COMPARATIVE STUDY OF SILO SUPPORTING STRUCTURE USING RCC & STEEL

Ms Rini Riyansi.E[1];Mrs. Abida Justus[2]

[1]PG Student, Department of Civil Engineering, Sathyabama University, Chennai – 600 119,Tamil Nadu, India.

[2]Asst Professor, Department of Civil Engineering, Sathyabama University, Chennai – 600 119, Tamil Nadu, India.

Abstract:A silo is a structure for storing bulk materials. They are commonly used for bulk storage of coal, cement, carbon black, woodchips, food products and sawdust. The design of silos to store bulk solids involves bulk materials, geometry and structural considerations. Generally the supporting structures are said to be staging. Here 3 number of silos are taken into consideration. In this Project,analysing, designing and comparative study on silo supporting structure using RCC and STEEL are done.The General Arrangement (GA) drawings are prepared using the 2D drawing software- AUTOCAD and the structural modelling, analysis and design can be done using structural software-STADD PRO v8i. The structural analysis can be done using stiffness matrix method and the design will be done based on IS code standards.

For this structure, not only considering the vertical forces (Dead load & live load) but also considering the laterals forces like wind load and Seismic loads for structural analysis and design.

Keywords:- *Silos, Silo supporting structures, Analysis and Design.*

Introduction: In this project, a bulk material is chosen as food grains stored in silo and the corresponding supporting structure is analysed and designed. Silos are the generic name for upright containers used for storing granular materials and their supports. Containers are the tanks for storing granular materials. The term granular materials are taken to include "fine particles". Silo walls are the upright wall of the containers. Hopper is the inclined wall of the containers. The structural materials of the silos can be reinforced concrete and steel. The design of silos & their supporting structure involves three important factors like, bulk material, geometric, and structural considerations. Bulkmaterial considerations are important because the frictional and cohesive properties of bulk solids vary from one solid to another, and these propertiesaffectmaterial behaviour considerably. Inaddition, a given bulk solid's flow properties can vary dramatically with changes in numerous parameters, including particle size, moisture, temperature, and consolidating pressure. This variability of properties makes testing at actual conditions more important for proper bin and silo design than at first appear.

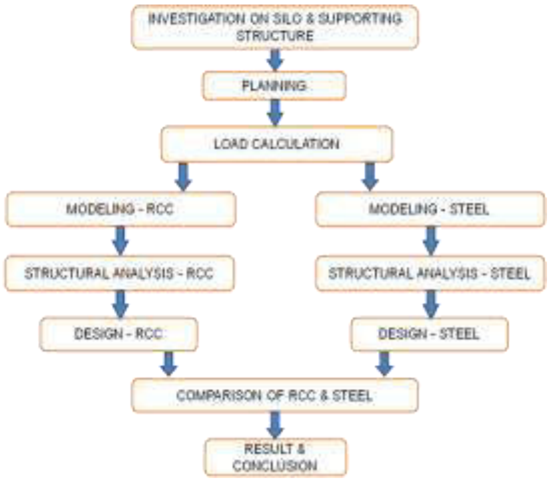
Established design procedures include selection of the optimum hopper angles and minimum outlet dimensions. The ideal discharge mode is one where, at steady state, all material flows without obstruction. This is referred to as mass flow. The discharge mode where only some of the material flows are allowed is called funnel flow. In mass flow, the material does not necessarily move at a uniform rate throughout: velocity variations across any horizontal cross-section are possible.

The structural design of a silo requires, among other things, knowledge of the distribution of pressures and shear stresses on its walls (caused by the stored material) and how that distribution varies during charging, storage at rest, discharging, and recharging.

SCOPE &OBJECTIVE: The scope of this project is to analyse, design and make a comparative study of silo supporting structure using RCC and STEEL. i.e. geometry and structural considerations. Here we are not only considering the vertical forces (Dead load & live load) but also considering the laterals forces like wind load and Seismic loads for structural analysis and design.To enhance design concepts of supporting structure elements.Bulk material storage facilities take many forms depending on the quantity of material to be stored, the purpose of storage, and the location of the store.

SOFTWARES USED: The General Arrangement (GA) drawings and fabrication drawings are prepared using the 2D drawing software -AUTOCAD.Structural modelling, analysis and design can be done using structural software - STAAD Pro v8i.Analysis is done using stiffness matrix method.

METHODOLOGY



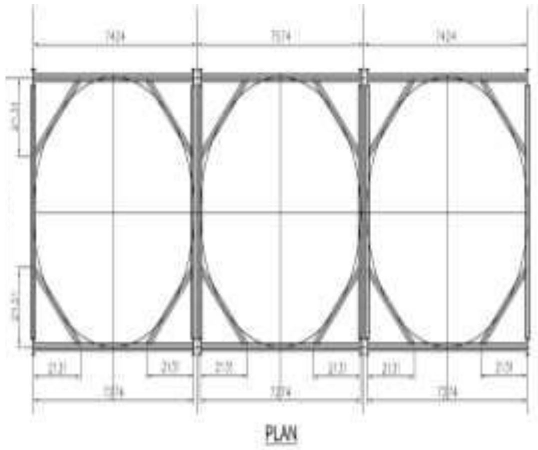
SILO SUPPORTING STRUCTURE

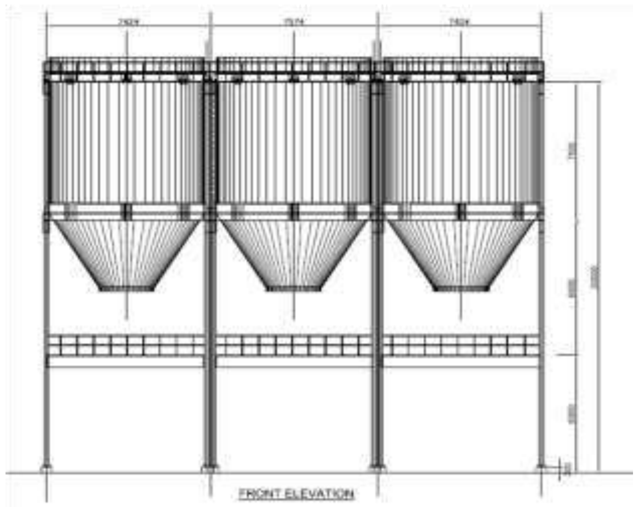
Silos and their supports should be designed to contain all applicable loads taking into account the properties of stored materials, the shape of the silos, methods of material handling, etc. The shape of the silo should be as simple as possible, be symmetrical about its axis, and should have structural members which are proportioned to provide adequate strength. The foundations for silos should be designed to support stresses from the upper structural members of the silos and their supports. The design should include measures to prevent dust or gas explosions and exothermic reaction of stored materials. In the event that fumigation with insecticides is required, the silo should be air tight in accordance with the applicable regulations.The internal surfaces of silos which are used for storing bulk materials or feed stock should meet the relevant safety regulations.

