International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Analysis & Design of Modular Technological Structure for Lifting & Transport Analysis

Harshad Rajaram Jamdhade[1], Prof. Vishwajit Kadlag[2]

Department of Civil Engineering, D Y Patil,
Pune, India.

---***---

Abstract - The Project considers methods of using modular units in construction. The advanced world experience in the construction of modular technological structure is analyzed. It is emphasized that modular construction has the potential to shorten project design and engineering time, reduce costs and improve construction productivity. The installation of modular technological structure is cost-efficient, safe and eco-friendly. A modular technological structure is a prefabricated building that consists of repeated sections called modules. Modularity involves constructing sections away from the structure site, then delivering them to the intended site. Installation of the prefabricated sections is completed on site. Prefabricated sections are sometimes placed using a crane. The modules can be placed side-by-side, end-to-end, or stacked, allowing for a variety of configurations and styles. After placement, the modules are joined together using inter-module connections, also known as inter-connections. The inter-connections tie the individual modules together to form the overall technological structure. For this purpose, a reference project of USA location is taken and modelling in STAAD Pro. software to Analysis & Design of Structure.

***Key Words*: -** Modular, Technological Structure, Prefabricate, Lifting, Transport

INTRODUCTION

A technological structure is a multi-tier steel structure with moment resisting frames (OMRF or SMRF) in one direction and with braced frames in the other. This structure generally supports piping and other equipment such as boilers, condensers, exchangers, vessels, Pump, tank, Air Blower, Turbo Washer etc. on one or more levels. For the design and engineering time, reduce costs and improve construction productivity. To use modular concept in this structure.

A modular building is a prefabricated building that consists of repeated sections called modules. Modularity involves constructing sections away from the building site, then delivering them to the intended site. Installation of the prefabricated sections is completed on site. The structure and various elements are designed for the force and the moment's results under the effect of intended loads. In the structural design, dead load of structure, Equipment load, impact load, live load, wind loads, Wind load on Equipment, Friction load on structure due to Equipment & Piping, Earthquake load etc., are consider for

1.Erection Condition

2.Lifting Condition (Vertical Lifting, Tilting Lifting & Horizontal Lifting)

3.Transport Analysis (Road Transport & Sea Transport)

4.Operating Condition Components of Technological Structure:

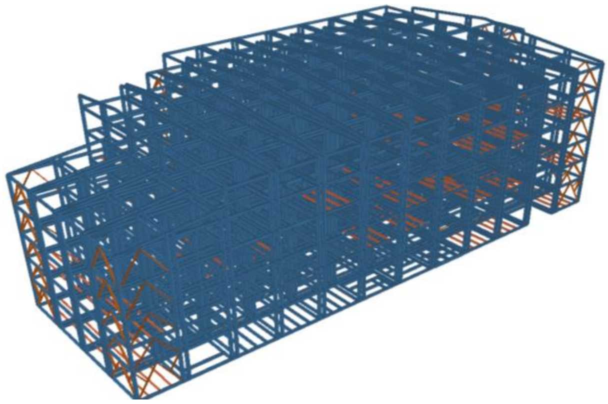


Fig No.1: Technological Structure

The elements of Technological Structure are listed below.

1) Column and Column Base.

A column is a structural member which is straight to two equal and opposite compressive forces applied at the ends. Stability plays an important role in the design of compression member because in columns buckling is involved. The problem of determining the column load distribution in an industrial building column is statically indeterminate. To simplify the analysis the column is isolated from the space frame and is analyzed as a column subjected to axial load An industrial building column is subjected to following loads in addition to its self-weight.

Dead load, Live load, Crane load, Wind Load, Seismic Load, Temperature Load.

2) Main Beam

A beam is a structural element that primarily resists loads applied laterally to the beam's axis (an element designed to carry primarily axial load would be a strut or column). Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. For main periphery of Structure, the main beam is design.

3) Secondary Beam

To carry the Supports equipment lug, Mezzanine Floors etc. to transfer the load on main beam.

4) Mezzanine Floors

In industrial applications, mezzanine floor systems are semi-permanent floor systems typically installed within buildings, built between two permanent original stories. These structures are usually free standing and, in most cases, can be dismantled and relocated. Commercially sold mezzanine structures are generally constructed of three main materials; steel, aluminum, and fiberglass. The decking or flooring of a mezzanine will vary by application but is generally composed of b-deck underlayment and wood product finished floor or a heavy-duty steel, aluminum or fiberglass grating.

