PREPARED BY: mechworks ENGINEERING CONSULTANCY

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V. N. I. T. Civil Engg. Deptt. NAGPUR

3HP 9-MODULE SOLAR PUMP MMS STRUCTURE REPORT

PROJECT NO:	**MEC-EMMVEE-001**
REPORT:	**STAD PRO ANALYSIS**
REVISION NO:	**002**
ISSUE NO:	**001**
RELEASE DATE:	**26-FEB-2022**
REVISION DATE:	**26-FEB-2022**

EMMVEE

EMMVEE PHOTOVOLTAIC POWER PVT. LTD.

#13/1 International Airport Road, Bettahalasur Post,
Bengaluru - 562 157, India

TABLE OF CONTENTS

1. GENERAL

1.1 SCOPE

This document covers the Analysis & Design of Super Structure of Module mounting structure for Solar Mounting Structure. This analysis is also including existing structure shade with assumed dimension of structure.

1.2 UNITS OF MEASUREMENTS

Units of measurements used in analysis shall be of SI Units.

1.3 CODES AND REFERENCES

The following codes and references have been referred: for the design of Module mounting

Project Reference Drawing/Documents		
1	----	Geo-technical Investigation
2	----	Plot Plan
Indian Standard Codes		
3	IS 456 - 2000	Plain and Reinforced Concrete -Code of Practice
4	IS 875: Part 1 & 2	Code of practice for design loads
5	IS 875: Part 3	Code of practice for the design loads for buildings and structures Wind Loads
6	IS 800:2007 (LSD)	Code of practice for General construction in steel of Hot Rolled.
7	IS 801: 1975	Code of practice for cold formed steel
8	IS 811: 1987	Specifications for Cold Formed Light gauge structural steel sections.
9	IS: 2062	Hot Rolled Medium and High Tensile Structural Steel

1.4. MATERIAL PROPERTY

Material	Property	Value	UNIT
Lean Concrete M25	Density	24	KN/m^3
	Characteristic Strength	25	N/sq. mm
Structural Steel	Density	78.5	KN/m^3
	Characteristic Strength	250	MPa
	Modulus of Elasticity	205	GPa.

2. METHODOLOGY

2.1 SOFTWARE REFERANCE

- STAAD - Pro V8i, - For Load Input, analysis & Design of MMS.
- In-house developed MS-Excel programs - Wherever Excel programming is required. The above software packages are used for the structural analysis and the same are carried out in this document.
- Basic wind speed given below as per IS 875- part III-2015

Figure 1: Basic wind speed in m/s (based on 50 year return period)

2.2 ACCEPTANCE CRITERIA

The acceptance criteria are to ensure all the structural members are SAFE with in the allowable as per IS codes

2.3 DESIGN PHILOSOPHY

- The module mounting structure is designed using the structural analysis software package STAADPRO V8i.
- The analysis is performed for self-weight of structural members, other Dead Load on the members, Equipment Loads, Wind loads, Seismic load.
- Various possible load combinations of the above loads are listed in section 3.3 and 3.4. In load combinations involving wind or seismic loads.
- The permissible stresses in steel structural members may be increased by 33 percent. For anchor bolts and construction loads this increase shall be limited to 25 percent. Such an increase in allowable stresses should not be considered if the wind or seismic load is the major load in the load combination. (IS 800: 2007, CLAUSE NO. 11.1.4)

2.4 STRUCTURAL CONFIGURATION & MODELLING ASSUMPTIONS:

- The purlin and columns are pinned connected to each other to accommodate the proper tilt of structure.
- Columns are fixed support for both directions.
- Wind load is applied as per IS: 875-Part-III by using pressure coefficient method. Wind load has been basically applied as UDL over the purlin considering modules are in a continuous touch purlin.
- Deflection of members has been confined as a limit of L/150 for Rafter and Purlin & H/150 for columns. (TABLE NO. 7- IS 800: 2007)

2.5 RECOMMENDATION:

- Each and every Nut-Bolt must properly tighten and must use of washer.
- For better life of steel use oil paint each year.

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3. DESIGN INPUTS

3.1 SITE INPUT

Following are the design inputs as per client.

1. As per Module spec sheet,

- Module Length = **1993** mm
- Module Width = **1006** mm

2. Maximum inclination of the solar panel,

- Tilt Module = **20°**

3. Weight of the solar panel,

- **Module Weight** = **24 kg**

4. Wind speed,

- **V** = **150 km/h**

3.2 PRIMARY LOAD CASES

SR. NO.	PRIMARY LOAD CASES	LOAD TYPE
1.	Self wt.	DL
2.	Module wt.	DL
3.	Wind load Upward	WL UP
4.	Wind load Downward	WL DN
5.	Wind load in X+ direction	WL x+
6.	Wind load in X- direction	WL x-
7.	Wind load in Z+ direction	WL z+
8.	Wind load in Z- direction	WL z-

3.3 COMBINE LOAD CASES

Service load combinations	
9.	DL+WL UP + WLX+
10.	DL+ WL UP +WLX-
11.	DL+ WL UP +WL Z+
12.	DL+ WL UP +WL Z-
13.	DL+ WL DN +WL X+
14.	DL+ WL DN +WL X
15.	DL+ WL DN +WL Z+
16.	DL+ WL DN +WL Z-
Ultimate load combinations	
101.	1.5 (DL + WL X+)
102.	1.5 (DL + WL X-)
103.	1.5 (DL + WL Z+)

104.	1.5 (DL + WL Z-)
201.	0.9DL + 1.5WL X+
202.	0.9DL + 1.5WL X
203.	0.9DL + 1.5WL Z+
204.	0.9DL + 1.5WL Z

4. LOAD CALCULATION

4.1. DEAD LOAD

Force exerted by one solar panel,

F_{Module} = Module Weight

As the Dead Weight acts in vertically downward direction,

Unit force acting on each Module Base is,

$F_{Module\ base} = F_{Module} / 2$
$= 0.15$ kN/m

4.2. WIND LOAD

Basic wind speed	Vb	=	150	kmph	Appendix A - IS875 Part-3 2015
Risk coefficient	K1	=	0.9		Table -1
Height of the building for K2		=	10	m	
Terrain, Height, Structure size factor	K2	=	0.91		Table -2
Topography factor	K3	=	1.0		Sec. 5.3.3.1
Importance factor for cyclonic region	K4	=	1.0		Sec. 5.3.4
Wind speed, **Vz=Vb*K1*K2*K3*K4**	Vz	=	34.125	m/sec	Sec. 5.3
Wind pressure					
Pz=0.6x(Vz)^2	Pz	=	0.699	kN/m^2	Sec. 5.4
Design wind pressure	Pd	=	**Kd x Ka x Kc x Pz**		Sec. 5.4
wind directionality factor	Kd	=	1.0		Sec. 5.4.1
Area average factor	Ka	=	0.9		Sec. 5.4.2
Combination factor	Kc	=	1.0		Sec. 6.2.2.13 (Table 19)
Wind pressure acting Pd	Pd	=	0.629	kN/m^2	