SILO LOADS

The loads which bulk materials exert on silo structures can generally be divided into two categories: those due to initial fill and those which are as a result of flow. Initial fill loads develop, as the name implies, when a silo is filled from an empty condition without any withdrawal taking place. The term flow-induced loads, on the other hand, is somewhat of a misnomer since it implies that the material must be in motion for these loads to develop. In fact, the only requirement is that there be some withdrawal of material which allows the flow induced loads to develop. Once this occurs, flow can be stopped and then restarted without having any appreciable effect on the silo loads. In addition, the rate of discharge is usually not a significant variable in affecting the magnitude of the silo loads. The primary reason for this is that most bulk materials are not viscous or viscous-elastic, so their rate of movement has little effect on their frictional properties. The above furnished loads are calculated and transferred to the silo supporting structures.

GENERAL ARRANGEMENT DRAWINGS:





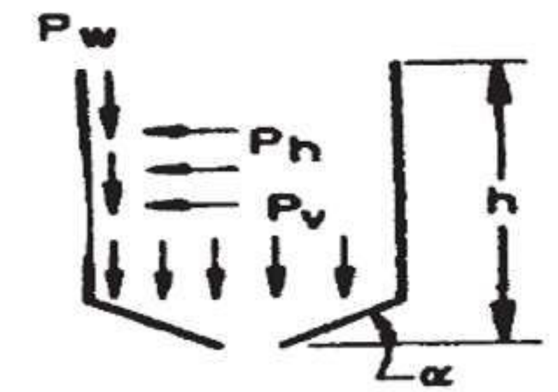
SILO LOAD CONSIDERATION

Silo Load. - There are three types of loads caused by a stored material in a Silo and they are:

a) Horizontal load or horizontal pressure (Ph)acting on the sidewalls,

b) Vertical load of vertical pressure (Pv)acting on the cross-sectional area of the silo filling,

c) Frictional wall load or frictional wall pressure (Pw) introduced into the side walls through wall friction.



SILO LOADS DUE TO GRANULAR MATERIALS

Normal Filling and Emptying: Maximum pressures - The maximum values of the horizontal pressures on the wall (Ph), the vertical pressure on the horizontal cross section of the stored' material (P,,) and the vertical load transferred to the wall per unit area due to friction (,Pw) shall be calculated as follows

Name of Pressure	*During Filling*	*During Emptying*
Maximum P_w	WR	WR
Maximum P_h	$\frac{WR}{\mu_f}$	$\frac{WR}{\mu_e}$
Maximum P_v	$\frac{WR}{\mu_f \lambda_f}$	$\frac{WR}{\mu_e \lambda_e}$

Depth as

$$\sum_{0}^{Z} P_w = \pi DWR\left(Z + \frac{1}{Z_{oe}} \cdot e^{-Z/Z_{oe}} - Z_{oe}\right)$$

Ph= Ka x Density x Z		
Where ,		
Ka =Co - eff of Active Pressure		
Ka =	(1-SINθ)/(1+Sinθ)	0.2174
Density of rice (y)	0.9	T/m3
Sample calculation		
Z	0.5	m
Ph for Z @ 0.5m	0.09783	

SILO LOAD CALCULATION

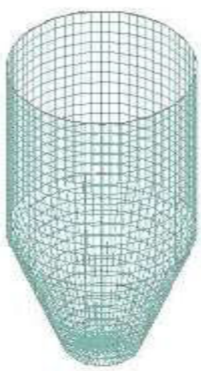
DESCRIPTION	**VALUE**	**UNIT**
DEAD LOAD CALCULATION		
Floor Load		
Thickness of slab	0.15	M
Self wt. Of slab	0.375	T/Sqm
Grain Load	0.06	T/Sqm
Total Load	0.435	T/Sqm
LIVE LOAD CALCULATION		
Live load is taken as 500kg/Sqm	0.5	MT/Sqm

PRESSURE CALCULATION ON SILO STATIC CONDITION: RICE GRAIN		
For Cylindrical Portion		
Horizontal pressure due to static condition of rice		
Ph at Z from Top		

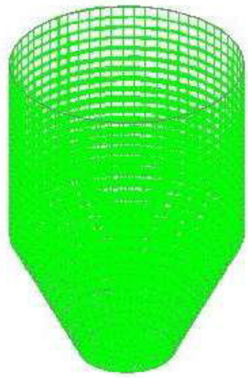
Height (From top of silo) in "m"	**Vertical Pressure(T/Pressure)**	**Horizontal Pressure at silowall (T/Sqm)**
Z	Pv=yz	Ph=Pv*Ka
0.500	0.450	0.098
1.000	0.900	0.196
1.500	1.350	0.293
2.000	1.800	0.391
2.500	2.250	0.489
3.000	2.700	0.587
3.500	3.150	0.685
4.000	3.600	0.783
4.500	4.050	0.880
5.000	4.500	0.978

5.500	4.950	1.076
6.000	5.400	1.174
6.500	5.850	1.272
7.000	6.300	1.370
7.500	6.750	1.467
8.000	7.200	1.565
8.500	7.650	1.663
9.000	8.100	1.761
9.455	8.510	1.850
9.910	8.919	1.939
10.365	9.329	2.028
10.820	9.738	2.117
11.275	10.148	2.206
11.730	10.557	2.295
12.185	10.967	2.384
12.640	11.376	2.473
13.095	11.786	2.562
13.550	12.195	2.651
14.005	12.605	2.740

