - PiPE 42.4x3.2	0.0	-90.0	0.0	0	0	0	Node



Cross-sections

Name	Material
2 - PiPE 42.4x3.2	S 245

Anchors

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M12 8.8	M12 8.8	12	800.0	113

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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION

Load effects (equilibrium not required)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	COL	-0.1	1.0	0.0	0.0	0.0	1.0

Check

Summary

Name	Value	Status
Analysis	100.0%	OK
Plates	0.1 < 5.0%	OK
Welds	89.1 < 100%	OK

Plates

Name	Material	Thickness [mm]	Loads	σ_{Ed} [MPa]	ϵ_{Pl} [%]	$\sigma_{C_{Ed}}$ [MPa]	Status
COL	S 245	3.2	LE1	245.1	0.1	0.0	OK
BP1	S 345	8.0	LE1	291.6	0.0	0.0	OK

Design data

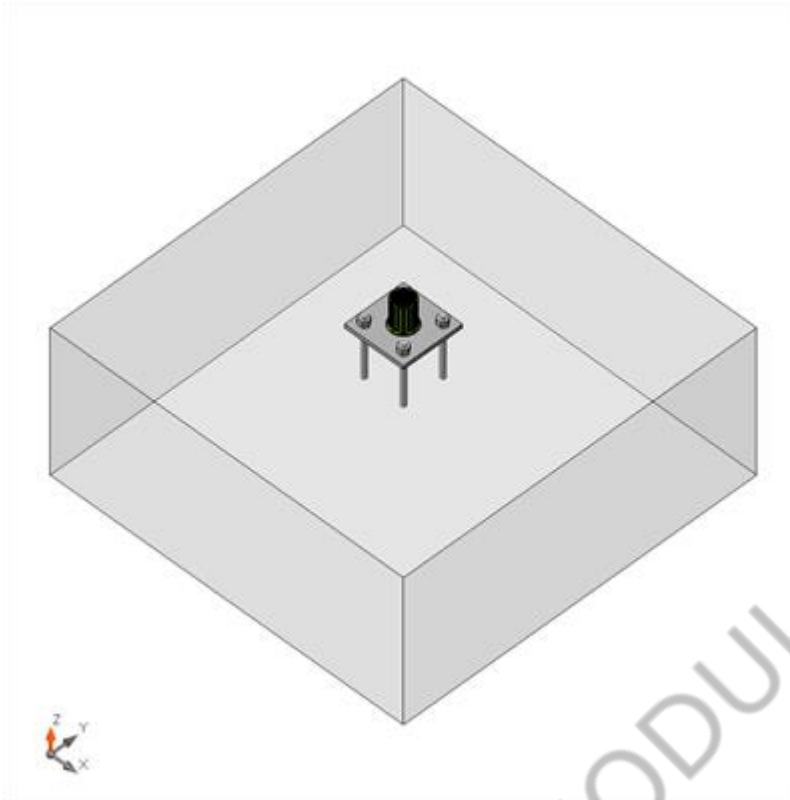
Material	f_y [MPa]	ϵ_{lim} [%]
S 245	245.0	5.0
S 345	345.0	5.0

Symbol explanation

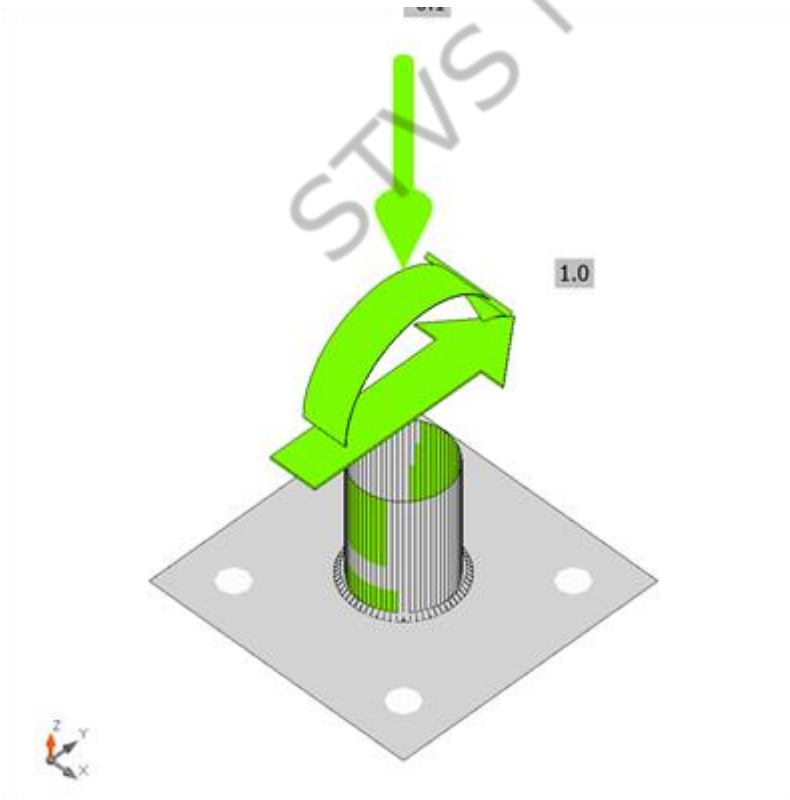
ϵ_{Pl}	Strain
σ_{Ed}	Eq. stress
$\sigma_{C_{Ed}}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