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Wind load on the Roof Calculations:

Roof Angle considered More than 20% openings considered		=	**20°**		
Solidity ratio	ø	=	0		
External pressure Coefficients	**Cpup** **Cpdown**	= =	**1.3** **0.8**	&	Table -8 Table -8
Wind pressure acting on the members	**F**	=	Cp x Pd x Area x 0.8		(20% opening considered)
Total design wind pressure on the roof upward		=	**0.65**	kN/m	
Total design wind pressure on the downward		=	**0.40**	kN/m	

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4.3. PILE CALACITY CALCULATIONS

Pile capacity calculation as per IS 2911

Type of Pile	=	Bored Cast n Situ Pile	
Dia of Pile	D	0.3	m
Area of Pile	Ap	0.07065	m2
Surface area of Pile	As	1.5072	m2
Unconfined Compressive Strength	q_c	147	kN/m^2
Angel of Shear(ϕ)		0	
Vertical Load on Pile (P)	P	1.1	T
Unit Weight of Water	γw	1	Consider Water table at pile cutoff level
Max. Overburdan Pressure, (15D X Density)		4.5	T/m2
Thickness of Pile Cap		0.3	m
Free Length of the Pile	L1	1.6	m
Length of Pile fro Pile cutoff level to pile tip	Le	1.8	m
Factor of Safety	F	2	

The ultimate load capacity (Qu) of piles, in kN, in granular soils is given by the following formula:

$$Q_u = Q_b + Q_f$$

$$Q_u = A_p * N_c * C_p + \Sigma_{i=1}^{n} \alpha_i C_i A_{si}$$

Where first term gives bearing pressure and second term gived=s frictional resistance.

Base Resistance of Piles :

Unit weight of soil(γ)	=	2.5	T/M^3
Adhesion factor (α)	=	1	
Avg.cohesion at pile tip (C_p)	=	1.1	T/M^2
N_c	=	5.14	

As we know from IS 2911 :

$Q_b = Ap*Nc*Cp$	=	0.39946	T/M^2
$Q_{bsafe} = Qb/FOS$	=	0.19973	T/M^2

Note : In calculating pile capacity by static formula,the maximum over burden at pile tip should correspond to critical depth.

Frictional Resistance of piles :

Eff.overburden pressure	P_{di}	1.5
Angel of wall friction	δ	0

$Q_f = \Sigma^{n}_{i=1} \alpha_i C_i A_{si}$	=	1.65792	T
$Q_{safe} = Qf/FOS$	=	0.82896	T

Self Weight of Pile :

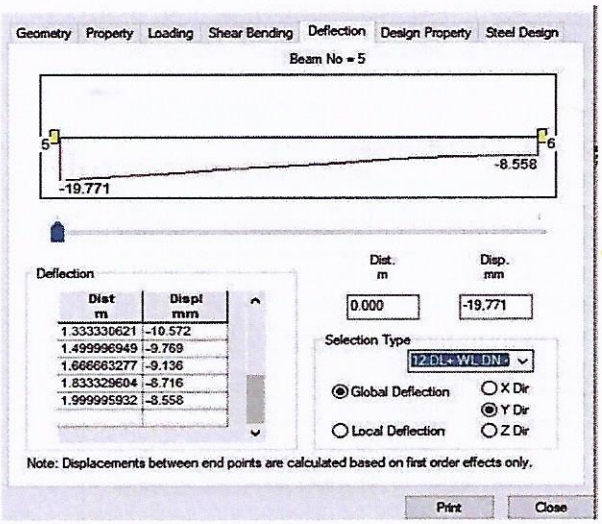
Weight	=	0.32	T

Result :-

Vertical uplift load bearing capacity of pile	=	1.15	T	SAFE
(Self Weight + Friction Resistance)				

5. STAAD OUTPUT FILE

5.1. DEFLECTION CHECK FOR PURLIN



As per IS 800: 2007 Permissible vertical Deflection Check for purlin = 2000/150 = 13.33 mm

Maximum vertical deflection of purlin in our structure = 19.77-8.55 = 11.22 mm (Beam 05, L/C - 12).

5.2. DEFLECTION CHECK FOR COLUMN:

As per IS 800: 2007 Permissible lateral Deflection for Column = 1200/150 = 8mm.

Actual lateral deflection of column in our structure = 6.79 mm (Node 19, L/C - 8).

All Summary

		Horizontal	Vertical	Horizontal	Resultant	Rotational		
Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
19	8 DL+ WL UP	6.799	0.007	0.000	6.799	0.000	-0.000	-0.008
	9 DL+ WL UP	6.713	0.007	0.000	6.713	0.000	-0.000	-0.008
	10 DL+ WL U	6.756	0.007	0.043	6.756	0.000	-0.000	-0.008
	11 DL+ WL U	6.756	0.007	-0.043	6.756	-0.000	0.000	-0.008
	12 DL+ WL D	-4.814	-0.016	0.000	4.814	0.000	-0.000	0.006
	13 DL+ WL D	-4.900	-0.016	0.000	4.900	0.000	-0.000	0.006
	14 DL+ WL D	-4.857	-0.016	0.043	4.857	0.000	-0.000	0.006
	15 DL+ WL D	-4.857	-0.016	-0.043	4.857	-0.000	0.000	0.006

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	Part JOB REF ENGINEER NAME NPT		
Job Title Solar Pump Structure	Ref		
	By	Date 7/22/2021	Chd DGB
Client Mechworks Engineering Consultancy	File R4_Pump Structure.STD	Date/Time 26-Feb-2022 17:15	