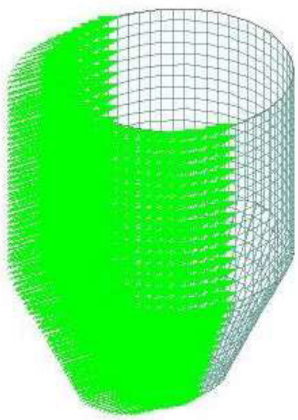
ISOMETRIC VIEW OF SILO



LOAD ASSIGNMENT ON SILO

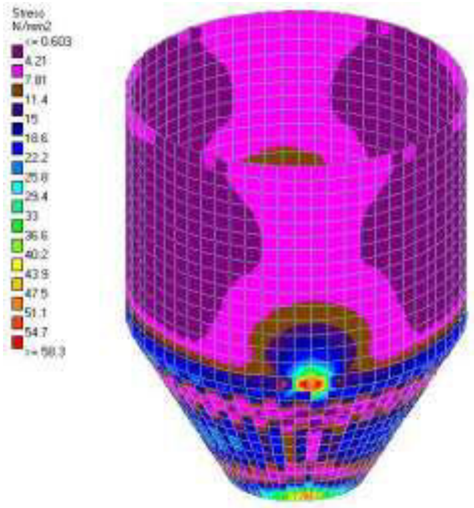


LIVE LOAD & FRICTIONAL LOAD ASSIGNMENT



WIND LOAD ASSIGNMENT

STRESS DISTRIBUTION OF SILO



STRESS DISTRIBUTION DIAGRAM

DETAILS OF SILO SUPPORTING STRUCTURE

The following parameters for silo supporting structures and its components are follows:

1. Length of the span = 22.41 m
2. Width of the span =7.27 m
3. Terrain Type considered = Plain (Flat)
4. Terrain Category = 2 (Category - 2)
5. Class of the structure = B
6. Return Period = 100 years.
7. Wind Zone = II
8. Basic Wind Speed = 50 m/s
9. Design Wind Pressure E = 1.025 KN/ m^2
10. Seismic Zone = III
11. Zone Factor (Z) = 0.16
12. Important building (I) = 1.5

LOAD CALCULATION FOR THE SILO SUPPORTING STRUCTURE

To determine the load on silo supporting structure, the silo supporting structure is divided into different panels having length "L". These panels should normally be taken between the intersections of vertical and horizontal. For silo supporting structure, load calculation given below and wind load calculation.

Dead Load Calculation, DL	
Spacing of the Purlin	= 1.5 m
Extra load form fixtures	= 0.05 KN/m^2
Total load from Purlin	= 0.075 KN/m
Self-weight of the structure	= 0.5 KN/m
Total dead load, DL	= 0.575 KN/m

Live Load Calculation, LL	
Live load, LL	= 0.400 KN/m^2
Total live load, LL	= 0.400 KN/m^2

Wind Load Calculation, WL		
Length of the Structure (L)	= 22.41 m	
Width of the Structure, w (l)	= 7.27 m	
Height of the Structure (H)	= 20.00 m	
Site Location	= Gummidipoondi	
Basic Wind Speed (V_b)	= 50 m/s	
Terrain Category	= II	

SEISMIC LOAD CALCULATION

The Seismic loads on structures will be as per IS : 1893 (Part 1) - 2002

Zone Factor (Zone III) (Z) = 0.16

Importance Factor (I) = 1.5

Response Reduction Factor (R) = 4

Total height of the structure = 20.00 m

Depth of Foundation = 1.5 m

Fundamental Natural period Ta = 0.075 h

Fundamental Natural period, Ta = 0.075 $h^{0.75}$

Ta =0.76sec

Average Response Acceleration

Co-efficient (Sa/g) = 1.0/T

(For Rocky or hard sites) Sa/g = 1.304

Design horizontal Seismic

Co-efficient, A_h =Z I Sa / 2 R g

For 1.5m Foundation Depth

Design horizontal seismic

Co-efficient = 0.04 A_h

Design Seismic Base Shear, V_b = 0.04 A_h * W

Primary load case

i) Seismic load x +ve / x –ve direction

ii) Seismic load z +ve / z –ve direction

iii) Wind load x +ve / -ve direction

iv)Dead load

V) Live Load

Load Combination

(i) (1.5)Dead Load + (1.5)Live Load

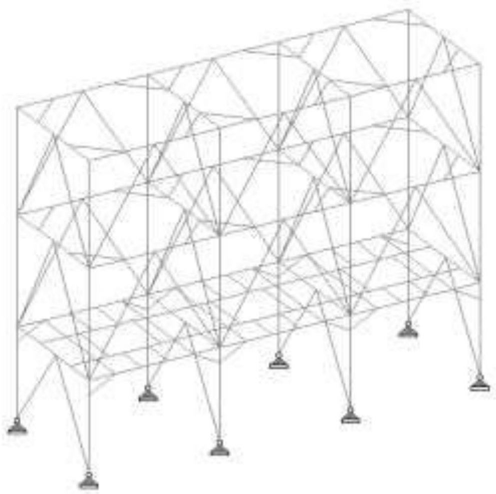
(ii) (1.5)Dead Load +(1.5)Wind Load

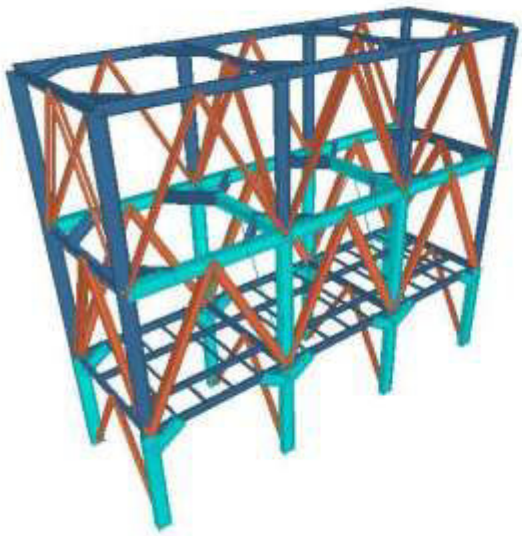
(iii) (1.5) Dead Load + (1.5)Seismic Load