5) Roof Trusses
Roof trusses are elements of the structure. The members are subjected to direct stresses. Truss members are subjected to direct tension and direct compression.

6) Staircase Tower
Stair tower means a structure twelve feet or taller in height, typically consisting of one or more flights of stairs, usually with landings to pass from one level to another.

7) Crane
Crane boom deflection is another phenomenon that happens to all cranes. It occurs when a crane is lifting a load and its boom appears to be bending. All booms have this ability to flex so they can absorb the loading forces that come from lifting a heavy weight.

8) Bracing
A bracing is structural member commonly used in structures subject to lateral loads such as wind and seismic forces. The bracing member is generally made of structural steel which can work effectively in tension and compression. Bracing transfer the lateral forces axially and reduce sway of structure and structure will be economical. It is observed that lateral movement decreases up to 80% due to the incorporation of the bracing system. By (Nayanmoni Chetia, 2016). The beam and columns that form a frame carry vertical loads and bracing system carries lateral loads.

Load Consider on Technological Structure:

1) Earthquake Load (EQ)
Following Seismic site parameter are considered in the calculations.
Ss = 0.103, S1 = 0.055, TL = 12 Sec. Importance factor (I) = 1, Response Modification Factor (R) = 4, Site Class = D, Fa = 1.6 & Fv = 2.4 Seismic analysis has been done by using Response Spectrum Method (SRSS) in STAAD.

2) Dead Loads (DL)
Self-Weight of Structure = 1.10 x Total weight of Structural member

3) Cable Tray + Cable Load (CTC)
Dead loads for cable trays on pipe racks shall be estimated as follows, unless actual load information is available and requires otherwise, A uniformly distributed dead load of 1.0 kPa for a single level of cable trays and 1.9 kPa for a double level of cable trays.

4) Platform Dead Load (PDL)
Dead load of walking platform, Handrails etc.

5) Fire Proofing Load (FP)
Fire protection refers to measures taken to prevent fire from becoming destructive, reduce the impact of an uncontrolled fire, and save lives and property.

6) Live Load (L)
Live loads are gravity loads produced by the use and occupancy of the building or structure. These include the weight of all movable loads, such as personnel, tools, miscellaneous equipment, movable partitions, wheel loads, parts of dismantled equipment, stored material, etc.

7) Snow Load (S)
Snow load is the downward force on a building's roof by the weight of accumulated snow and ice. The roof or the entire structure can fail if the snow load exceeds the weight the building was designed to shoulder. Or if the building was poorly designed or constructed. It doesn't take a blizzard to cause problems.

8) Pipe Empty Load (PE)
For checking uplift and components controlled by minimum loading, 60% of the estimated piping operating loads shall be used if combined with wind or earthquake unless the actual conditions require a different percentage.

9) Pipe Operating Load (PO)
Pipe content load is the weight of contents (fluid load) minus the empty weight of process equipment, vessels, tanks, piping, and cable trays maximum during normal operation.

10) Pipe Test Load (PT)
Test dead load (DT) is the empty weight of the pipe plus the weight of test medium contained in a set of simultaneously tested piping systems. The test medium shall be as specified in the contract documents or as specified by the owner. Unless otherwise specified, a minimum specific gravity of 1.0 shall be used for the test medium.

11) Equipment Empty Load (EE)
for process equipment and vessels is the empty weight of the equipment or vessels, including all attachments, trays, internals, insulation, fireproofing, agitators, piping, ladders, platforms, etc. Empty dead load also includes weight of machinery (e.g., pumps, compressors, turbines, and packaged units).

12) Equipment Operating Load (EO)
for process equipment and vessels is the empty dead load (EE) plus the maximum weight of contents (including packing/catalyst) during normal operation.

13) Equipment Test Load (ET)
for process equipment and vessels is the empty dead load (De) plus the weight of test medium contained in the system. The test medium shall be as specified in the contract documents or as specified by the owner. Unless otherwise specified, a minimum specific gravity of 1.0 shall be used for the test medium. Equipment and pipes that may be simultaneously tested shall be included. Cleaning load shall be used for test dead load if the cleaning fluid is heavier than the test medium.