Job Information

	Engineer	Checked	Approved
Name:		DGB	KHR
Date:	7/22/2021	7/22/2021	7/22/2021

Project ID	
Project Name	

Structure Type	SPACE FRAME

Number of Nodes	31	Highest Node	31
Number of Elements	40	Highest Beam	40

Number of Basic Load Cases	7
Number of Combination Load Cases	16

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL
Primary	2	WL UP
Primary	3	WL DN
Primary	4	WL X+
Primary	5	WL X-
Primary	6	WL Z+
Primary	7	WL Z-
Combination	8	DL+ WL UP +WL X+
Combination	9	DL+ WL UP +WL X-
Combination	10	DL+ WL UP +WL Z+
Combination	11	DL+ WL UP +WL Z-
Combination	12	DL+ WL DN +WL X+
Combination	13	DL+ WL DN +WL X-
Combination	14	DL+ WL DN +WL Z+
Combination	15	DL+ WL DN +WL Z-
Combination	101	1.5 (DL + WL X+)
Combination	102	1.5 (DL + WL X-)
Combination	103	1.5 (DL + WL Z+)
Combination	104	1.5 (DL + WL Z-)
Combination	201	0.9DL + 1.5WL X+
Combination	202	0.9DL + 1.5WL X-
Combination	203	0.9DL + 1.5WL Z+
Combination	204	0.9DL + 1.5WL Z-

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Job No	Sheet No	Rev
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Job Title Solar Pump Structure

Ref

By Date 7/22/2021 Chd DGB

Client EMMVEE Photovoltaic Power Pvt Ltd

File R4_Pump Structure.STD Date/Time 26-Feb-2022 17:15

Nodes

Node	X (m)	Y (m)	Z (m)
1	-1.412	2.427	-2.000
2	-1.412	2.427	0
3	-1.412	2.427	2.000
4	-1.370	2.400	-2.500
5	-1.370	2.400	-2.000
6	-1.370	2.400	0
7	-1.370	2.400	2.000
8	-1.370	2.400	2.500
9	-1.286	2.345	0
10	-0.643	1.523	0
11	-0.367	1.741	-2.500
12	-0.367	1.741	-2.000
13	-0.367	1.741	0
14	-0.367	1.741	2.000
15	-0.367	1.741	2.500
16	0	0.292	0
17	0	0.700	0
18	0	1.500	-2.000
19	0	1.500	0
20	0	1.500	2.000
21	0.367	1.259	-2.000
22	0.367	1.259	0
23	0.367	1.259	2.000
24	0.643	0.678	0
25	1.286	0.655	0
26	1.370	0.600	-2.000
27	1.370	0.600	0
28	1.370	0.600	2.000
29	1.412	0.573	-2.000
30	1.412	0.573	0
31	1.412	0.573	2.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	5	0.050	6	0
2	2	6	0.050	5	0
3	3	7	0.050	6	0
4	4	5	0.500	7	340
5	5	6	2.000	7	340
6	6	7	2.000	7	340
7	7	8	0.500	7	340
8	6	9	0.100	5	0
9	10	9	1.044	1	0
10	5	12	1.200	6	0
11	7	14	1.200	6	0
12	9	13	1.100	5	0

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Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
13	11	12	0.500	7	340
14	12	13	2.000	7	340
15	13	14	2.000	7	340
16	14	15	0.500	7	340
17	17	10	1.044	4	0
18	12	18	0.439	6	0
19	13	19	0.439	5	0
20	14	20	0.439	6	0
21	16	17	0.408	3	0
22	18	17	2.154	2	0
23	17	19	0.800	3	0
24	20	17	2.154	2	0
25	18	21	0.439	6	0
26	19	22	0.439	5	0
27	20	23	0.439	6	0
28	17	24	0.644	4	0
29	21	22	2.000	7	340
30	22	23	2.000	7	340
31	22	25	1.100	5	0
32	21	26	1.200	6	0
33	23	28	1.200	6	0
34	24	25	0.644	1	0
35	25	27	0.100	5	0
36	26	27	2.000	7	340
37	27	28	2.000	7	340
38	26	29	0.050	6	0
39	27	30	0.050	5	0
40	28	31	0.050	6	0

Section Properties

Prop	Section	Area (in^2)	I_{yy} (in^4)	I_{zz} (in^4)	J (in^4)	Material
1	PIP269L	0.276	0.033	0.033	0.065	STEEL
2	PIP337L	0.394	0.074	0.074	0.149	STEEL
3	PIP1143M	2.403	5.629	5.629	11.259	STEEL
4	PIP337L	0.394	0.074	0.074	0.149	STEEL
5	80X40X2MMBOX	0.719	0.315	0.936	0.728	STEEL
6	80X40X2MMBOX	0.719	0.315	0.936	0.728	STEEL
7	80X50X15X2MMCS	0.626	0.348	1.032	0.002	STEEL

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1 DL : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
4	UNI kN/m	GY	-0.150	-	-	-	-
5	UNI kN/m	GY	-0.150	-	-	-	-
6	UNI kN/m	GY	-0.150	-	-	-	-
7	UNI kN/m	GY	-0.150	-	-	-	-
13	UNI kN/m	GY	-0.150	-	-	-	-
14	UNI kN/m	GY	-0.150	-	-	-	-
15	UNI kN/m	GY	-0.150	-	-	-	-
16	UNI kN/m	GY	-0.150	-	-	-	-
29	UNI kN/m	GY	-0.150	-	-	-	-
30	UNI kN/m	GY	-0.150	-	-	-	-
36	UNI kN/m	GY	-0.150	-	-	-	-
37	UNI kN/m	GY	-0.150	-	-	-	-

1 DL : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

2 WL UP : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
4	UNI kN/m	Y	0.650	-	-	-	-
5	UNI kN/m	Y	0.650	-	-	-	-
6	UNI kN/m	Y	0.650	-	-	-	-
7	UNI kN/m	Y	0.650	-	-	-	-
13	UNI kN/m	Y	0.650	-	-	-	-
14	UNI kN/m	Y	0.650	-	-	-	-
15	UNI kN/m	Y	0.650	-	-	-	-
16	UNI kN/m	Y	0.650	-	-	-	-
29	UNI kN/m	Y	0.650	-	-	-	-
30	UNI kN/m	Y	0.650	-	-	-	-
36	UNI kN/m	Y	0.650	-	-	-	-
37	UNI kN/m	Y	0.650	-	-	-	-