(iv)(1.2)Dead Load+(1.2)LiveLoad+(1.2)Wind load

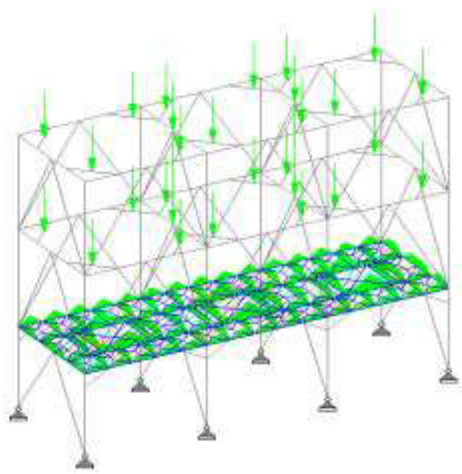
(v) (1.2)Dead Load+(1.2)LiveLoad+(1.2)SeismicLoad

3D MODELING VIEW – STEEL SUPPORTING STRUCTURE

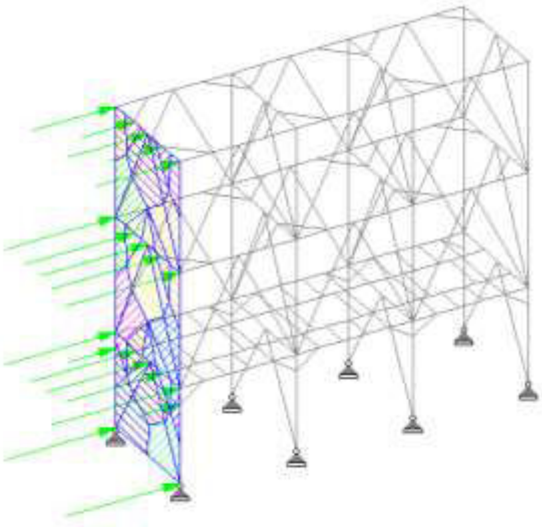




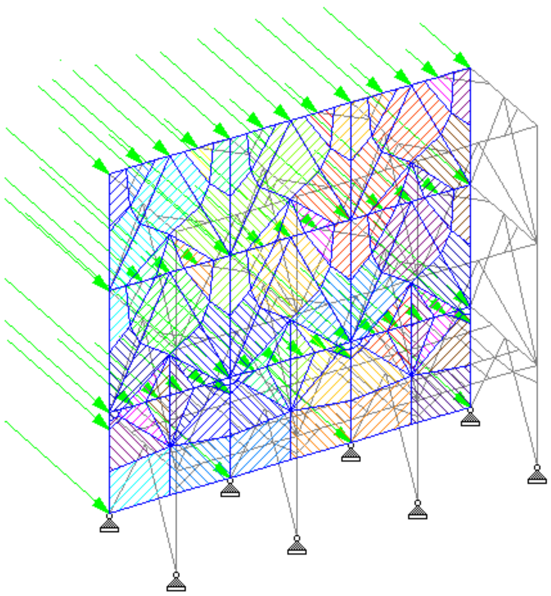
VERTICAL LOAD ASSIGNMENT



WIND LOAD ASSIGNMENT

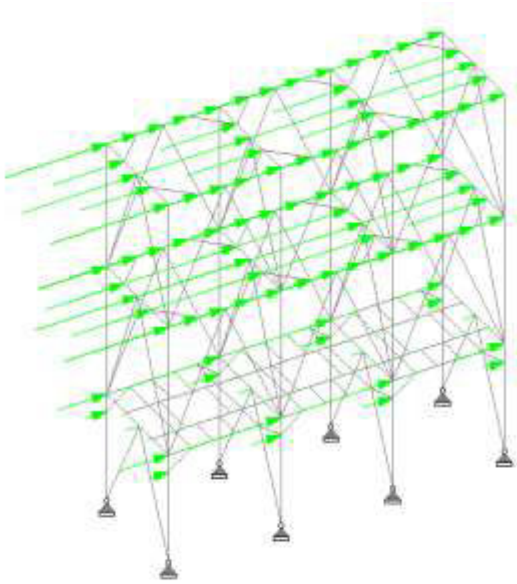


X-DIRECTION

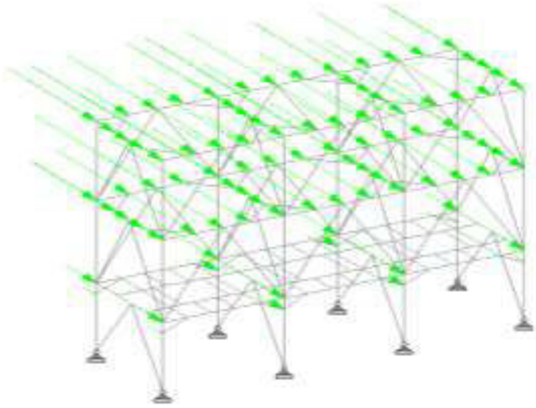


Z-DIRECTION

SEISMIC LOAD ASSIGNMENT



X-DIRECTION

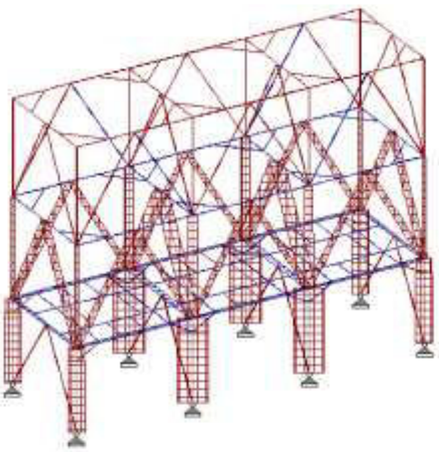


Z-DIRECTION

ANALYSIS OUTPUT – REACTION SUMMARY

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	1	7 DL + LL	**14.438**	1763.927	28.756	0.000	0.000	0.000
Min Fx	6	12 DL + WL X	**-43.042**	434.987	-41.072	0.000	0.000	0.000
Max Fy	6	7 DL + LL	4.521	**3794.421**	-83.183	0.000	0.000	0.000
Min Fy	3	6 WLZ	0.082	**-335.791**	-134.333	0.000	0.000	0.000
Max Fz	2	7 DL + LL	5.010	3774.701	**82.270**	0.000	0.000	0.000
Min Fz	6	13 DL + WL Z	0.533	941.132	**-186.026**	0.000	0.000	0.000
Max Mx	1	1 SL IN X-DIR	-2.205	-8.277	-0.030	**0.000**	0.000	0.000
Min Mx	1	1 SL IN X-DIR	-2.205	-8.277	-0.030	**0.000**	0.000	0.000
Max My	1	1 SL IN X-DIR	-2.205	-8.277	-0.030	0.000	**0.000**	0.000
Min My	1	1 SL IN X-DIR	-2.205	-8.277	-0.030	0.000	**0.000**	0.000
Max Mz	1	1 SL IN X-DIR	-2.205	-8.277	-0.030	0.000	0.000	**0.000**
Min Mz	1	1 SL IN X-DIR	-2.205	-8.277	-0.030	0.000	0.000	**0.000**

ANALYSIS OUTPUT – AXIAL FORCES



ANALYSIS OUTPUT – SUMMARY OF FX, FY & FZ

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN
Max Fx	12	7 DL + LL	2	**3651.389**	-5.029	7.307
Min Fx	182	7 DL + LL	75	**-621.236**	-20.486	1.330
Max Fy	351	7 DL + LL	168	-37.984	**617.190**	-0.016
Min Fy	247	7 DL + LL	170	-38.023	**-616.993**	0.708
Max Fz	294	15 DL + LL +	142	2641.184	-6.578	**90.241**
Min Fz	298	7 DL + LL	146	3573.672	-9.817	**-69.077**
Max Mx	254	7 DL + LL	111	-0.451	320.592	0.009
Min Mx	253	7 DL + LL	118	-1.982	320.965	-0.056