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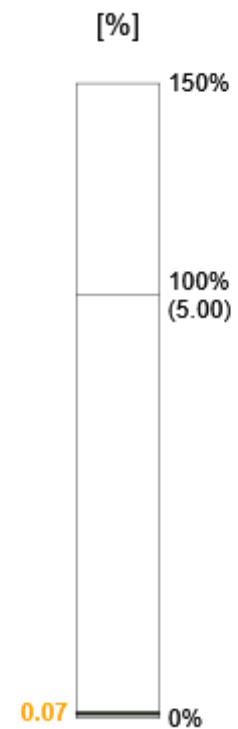
MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION



Overall check, LE1

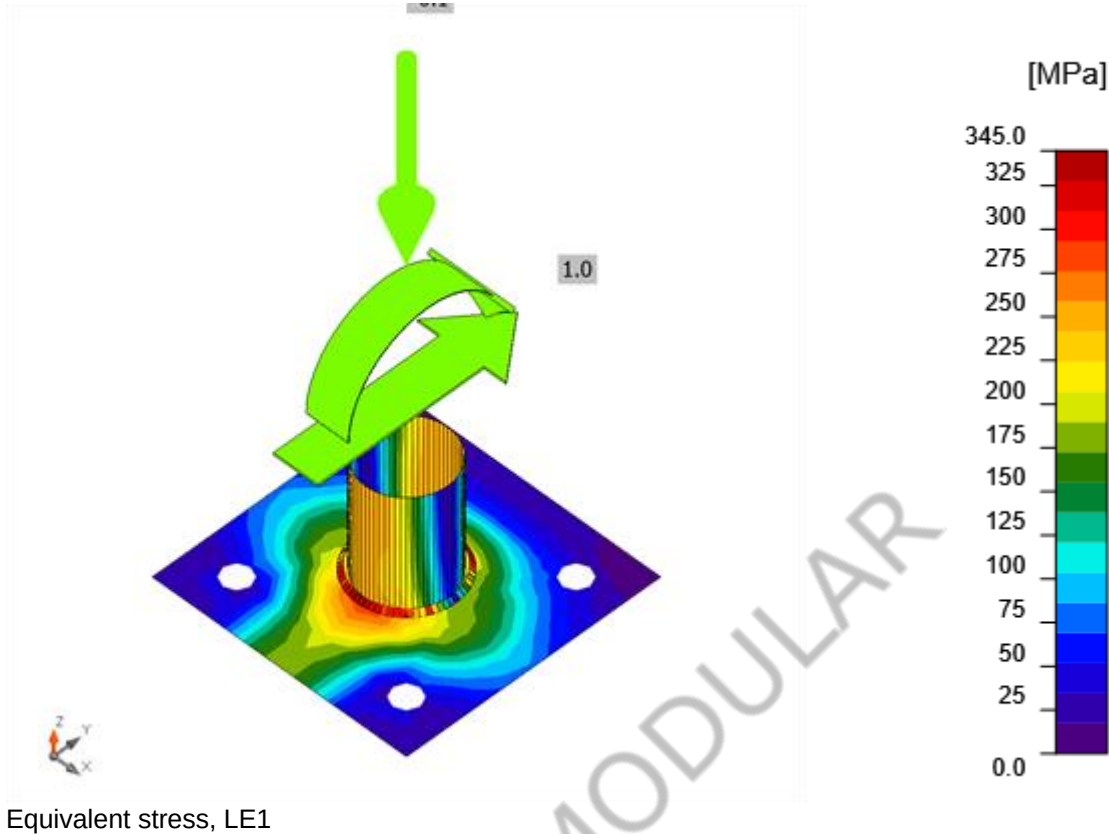


Strain check, LE1



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MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION



Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{PI} [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	Ut [%]	Ut _c [%]	Status
BP1	COL	3.0	123	LE1	388.2	0.0	-227.5	-2.9	181.6	89.1	60.4	OK

Design data

	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9σ [MPa]
S 345	0.90	435.6	352.8

Symbol explanation

ϵ_{PI}	Strain
$\sigma_{w,Ed}$	Equivalent stress
$\sigma_{w,Rd}$	Equivalent stress resistance
$\sigma_{\perp}$	Perpendicular stress
$\tau_{\parallel}$	Shear stress parallel to weld axis
$\tau_{\perp}$	Shear stress perpendicular to weld axis
0.9σ	Perpendicular stress resistance - $0.9 \cdot f_u / \gamma_{M2}$
β_w	Corelation factor EN 1993-1-8 tab. 4.1
Ut	Utilization
Ut _c	Weld capacity utilization

STVS MODULAR**MODULAR HANDRAIL TYPE 1 & TYPE 2 CALCULATION****Code settings**

Item	Value	Unit	Reference
γ_{M0}	1.00	-	EN 1993-1-1: 6.1
γ_{M1}	1.00	-	EN 1993-1-1: 6.1
γ_{M2}	1.25	-	EN 1993-1-1: 6.1
γ_{M3}	1.25	-	EN 1993-1-8: 2.2
γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	0.67	-	EN 1993-1-8: 6.2.5
Effective area - influence of mesh size	0.10	-	
Friction coefficient - concrete	0.25	-	EN 1993-1-8
Friction coefficient in slip-resistance	0.30	-	EN 1993-1-8 tab 3.7
Limit plastic strain	0.05	-	EN 1993-1-5
Weld stress evaluation	Plastic redistribution		
Detailing	Yes		
Distance between bolts [d]	2.20	-	EN 1993-1-8: tab 3.3
Distance between bolts and edge [d]	1.20	-	EN 1993-1-8: tab 3.3
Concrete breakout resistance check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated α_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5