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3 WL DN : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
4	UNI kN/m	Y	-0.400	-	-	-	-
5	UNI kN/m	Y	-0.400	-	-	-	-
6	UNI kN/m	Y	-0.400	-	-	-	-
7	UNI kN/m	Y	-0.400	-	-	-	-
13	UNI kN/m	Y	-0.400	-	-	-	-
14	UNI kN/m	Y	-0.400	-	-	-	-
15	UNI kN/m	Y	-0.400	-	-	-	-
16	UNI kN/m	Y	-0.400	-	-	-	-
29	UNI kN/m	Y	-0.400	-	-	-	-
30	UNI kN/m	Y	-0.400	-	-	-	-
36	UNI kN/m	Y	-0.400	-	-	-	-
37	UNI kN/m	Y	-0.400	-	-	-	-

4 WL X+ : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
21	UNI kN/m	GX	0.075	-	-	-	-
23	UNI kN/m	GX	0.075	-	-	-	-

5 WL X- : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
21	UNI kN/m	GX	-0.075	-	-	-	-
23	UNI kN/m	GX	-0.075	-	-	-	-

6 WL Z+ : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
21	UNI kN/m	GZ	0.075	-	-	-	-
23	UNI kN/m	GZ	0.075	-	-	-	-

7 WL Z- : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
21	UNI kN/m	GZ	-0.075	-	-	-	-
23	UNI kN/m	GZ	-0.075	-	-	-	-

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	Part JOB REF ENGINEER NAME NPT		
Job Title Solar Pump Structure	Ref		
	By	Date 7/22/2021	Chd DGB
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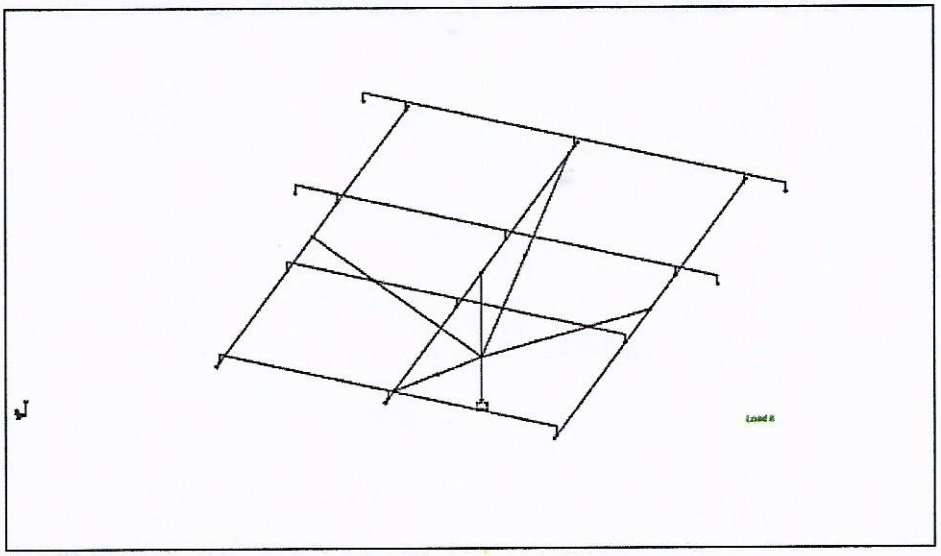
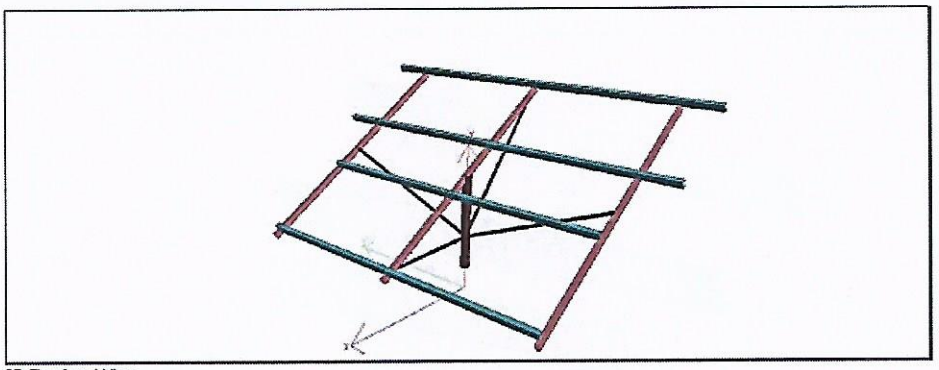


Whole Structure



3D Rendered View

Print Time/Date: 26/02/2022 17:19 STAAD.Pro CONNECT Edition 22.00.00.15 Print Run 6 of 11

REVISION NO.	001	PREPARED BY:	NPT	Prepared By
ISSUE NO.	001	CHECKED BY:	PRH	mechworks ENGINEERING CONSULTANCY
RELEASE DATE:	26-FEB-22	APPROVED BY:	PSU	