Max My	353	12 DL + WL X	14	109.358	-4.137	9.735
Min My	295	15 DL + LL +	143	2633.243	-1.931	89.120
Max Mz	351	7 DL + LL	168	-37.984	617.190	-0.016
Min Mz	234	7 DL + LL	116	-36.460	364.585	-0.020

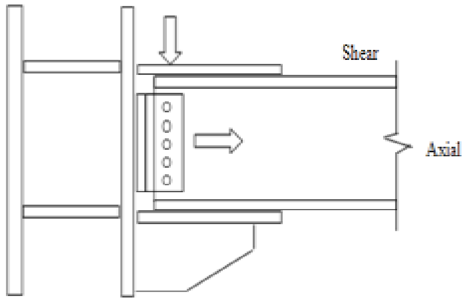
DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE (PRIMARY ELEMENTS)

MEMBER	TABLE / FX	RESULT/ MY	CRITICAL COND/ MZ	RATIO/ LOCATION	LOADING/
19 ST	ISHB225A	PASS	IS-7.1.2	0.987	7
	211.05 T	-14.00	5.41	1.47	
20 ST	ISWB175	PASS	IS-7.1.2	0.954	7
	132.44 T	-2.11	6.19	1.47	
21 ST	ISWB225	PASS	IS-7.1.2	0.963	7
	170.79 T	-6.29	3.60	1.50	
22 ST	ISHB200	PASS	IS-7.1.2	0.856	7
	310.37 T	2.52	-15.58	2.25	
23 ST	ISHB300	PASS	IS-7.1.2	0.963	14
	490.99 T	6.97	-39.31	2.25	
24 ST	ISLB400	PASS	IS-7.1.2	0.973	7
	617.83 T	-1.15	-51.58	2.25	

DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE(PRIMARY ELEMENTS)

MEMBER	TABLE / FX	RESULT/ MY	CRITICAL COND/ MZ	RATIO/ LOCATION	LOADING/
29 ST	ISWB600	PASS	IS-7.1.1(A)	0.806	7
	470.98 C	11.55	78.26	7.30	
32 ST	ISWB600	PASS	IS-7.1.1(A)	0.796	7
	468.24 C	11.51	-80.45	7.30	
33 ST	ISWB600	PASS	IS-7.1.1(A)	0.808	7
	464.14 C	-12.74	78.02	7.30	
36 ST	ISWB600	PASS	IS-7.1.1(A)	0.803	7
	463.17 C	-12.73	-80.36	7.30	
40 ST	ISMB450	PASS	IS-7.1.1(A)	0.952	15
	33.24 C	-1.55	-164.80	2.00	

DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE(CONNECTIONS)



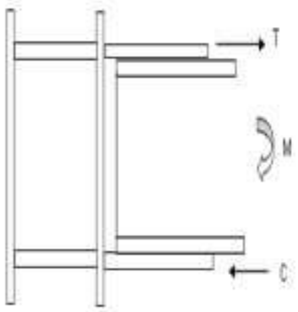
DATA:

Yield strength of the steel material	fy	=	250	N/mm^2
Permissible stress in axial tension ($\sigma_{at} = 0.6fy$)	σ_{at}	=	150	N/mm^2
Permissible stress in Shear ($\sigma_s = 0.4fy$)	σ_s	=	100	N/mm^2
Permissible stress in Bending ($\sigma_b = 0.66fy$)	σ_b	=	165	N/mm^2
Permissible stress in Bearing ($\sigma_p = 0.75fy$)	σ_p	=	187.5	N/mm^2

Beam Details

Depth of the beam	D	=	600	mm
Width of the beam	W	=	300	mm
Thickness of the flange	tf	=	20	mm
Thickness of the Web	tw	=	12	mm
Section Modulus of the beam	z	=	4E+06	mm^3

DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE (CONNECTIONS)