14) Pipe Friction Load (PF)
Friction forces caused by thermal expansion or contraction shall be determined using the appropriate static coefficient of friction. Coefficients of friction shall be in accordance with below Fig

Steel to Steel	0.4
Steel to Concrete	0.6
Proprietary Sliding Surfaces or Coatings (e.g., "Teflon")	According to Manufacturer's Instructions

15) Pipe Guide Load (PGL)
The pipe containing fluid is mostly have high temperature around 110°C to 120°C. because of this high temperature pipe tends to expand in both longitudinal and transverse direction. To restrict the movement of pipe in transverse direction guide support is provided. As the stiffness of pipe is minimum in transverse direction guide support are provided at short interval in one stretch of Piperack It resists the forces,
Transverse Pipe Friction load – PFT
Transverse Pipe Anchor load – PAT

16) Pipe Anchor Load (PAL)
When both guide and axial stop support are provided at same point then it is called as anchor support and the frame bay in which anchor bay lies it's a anchor bay. At anchor bay longitudinal and transverse forces are very high, so both side of bracing are provided at anchor bay mostly. It resists the forces,
Transverse Pipe Friction load – PFT
Transverse Pipe Anchor load – PAT
Longitudinal Pipe Friction load – PFT
Longitudinal Pipe Anchor load – PAT

17) Wind Load (WL)
Wind Load Calculation - As per ASCE 7-10

Basic wind speed at site (V) in mph	= 115 mph.
Eave's height of the structure (h) in ft.	= 60 ft.
Exposure category	= C
Building Type	= Enclosed

Primary load case & Load combination for Road & Sea Transport

1.0 SELF WEIGHT OF STRUCTURE
2.0 BALANCE OF THE SKID WEIGHT
3.0 GWR: RATING / MAX GROSS WEIGHT MGR
4.0 HORIZONTAL IMPACT LOAD IN X DIRECTION
5.0 HORIZONTAL IMPACT LOAD IN Z DIRECTION
6.0 WIND IN +X DIRECTION
7.0 WIND IN +Z DIRECTION
8.0 WIND IN -X DIRECTION
9.0 WIND IN -Z DIRECTION
10.0 ROAD ACC +X
11.0 ROAD ACC +Z
12.0 ROAD ACC +Y
13.0 SEA ACC +X
14.0 SEA ACC +Z
15.0 SEA ACC -Y

Load Combination for Road Transport & Sea Transport
1.0 GWR + 1 WIND IN X
2.0 GWR + 1 WIND IN Z
3.0 GWR + 1 WIND IN -X
4.0 GWR + 1 WIND IN -Z
5.0 ROAD TRANSPORT +X
6.0 ROAD TRANSPORT -X
7.0 ROAD TRANSPORT +Z
8.0 ROAD TRANSPORT -Z
9.0 ROAD TRANSPORT -Y
10.0 ROAD TRANSPORT +X+Y+Z
11.0 ROAD TRANSPORT -X+Y-Z

12.0 SEA TRANSPORT +X
13.0 SEA TRANSPORT -X
14.0 SEA TRANSPORT +Z
15.0 SEA TRANSPORT -Z
16.0 SEA TRANSPORT -Y

Road & Sea Transport Criteria
Acceleration value consider for Road Transport

Road Transport

Direction secured in	Acceleration coefficient			
	Long		Trans	Vertical down (min)
	Forward	Rearward		
Long	0.8	0.5	-	1.0
Trans	-	-	0.5	1.0

Fig No.2: Acceleration Coefficients for Road Transport

Acceleration value consider for Sea Transport

Sea Transport

Hs	Direction secured in	Acceleration coefficient		
		Long	Trans	Vertical down (min)
<8m	Long	0.3	-	0.5
	Trans	-	0.5	1.0
>8m, <12m	Long	0.3	-	0.3
	Trans	-	0.7	1.0
>12m	Long	0.4	-	0.2
	Trans	-	0.8	1.0

Fig. No.3: Acceleration Coefficients for Sea Transport

Aim:

- To design heavy equipment supporting technological structure for operating, lifting & transport condition.
- To check the behavior of structure for lifting analysis (Vertical Lifting, Tilting Lifting & Horizontal Lifting), Road & Sea transport analysis for with & without Bracing.

Problem Statement:
- We need to Analysis & Design of 14'5"x 14'5" x 66' module of 180'5" x 197' x 66' Technological structure with heavy equipment's like boilers, condensers, exchangers, vessels, Pump, tank, Air Blower, Turbo Washer etc. for operating condition after the structure is safe for Deflection, Story Drift, Utility Ratio.
- Then check 14'5"x 14'5" module for Lifting condition for Vertical Lifting, Tilting Lifting, Horizontal Lifting &

Transport condition for Road Transport Analysis & Sea Transport Analysis in Staad Pro.