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		Ref	
		By	Date 7/22/2021 Chd DGB
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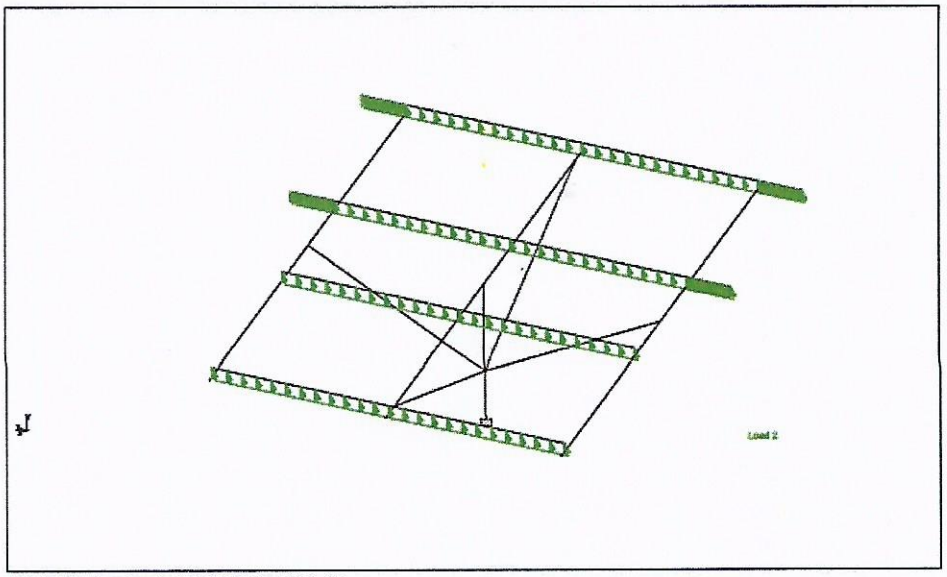
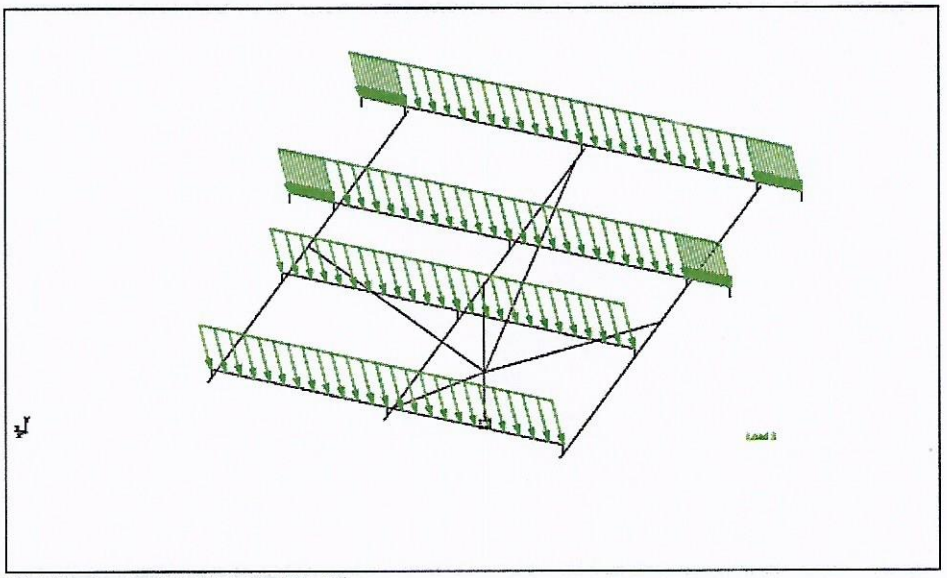


Whole Structure Loads 105.076kN:1m 2 WL UP



Whole Structure Loads 105.076kN:1m 3 WL DN

Print Time/Date: 26/02/2022 17:19 STAAD.Pro CONNECT Edition 22.00.00.15 Print Run 7 of 11

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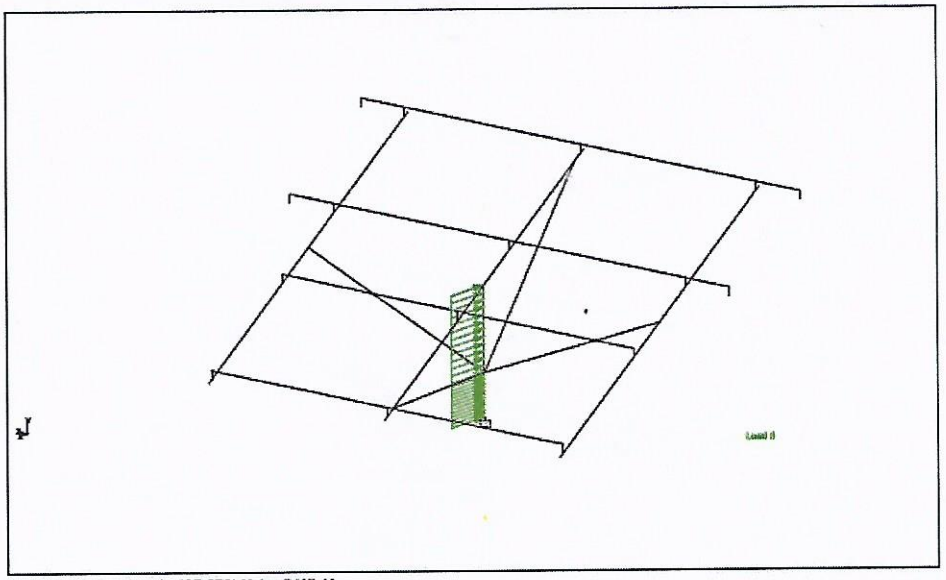
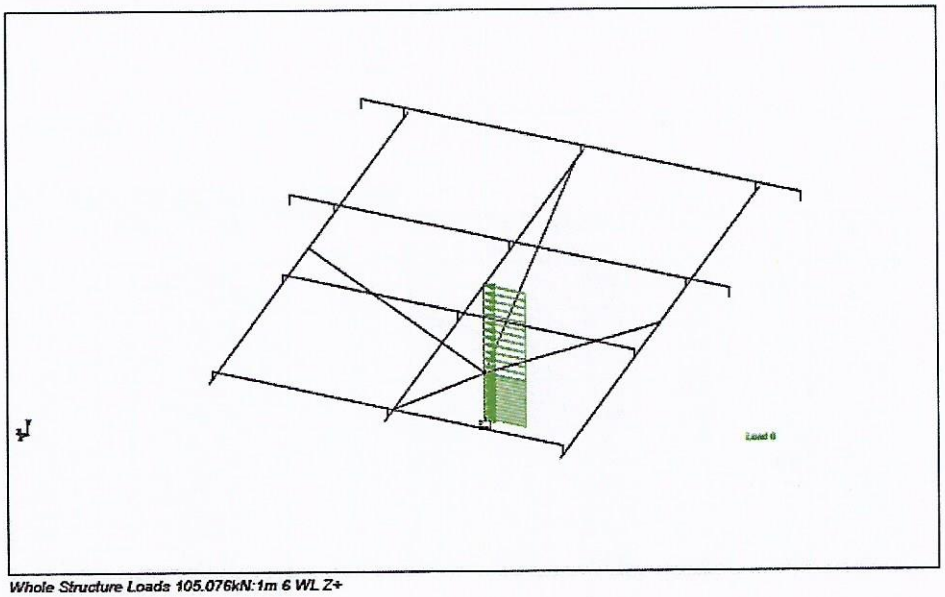
Software licensed to STAAD.Pro CONNECTED User: Not signed in	Job No 1	Sheet No 8	Rev 1
	Part JOB REF ENGINEER NAME NPT		
Job Title Solar Pump Structure	Ref		
	By	Date 7/22/2021	Chd DGB
Client EMMVEE Photovoltaic Power Pvt Ltd	File R4_Pump Structure.STD	Date/Time 26-Feb-2022 17:15	