Moment Capacity of the Section	$(M = \sigma b \times Z)$	M	=	651.87	kNm
Forces in the Flange plate	$(T = M/D)$	T	=	651.868 x 10^3 / 600	
			=	1086.5	kN
Area of the Plate Required	$(Ap = T/\sigma at)$	Ap	=	1086.45 x 10^3 /150	
			=	7243	mm^2
Length of the plate required		Lp	=	362.15	mm

DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE (CONNECTIONS)

Capacity of Web in Shear & Tension :

Shear & Tensile Capacity of the Beam:

Shear Area of the Beam	As	=	(600 - 2x20) x 12	
		=	6720	mm^2
Shear Capacity of the Beam Web		=	100x6720	
		=	**672**	**kN**
Tensile Capacity of the beam		=	150x6720	
		=	**1008**	**kN**

Bolt Group : Check For Shear

Percentage of Shear capacity of web for design	=	40	%
Design shear force for connection	=	268.8	kN
Shear Strength of the single bolt	=	73.2	kN
No of bolts required	=	268.8/73.2	
	=	3.6721	
	Hence Provide 4 Nos of bolts		

Bolt Group : Check For Tension

Percentage of Tensile capacity of web for design	=	50	%
Design Tensile force for connection	=	504	kN
Tensile Strength of the single bolt	=	127	kN
Tensile Capacity of the Bolt group	=	4x127	
	=	508	kN > 504

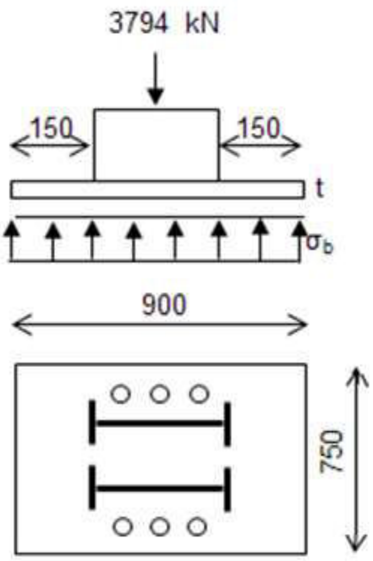
Hence ok

Provide ISA 100x100x10 Cleat angle

DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE (BASE PLATE)

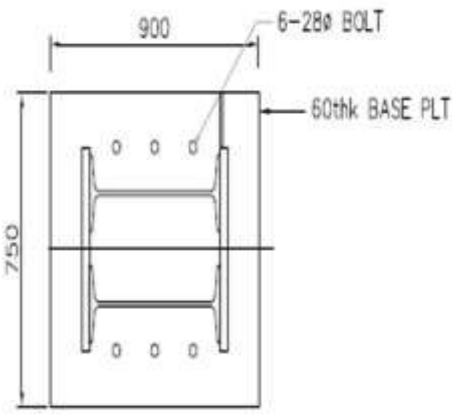
DATA:

Vertical load (V)	=	3794.42 KN
Horizontal load (Fx)	=	43.04 KN
Horizontal load (F_z)	=	186.02 KN
Base plate dimensions	=	900mm x 750mm
Comp. strength of concrete	=	40 N/mm^2

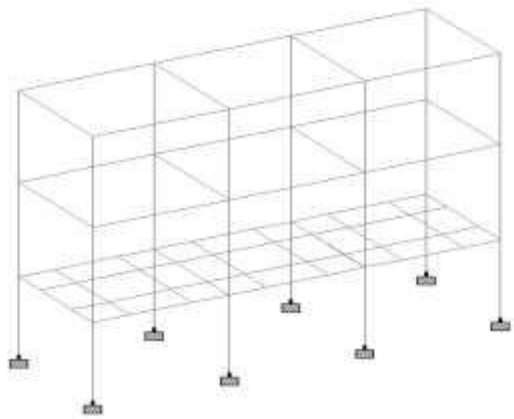


DESIGN OUTPUT – STEEL SUPPORTING STRUCTURE(BASE PLATE)

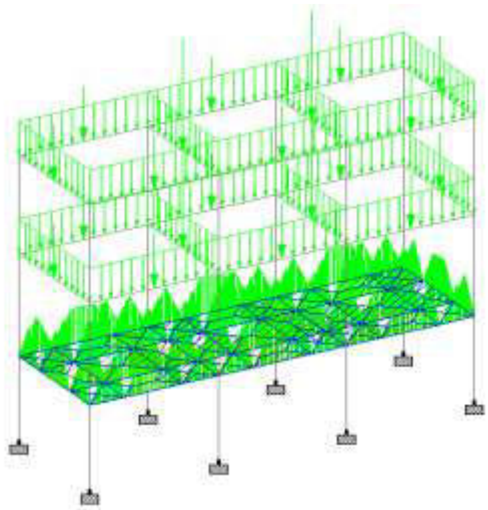
Provide 6 nos of 28mm dia. bolt for column base plate



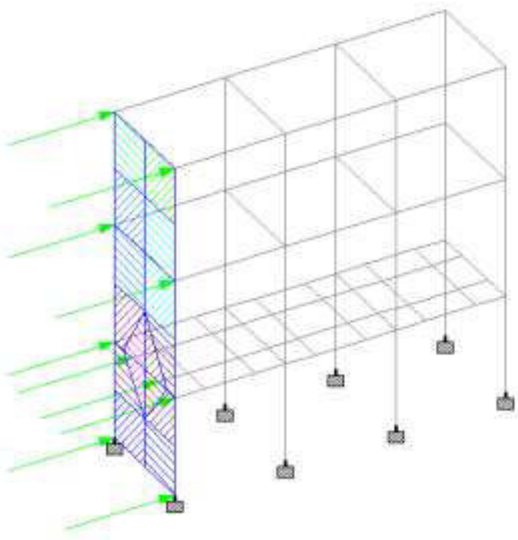
3D MODELING VIEW – RCC SUPPORTING STRUCTURE