Objective:

- In the present study, Following Objectives were set:
- Design & Analysis of modular Technological Structure for Heavy Equipment for operating, lifting & Transport condition in STAAD Pro.
- To analyze the structure by square root of sum of squares (SRSS) method for seismic analysis.
- To study the different loads and their behavior on structure.
- To reduce the effect of horizontal loads on structure.
- To calculate the Displacement, and storey drift.
- To calculate the tonnage of the structure.

Lifting Analysis of Modular Technological Structure

Fig. No.4: Vertical Lifting

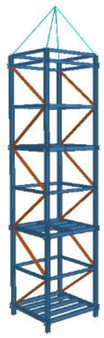


Fig. No.5: Vertical Lifting with Bracing

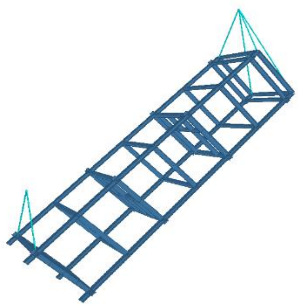


Fig. No.6: Tilting Lifting

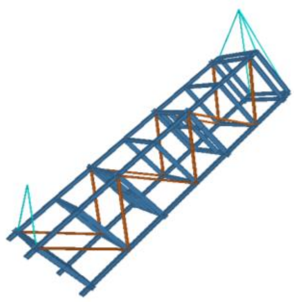


Fig. No.7: Tilting Lifting with Bracing

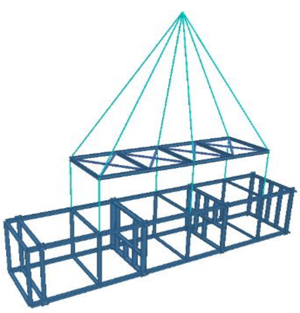


Fig. No.8: Horizontal

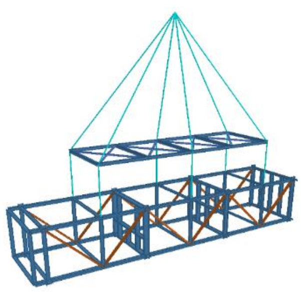


Fig. No.9: Horizontal Lifting

Lifting **with Bracing**

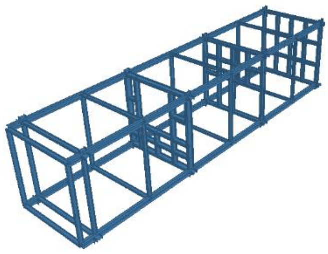


Fig. No.10: Road & Sea Transport

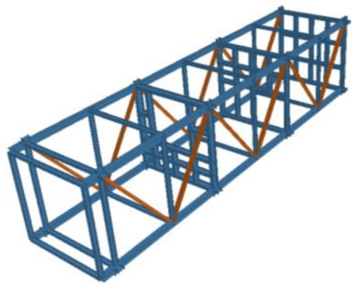


Fig. No.11: Road & Sea Transport with Bracing

RESULT AND DISCUSSION

GENERAL

A design of Equipment Supported Technological Structure is done with Deflection is within a limit, there are no member is failed is strength. Structure is Safe for operating condition & Erection point of view.

The structural analysis & design of the skid the structural steel material of grade ASTM A992 is used. Following are the material characteristic which used for design is mentioned: -

Characteristic Yield Strength of Steel for UB / UC Sections (A992) = 50 kip/inch2

Characteristic Ultimate Strength of Steel for UB/UC Section (A992) = 65 kip/inch2

Characteristic Yield Strength of Steel for Angle/Channel Section (A36) = 36 kip/inch2

Characteristic Ultimate Strength of Steel for Angle/Channel Section (A36) = 58 kip/inch2

Total Structural Steel Tonnage = **1007 Ton.**

DEFLECTION SUMMARY

Deflection Summary for Vertical Lifting

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	54	8003 DS+PDL	**19.119**	-5.041	-2.545	19.935
Min X	54	8004 DS+PDL	**-19.166**	-3.621	5.107	20.162
Max Y	84	8001 DS+PDL	0.000	**0.000**	0.000	0.000
Min Y	91	8005 DS+PDL	-0.016	**-7.061**	24.860	25.844
Max Z	101	8005 DS+PDL	-0.131	-6.683	**26.935**	27.752
Min Z	80	8006 DS+PDL	0.081	-3.465	**-25.325**	25.561