Whole Structure Loads 105.076kN:1m 5 WL X-



Whole Structure Loads 105.076kN:1m 6 WL Z+

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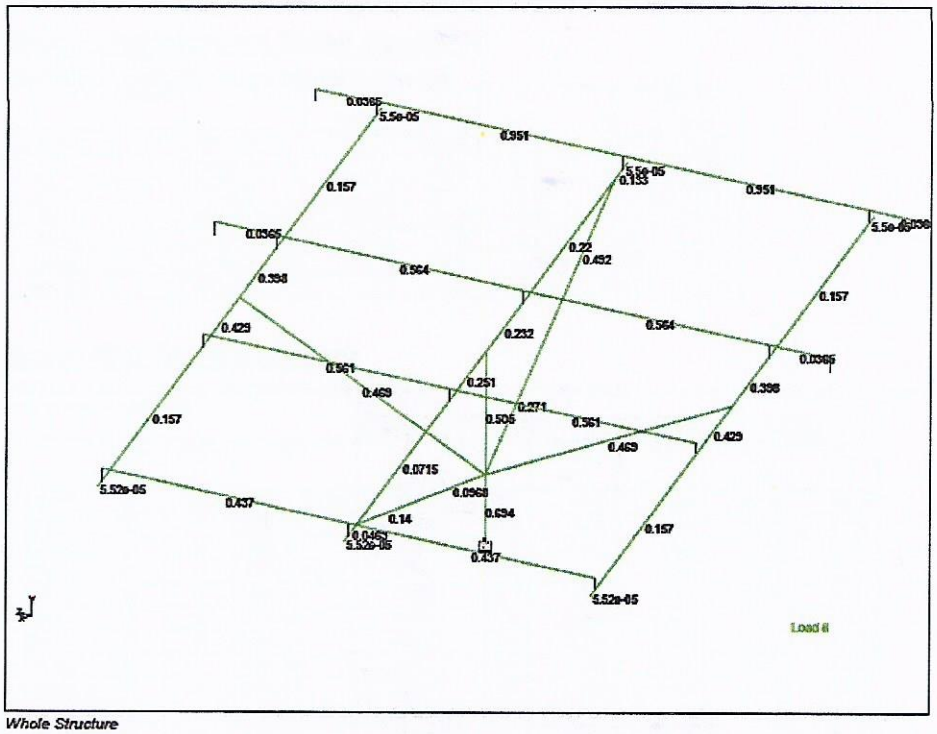
	Part JOB REF ENGINEER NAME NPT		
Job Title Solar Pump Structure	Ref		
	By	Date 7/22/2021	Chd DGB
Client EMMVEE Photovoltaic Power Pvt Ltd	File R4_Pump Structure.STD	Date/Time 26-Feb-2022 17:15	



Whole Structure

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	4	2:WL UP	30.270	29.230	-0.732	42.086	0.009	-0.006	-0.017
Min X	8	13:DL+ WL DN	-21.197	-23.771	-0.627	31.855	0.008	-0.005	0.014
Max Y	4	2:WL UP	30.270	29.230	-0.732	42.086	0.009	-0.006	-0.017
Min Y	8	14:DL+ WL DN	-21.115	-23.821	-0.544	31.837	0.008	-0.005	0.014
Max Z	20	14:DL+ WL DN	-7.734	-3.255	1.107	8.464	0.002	-0.001	0.009
Min Z	18	15:DL+ WL DN	-7.734	-3.255	-1.107	8.464	-0.002	0.001	0.009
Max rX	4	2:WL UP	30.270	29.230	-0.732	42.086	0.009	-0.006	-0.017
Min rX	8	2:WL UP	30.270	29.230	0.732	42.086	-0.009	0.006	-0.017
Max rY	8	2:WL UP	30.270	29.230	0.732	42.086	-0.009	0.006	-0.017
Min rY	4	2:WL UP	30.270	29.230	-0.732	42.086	0.009	-0.006	-0.017
Max rZ	1	13:DL+ WL DN	-19.130	-20.458	0.610	28.015	-0.008	0.005	0.014
Min rZ	1	2:WL UP	27.537	25.427	-0.741	37.488	0.009	-0.006	-0.017
Max Rst	4	2:WL UP	30.270	29.230	-0.732	42.086	0.009	-0.006	-0.017

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Job Title Solar Pump Structure		Ref	
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Client EMMVEE Photovoltaic Power Pvt Ltd		File R4_Pump Structure.STD	Date/Time 26-Feb-2022 17:15

Beam Displacement Detail Summary

Displacements shown in italic indicate the presence of an offset

	Beam	L/C	d (m)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	4	2:WL UP	0	31.644	29.230	-0.007	43.078
Min X	4	13:DL+ WL DN	0	-22.282	-23.771	0.005	32.582
Max Y	4	2:WL UP	0	*31.644*	29.230	-0.007	43.078
Min Y	7	14:DL+ WL DN	0.500	*-22.196*	-23.821	0.081778	32.560
Max Z	20	14:DL+ WL DN	0.439	-7.734	-3.255	1.107	8.464
Min Z	18	15:DL+ WL DN	0.439	-7.734	-3.255	-1.107	8.464
Max Rst	4	2:WL UP	0	*31.644*	*29.230*	*-0.007*	43.078

Beam End Force Summary

The signs of the forces at end B of each beam have been reversed. For example: this means that the Min Fx entry gives the largest tension value for an beam.