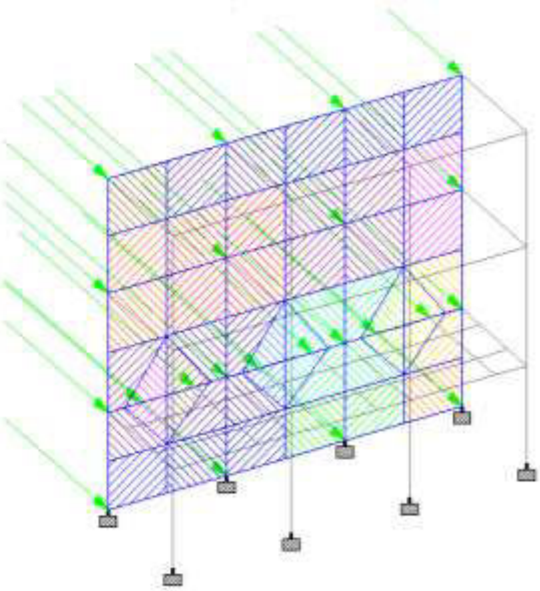
VERTICAL LOAD ASSIGNMENT



WIND LOAD ASSIGNMENT

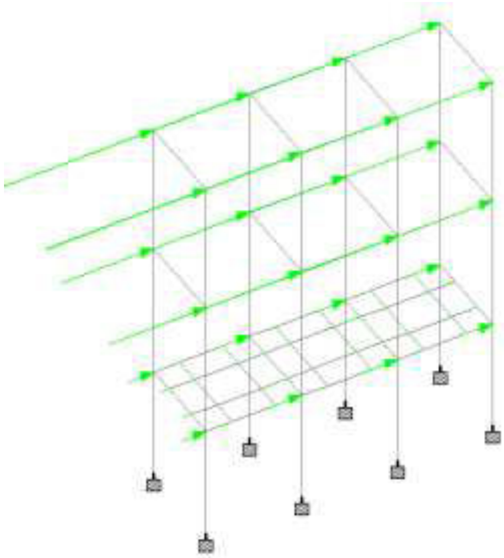


X-Direction

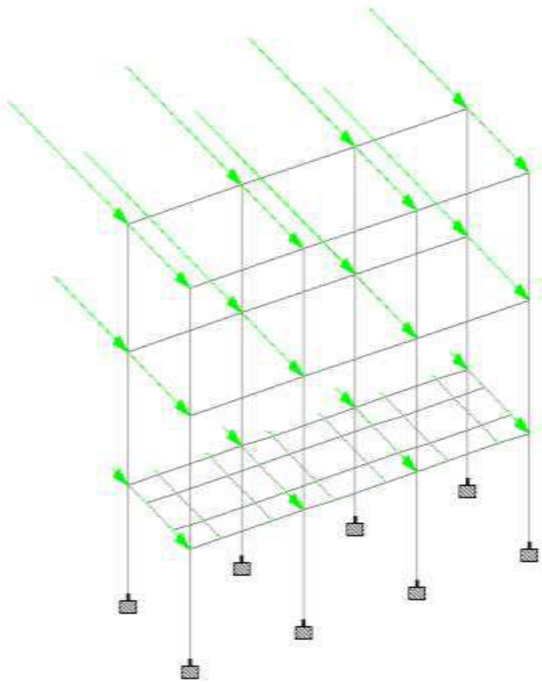


Z-Direction

SEISMIC LOAD ASSIGNMENT

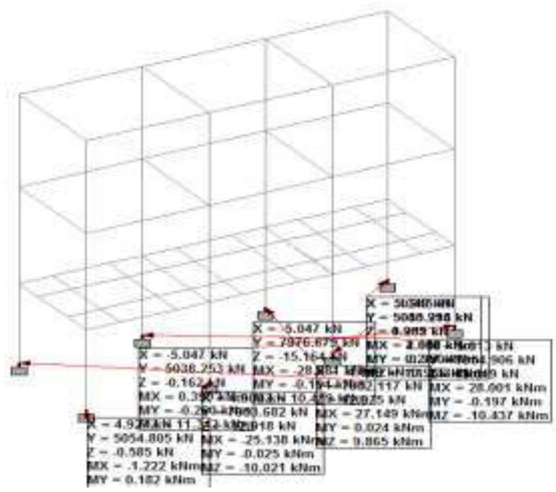


X-Direction

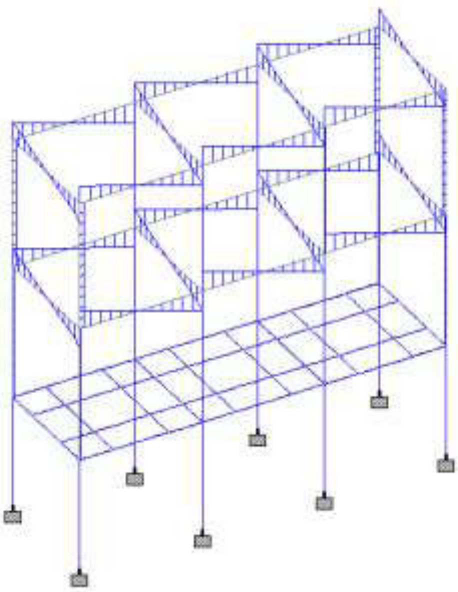


Z- Direction

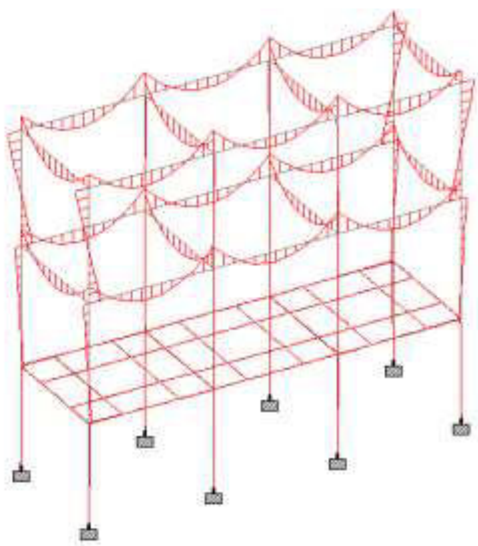
ANALYSIS OUTPUT – SUPPORT REACTIONS



ANALYSIS OUTPUT



SHEAR FORCE DIAGRAM



BENDING MOMENT DIAGRAM

DESIGN OUTPUT – RCC BEAM

BEAM SIZE : 300 X 900mm

Span of Beam = 7.35m

Negative Bending moment = 343.25kNm

Positive Bending moment = 539.07kNm

Shear force =147.93kN

A_{st}= 2022.94 mm^2

A_{sc} = 1214.50 mm^2

A_{sv} = 100.53 mm^2

Main reinforcement @ top – 4 Nos of 20mm dia.