Fig No.12: Deflection of Vertical Lifting without Bracing

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	110	8003 DS+PDL	**19.946**	-12.470	-0.566	23.530
Min X	110	8004 DS+PDL	**-20.029**	-11.037	1.399	22.912
Max Y	84	8001 DS+PDL	0.000	**0.000**	0.000	0.000
Min Y	100	8005 DS+PDL	-0.485	**-13.572**	4.269	14.236
Max Z	14	8005 DS+PDL	1.098	-10.930	**5.203**	12.155
Min Z	101	8006 DS+PDL	-0.825	-12.533	**-4.249**	13.260

Fig No.13: Deflection of Vertical Lifting with Bracing

According Fig No. 12 & Fig No. 13 vertical lifting is of structure designed without bracing have more deflection in Z direction than the Temporary bracing is added for vertical lifting analysis of structure & structure designed with bracing.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Deflection Summary for Tilting Lifting

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	81	8003 DS+PDL	**50.550**	-33.073	30.059	67.474
Min X	55	8004 DS+PDL	**-52.324**	6.451	-79.953	95.770
Max Y	56	8004 DS+PDL	-46.625	**12.198**	-24.825	54.212
Min Y	80	8003 DS+PDL	50.442	**-33.179**	12.648	61.686
Max Z	31	8003 DS+PDL	26.080	-6.308	**43.561**	51.162
Min Z	31	8004 DS+PDL	-49.694	3.667	**-83.782**	97.480

Fig No.14: Deflection of Tilting Lifting without Bracing

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	53	8003 DS+PDL	**29.251**	-8.452	39.225	49.656
Min X	49	8004 DS+PDL	**-38.945**	3.434	-0.042	39.096
Max Y	47	8003 DS+PDL	-4.037	**8.387**	40.407	41.466
Min Y	47	8004 DS+PDL	5.688	**-15.591**	-56.498	58.885
Max Z	77	8003 DS+PDL	26.903	-6.771	**42.723**	50.940
Min Z	78	8004 DS+PDL	3.851	-12.830	**-60.629**	62.091

Fig No.15: Deflection of Tilting Lifting with Bracing

According Fig No. 14 & Fig No. 15 tilting lifting is of structure designed without bracing have more deflection in X & Z direction than the Temporary bracing is added for tilting lifting analysis of structure & structure designed with bracing

Deflection Summary for Horizontal Lifting

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	32	8006 DS+PDL	**4.694**	-3.226	0.000	5.696
Min X	40	8006 DS+PDL	**-4.702**	-4.327	-0.056	6.390
Max Y	69	8001 DS+PDL	0.000	**0.000**	0.000	0.000
Min Y	81	8006 DS+PDL	0.238	**-15.142**	-0.033	15.144
Max Z	45	8005 DS+PDL	0.104	-7.680	**66.094**	66.539
Min Z	46	8006 DS+PDL	0.040	-7.691	**-66.603**	67.045

Fig No.16: Deflection of Horizontal Lifting without Bracing

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	40	8005 DS+PDL	**2.798**	-4.664	0.000	5.438
Min X	32	8005 DS+PDL	**-2.913**	-5.102	0.032	5.875
Max Y	69	8001 DS+PDL	0.000	**0.000**	0.000	0.000
Min Y	87	8005 DS+PDL	0.172	**-12.043**	28.059	30.535
Max Z	45	8005 DS+PDL	-0.060	-5.296	**39.513**	39.866
Min Z	46	8006 DS+PDL	-0.001	-5.467	**-39.335**	39.713

Fig No.17: Deflection of Horizontal Lifting with Bracing

According Fig No. 16 & Fig No. 17 Horizontal lifting is of structure designed without bracing have more deflection in Z direction than the Temporary bracing is added for Horizontal lifting analysis of structure & structure designed with bracing also in that structure control lifting is done.

Deflection Summary for Road Transport Analysis & Sea Transport Analysis

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	30	7000 SEA TR	**1.926**	-9.209	-0.037	9.408
Min X	90	7001 SEA TR	**-1.859**	-6.135	1.483	6.580
Max Y	154	7004 SEA TR	-0.139	**8.079**	0.000	8.080
Min Y	23	7004 SEA TR	0.342	**-19.587**	-0.063	19.590
Max Z	53	6002 ROAD T	-0.276	-9.888	**21.275**	23.462
Min Z	54	6003 ROAD T	-0.083	-9.683	**-20.119**	22.328