				Axial	Shear		Torsion	Bending	
	Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kN'm)	My (kN'm)	Mz (kN'm)
Max Fx	21	16	12:DL+ WL DN	10.670	-2.372	0.000	0.000	0.000	-4.249
Min Fx	21	16	2:WL UP	-10.994	4.002	-0.000	0.000	0.000	6.470
Max Fy	23	17	2:WL UP	0.156	6.159	-0.000	0.000	0.000	4.704
Min Fy	23	17	13:DL+ WL DN	0.725	-4.236	-0.000	0.000	0.000	-3.235
Max Fz	25	18	2:WL UP	0.489	-0.629	2.444	0.093	-0.624	-0.671
Min Fz	27	20	2:WL UP	0.489	-0.629	-2.444	-0.093	0.624	-0.671
Max Mx	10	5	2:WL UP	-0.252	0.262	0.284	0.123	-0.109	0.006
Min Mx	11	7	2:WL UP	-0.252	0.262	-0.284	-0.123	0.109	0.006
Max My	27	20	2:WL UP	0.489	-0.629	-2.444	-0.093	0.624	-0.671
Min My	25	18	2:WL UP	0.489	-0.629	2.444	0.093	-0.624	-0.671
Max Mz	21	16	2:WL UP	-10.994	4.002	-0.000	0.000	0.000	6.470
Min Mz	21	16	13:DL+ WL DN	10.670	-2.553	0.000	0.000	0.000	-4.359

Reaction Summary

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	FX (kN)	FY (kN)	FZ (kN)	MX (kN'm)	MY (kN'm)	MZ (kN'm)
Max FX	16	13:DL+ WL DN	2.553	10.670	0.000	-0.000	0.000	-4.359
Min FX	16	8:DL+ WL UP +	-4.092	-7.091	-0.000	-0.000	0.000	6.202
Max FY	16	12:DL+ WL DN	2.372	10.670	0.000	-0.000	0.000	-4.249
Min FY	16	2:WL UP	-4.002	-10.994	-0.000	-0.000	0.000	6.470
Max FZ	16	104:1.5 (DL + \	0.000	5.856	0.136	0.082	0.000	-0.484
Min FZ	16	103:1.5 (DL + \	0.000	5.856	-0.136	-0.082	0.000	-0.484
Max MX	16	204:0.9DL + 1.!	0.000	3.513	0.136	0.082	0.000	-0.290
Min MX	16	103:1.5 (DL + \	0.000	5.856	-0.136	-0.082	0.000	-0.484
Max MY	16	104:1.5 (DL + \	0.000	5.856	0.136	0.082	0.000	-0.484
Min MY	16	3:WL DN	2.463	6.766	0.000	0.000	-0.000	-3.981
Max MZ	16	2:WL UP	-4.002	-10.994	-0.000	-0.000	0.000	6.470
Min MZ	16	13:DL+ WL DN	2.553	10.670	0.000	-0.000	0.000	-4.359

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Job Title Solar Pump Structure		Part JOB REF ENGINEER NAME NPT	
		Ref	
		By	Date 7/22/2021	Chd DGB
Client EMMVEE Photovoltaic Power Pvt Ltd		File R4_Pump Structure.STD	DateTime 26-Feb-2022 17:15

Utilization Ratio

Beam	Analysis Property	Design Property	Actual	Allowable	Ratio (Act./Allow.)	Clause	L/C	Ax (in^2)	Iz (in^4)	Iy (in^4)	Ix (in^4)
1	80X40X2MM	80X40X2MM	0.000	1.000	0.000	Sec. 8.4	101	0.719	0.936	0.315	0.728
2	80X40X2MM	80X40X2MM	0.000	1.000	0.000	Sec. 8.4	101	0.719	0.936	0.315	0.728
3	80X40X2MM	80X40X2MM	0.000	1.000	0.000	Sec. 8.4	101	0.719	0.936	0.315	0.728
4	80X50X15X2	80X50X15X2	0.036	1.000	0.036	Sec. 9.3.1.3	12	0.626	1.032	0.348	0.002
5	80X50X15X2	80X50X15X2	0.951	1.000	0.951	Sec. 9.3.1.3	2	0.626	1.032	0.348	0.002
6	80X50X15X2	80X50X15X2	0.951	1.000	0.951	Sec. 9.3.1.3	2	0.626	1.032	0.348	0.002
7	80X50X15X2	80X50X15X2	0.036	1.000	0.036	Sec. 9.3.1.3	12	0.626	1.032	0.348	0.002
8	80X40X2MM	80X40X2MM	0.133	1.000	0.133	Sec. 8.2.1.2	2	0.719	0.936	0.315	0.728
9	PIP269L	PIP269L	0.492	1.000	0.492	Sec. 9.3.2.2	13	0.276	0.033	0.033	0.065
10	80X40X2MM	80X40X2MM	0.157	1.000	0.157	Sec. 9.3.2.2	14	0.719	0.936	0.315	0.728
11	80X40X2MM	80X40X2MM	0.157	1.000	0.157	Sec. 9.3.2.2	15	0.719	0.936	0.315	0.728
12	80X40X2MM	80X40X2MM	0.220	1.000	0.220	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
13	80X50X15X2	80X50X15X2	0.036	1.000	0.036	Sec. 9.3.1.3	12	0.626	1.032	0.348	0.002
14	80X50X15X2	80X50X15X2	0.564	1.000	0.564	Sec. 9.3.2.2	2	0.626	1.032	0.348	0.002
15	80X50X15X2	80X50X15X2	0.564	1.000	0.564	Sec. 9.3.2.2	2	0.626	1.032	0.348	0.002
16	80X50X15X2	80X50X15X2	0.036	1.000	0.036	Sec. 9.3.1.3	12	0.626	1.032	0.348	0.002
17	PIP337L	PIP337L	0.271	1.000	0.271	Sec. 9.3.2.2	15	0.394	0.074	0.074	0.148
18	80X40X2MM	80X40X2MM	0.398	1.000	0.398	Sec. 9.3.2.2	15	0.719	0.936	0.315	0.728
19	80X40X2MM	80X40X2MM	0.232	1.000	0.232	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
20	80X40X2MM	80X40X2MM	0.398	1.000	0.398	Sec. 9.3.2.2	14	0.719	0.936	0.315	0.728
21	PIP1143M	PIP1143M	0.694	1.000	0.694	Sec. 8.2.1.2	2	2.403	5.629	5.629	11.258
22	PIP337L	PIP337L	0.469	1.000	0.469	Sec. 9.3.2.2	15	0.394	0.074	0.074	0.148
23	PIP1143M	PIP1143M	0.505	1.000	0.505	Sec. 8.2.1.2	2	2.403	5.629	5.629	11.258
24	PIP337L	PIP337L	0.469	1.000	0.469	Sec. 9.3.2.2	14	0.394	0.074	0.074	0.148
25	80X40X2MM	80X40X2MM	0.429	1.000	0.429	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
26	80X40X2MM	80X40X2MM	0.251	1.000	0.251	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
27	80X40X2MM	80X40X2MM	0.429	1.000	0.429	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
28	PIP337L	PIP337L	0.097	1.000	0.097	Sec. 9.3.2.2	13	0.394	0.074	0.074	0.148
29	80X50X15X2	80X50X15X2	0.561	1.000	0.561	Sec. 9.3.2.2	2	0.626	1.032	0.348	0.002
30	80X50X15X2	80X50X15X2	0.561	1.000	0.561	Sec. 9.3.2.2	2	0.626	1.032	0.348	0.002
31	80X40X2MM	80X40X2MM	0.072	1.000	0.072	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
32	80X40X2MM	80X40X2MM	0.157	1.000	0.157	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
33	80X40X2MM	80X40X2MM	0.157	1.000	0.157	Sec. 9.3.2.2	2	0.719	0.936	0.315	0.728
34	PIP269L	PIP269L	0.140	1.000	0.140	Sec. 9.3.2.2	13	0.276	0.033	0.033	0.065
35	80X40X2MM	80X40X2MM	0.046	1.000	0.046	Sec. 8.4	2	0.719	0.936	0.315	0.728
36	80X50X15X2	80X50X15X2	0.437	1.000	0.437	Sec. 9.3.1.3	2	0.626	1.032	0.348	0.002
37	80X50X15X2	80X50X15X2	0.437	1.000	0.437	Sec. 9.3.1.3	2	0.626	1.032	0.348	0.002
38	80X40X2MM	80X40X2MM	0.000	1.000	0.000	Sec. 8.4	101	0.719	0.936	0.315	0.728
39	80X40X2MM	80X40X2MM	0.000	1.000	0.000	Sec. 8.4	101	0.719	0.936	0.315	0.728
40	80X40X2MM	80X40X2MM	0.000	1.000	0.000	Sec. 8.4	101	0.719	0.936	0.315	0.728