Main reinforcement @ bottom – 7 Nos of 20mm dia.

8mm # @ 2 legged stirrups @ 150 mm c/c

DESIGN OUTPUT – RCC COLUMN

COLUMN SIZE: 300 x 900mm

Factored load = 4464.94 KN

Factored Bending moment = 207.73 KNm

Factored Bending moment = 204.48 KNm

As per SP 16:1980,

A_{st}= 9450.00mm2

Provide 20nos of 25mm dia. bars as Main rod

Provide 8mm # @ 2 legged vertical stirrups at 300mm c/c

DESIGN OUTPUT – RCC FOUNDATION

Axial load = 4500kN

Moment in X direction = 207.73kNm

Moment in Z direction = 207.73kNm

Size of the square footing = 2.95 m x 2.95 m

Depth of slab = 360 mm

Reinforcement along X direction = 6313 mm^2

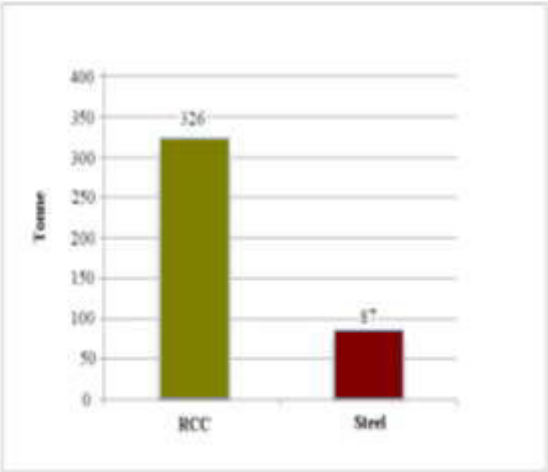
Reinforcement along Z direction = 6313 mm^2

Use 25mm dia bars 13nos in X directions

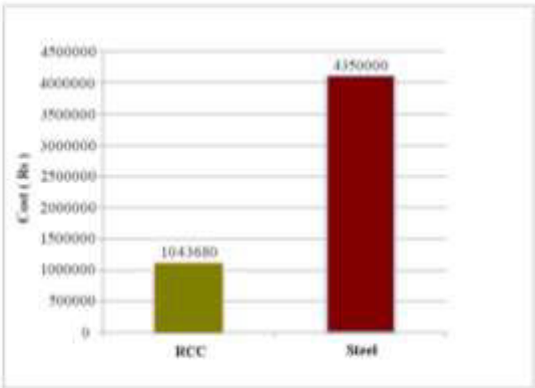
Use 25mm dia bars 13nos in Z directions

COMPARISON OF RCC AND STEEL

Structural analysis and design of silo supporting structure using RCC & steel is completed and the comparison according to weight and cost is given below.



Weight comparison



Cost Comparison

CONCLUSION:

In this project, comparative study, analysis and design of silo supporting structureusing RCC &STEEL are done.The silo supporting structure can adopt three numbers of silos. The diameter of silo is about 7.27m and the height of silo portion is 7.1m and the hopper bottom portion is 3.5m. The total length, breadth andthe height of supporting structure is 22.41m x 7.27m x 20m..Both RCC &STEEL silo supporting structures were modelled in Staad pro v8i , including the effect of lateral forces like wind and seismic.Structural analysis was done using stiffness matrix method and design follows Indian standards.Finally the weight and cost of silo supporting structure is compared for both RCC and Steel and the results are stated below.

Quantity of steel - 87 tonnes
Quantity of RCC - 326.15 tonnes
Cost of steel (material alone) - Rs. 4350000
Cost of RCC (material alone) - Rs. 1043680

REFERENCE:

1. Jinguang teng and j. Michael rotter (1991) “strength of welded steel silo hoppers under filling and flow pressures” j. Struct. Eng., 117(9), 2567–2582.
2. Hazim sharhan (2012) “stress concentrations in elevated steel storage tanks and silos” structures congress 2012: pp. 2046-2057
3. Adem dogangun, zeki karaca, ahmet durmus, and halil sezen (2009). ”cause of damage and failures in silo structures.” J. Perform. Constr. Facil., 23(2), 65–71
4. J. g. teng (1997). ”plastic buckling approximation for transition ringbeams in steel silos.” j. struct. eng., 123(12), 1622–1630.
5. Ashraf m. Elazouni (1997). ”constructability improvement of steel silos during field operations” j. Constr. Eng. Manage., 123(1), 21–25.
6. Eugeniusz hotala, lukasz skotny “experimental investigations on the stability of stiffened cylindrical shells of steel silos”
7. Y. Zhao, j. Yu “stability behaviour of column-supported steel silos with engaged columns”
8. Is 4995 (part 1) & (part2) – 1974: criteria for design of reinforced concrete bins for the storage of granular and powdery materials.
9. Is 875 (part 1) – 1987 - code of practice for design loads (other than earthquake) for buildings and structures – dead loads (unit weight of building materials and stored materials).
10. Is 875 (part 2) – 1987 - code of practice for design loads (other than earthquake) for buildings and structures – imposed loads.
11. Is 875 (part iii) – 1987: code of practice for design loads (other than earthquake) for buildings and structures – wind load.
12. Is 875 (part 5) – 1987 : code of practice for design loads (other than earthquake) for buildings and structures – special loads and combinations
13. Is 1893 (part 1): 2002 – criteria for earthquake Is 800: 2007 – general construction in steel – code of practice .
14. Is 456 : 2000 – plain and reinforced concrete – code of practice
15. Sp16 : 1980 – Design Aids For Reinforced Concrete to Is : 456 -1978