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6. BOM AND DESING DETAILS:

EMMVEE-MMS-001 - BILL OF MATERIAL					
DRAWING NO.	DESCRIPTION	DESCRIPTION	LENGTH (MM)	QTY.	TOTAL WEIGHT (kG)
EMMVEE-MMS-001-01	Column Post (Ø114.3 - 4.5mm)	IS 2062 E-250 HDGI-Avg 80 Micron	2108	1	26.77
	Top plate (Ø180x10 mm)	IS 2062 E-250 HDGI-Avg 80 Micron		1	
	Spigot Rod (Ø16mm)	IS 2062 E-250 HDGI-Avg 80 Micron	50	6	0.47
EMMVEE-MMS-001-02	Center Pin	IS 2062 E-250 HDGI-Avg 80 Micron	-	1	0.29
EMMVEE-MMS-001-03	Bracing Joint	IS 2062 E-250 HDGI-Avg 80 Micron	-	2	1.51
EMMVEE-MMS-001-04	N-S Bracing Front Bottom (Ø33.7 - 2.6mm)	IS 2062 E-250 HDGI-Avg 80 Micron	1000	1	2.56
	Plate Ø40x3 mm thk.			1	
	Plate 50x40x3 mm thk			1	
EMMVEE-MMS-001-05	N-S Bracing Rear Bottom (Ø33.7 - 2.6mm)	IS 2062 E-250 HDGI-Avg 80 Micron	1000	1	2.56
	Plate Ø40x3 mm thk.			1	
	Plate 50x40x3 mm thk			1	
EMMVEE-MMS-001-06	Middle Rafter (Box Pipe- 80x40x2 mm)	IS 1079 E-250 HDGI-Avg 80 Micron	3400	1	12.38
EMMVEE-MMS-001-07	N-S Bracing Cleat	IS 1079 E-250 HDGI-Avg 80 Micron	-	2	0.33
EMMVEE-MMS-001-08	End Rafter (Box Pipe- 80x40x2 mm)	IS 1079 E-250 HDGI-Avg 80 Micron	3400	2	24.75
EMMVEE-MMS-001-09	E-W Bracing Cleat	IS 1079 E-250 HDGI-Avg 80 Micron	-	2	0.42
EMMVEE-MMS-001-10	E-W Bracing (Ø33.7 - 2.6mm)	IS 1079 E-250 HDGI-Avg 80 Micron	1945	2	8.40
	Plate Ø40x3 mm thk.			1	
	Plate 50x40x3 mm thk			1	
EMMVEE-MMS-001-11	Purlin Cleat (80x80x3mm with Rib)	IS 1079 E-250 HDGI-Avg 80 Micron	-	16	4.00
EMMVEE-MMS-001-12	Purlin 1 (Box Pipe- 50x50x2 mm)	IS 1079 E-250 HDGI-Avg 80 Micron	5177	2	31.17
EMMVEE-MMS-001-13	Purlin 2 (Box Pipe- 50x50x2 mm)	IS 1079 E-250 HDGI-Avg 80 Micron	4361	2	26.25
EMMVEE-MMS-001-14	N-S Bracing Rear Top (Ø26.9 - 2.3mm)	IS 2062 E-250 HDGI-Avg 80 Micron	1000	1	1.73
	Plate Ø40x3 mm thk.			1	
	Plate 50x40x3 mm thk			1	
EMMVEE-MMS-001-15	N-S Bracing Front Top (Ø26.9 - 2.3mm)	IS 2062 E-250 HDGI-Avg 80 Micron	500	1	0.87
	Plate Ø40x3 mm thk.			1	
	Plate 50x40x3 mm thk			1	
EMMVEE-MMS-001-16	Top middle support			1	
	Top Support Mid Plate	IS 2062 E-250 HDGI-Avg 80 Micron	-	2	1.70
	Base Disc (Ø180 - 10 mm)	IS 2062 E-250 HDGI-Avg 80 Micron	-	2	3.96
	Top Support Rib (Plate- 100x40x50x5 mm)	IS 2062 E-250 HDGI-Avg 80 Micron	-	4	0.57
EMMVEE-MMS-001-17	Top mid plate flange(180x100x8mm)	IS 2062 E-250 HDGI-Avg 80 Micron	-	2	2.12
				Total weight of Steel Structure (kg)	152.81
				Total weight of Steel Structure with HDGI (kg)	163.51

Scrutinized & Vetted vide letter No. :
AGT- 377 /CE- 5993/1581
Dated : 7/4/22

Dr. Abhay Tawalare
Assistant Professor
Dept. of Civil Engg.
Visvesvaraya National Institute of Technology
Nagpur-440011

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