Fig No.18: Deflection of Road Transport & Sea Transport Analysis without Bracing

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	30	7000 SEA TR	**2.029**	-10.910	-0.043	11.098
Min X	90	7001 SEA TR	**-1.709**	-6.965	0.947	7.234
Max Y	154	7004 SEA TR	-0.360	**5.898**	0.000	5.909
Min Y	40	7004 SEA TR	0.838	**-14.927**	0.006	14.951
Max Z	53	6005 ROAD T	-0.134	-11.036	**20.875**	23.613
Min Z	52	6003 ROAD T	-0.280	-8.079	**-19.576**	21.180

Fig No.19: Deflection of Road Transport & Sea Transport Analysis with Bracing

According Fig No. 18 & Fig No. 19 Road & Sea Transport analysis is of structure designed without bracing have more deflection in Y direction than the Temporary bracing is added for Road & Sea analysis of structure & structure designed with bracing.

Utility Check Ratio

Utility ratio is the ratio of Actual Load on member to the capacity of member, if it exceeds more than 1 then load on member will be greater than its capacity and member gets collapsed.

Member Unity Ratio of Vertical Lifting for Dead load, Equipment load & Wind load combination

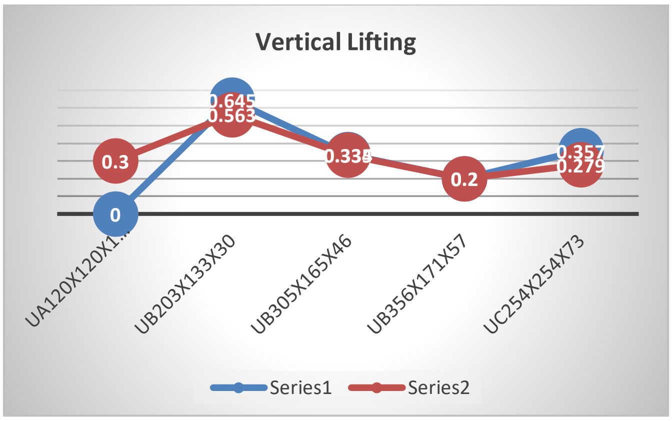
Vertical Lifting without Bracing (Series 1)	Member Type	Member Size	Utility Ratio
		UB203X133X30	0.645
		UB305X165X46	0.335
		UB356X171X57	0.200
	Column	UC254X254X73	0.357

Table No. 1: Unity Ratio of Vertical Lifting without Bracing

Vertical Lifting with Bracing (Series 2)	Member Type	Member Size	Utility Ratio
	Bracing Member	UA120X120X12	0.300
		UB203X133X30	0.563
		UB305X165X46	0.334
		UB356X171X57	0.200
	Column	UC254X254X73	0.279

Table No. 2: Unity Ratio of Vertical Lifting with Bracing

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930



Graph No.1: Unity Ratio of Vertical Lifting

In Graph No. 1, Series 1 represent the unity ratio of vertical lifting without bracing in that the maximum ratio is 0.645 in that beam member is critical & Series 2 represent the unity ratio of vertical lifting with bracing in that the maximum ratio is 0.563 in that beam is critical in LRFD-H1-1A Members Subject to Flexure and Compression.

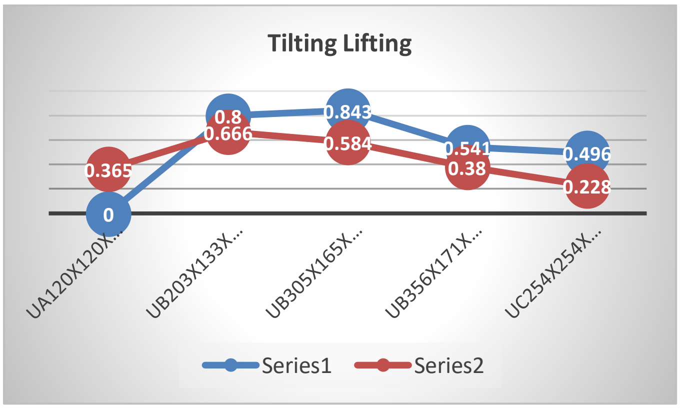
Member Unity Ratio of Tilting Lifting for Dead load, Equipment load & Wind load combination

	Member Type	Member Size	Utility Ratio
Tilting Lifting without Bracing (Series 1)		UB203X133X30	0.800
		UB305X165X46	0.843
		UB356X171X57	0.541
	Column	UC254X254X73	0.496

Table No.3: Unity Ratio of Tilting Lifting without Bracing

	Member Type	Member Size	Utility Ratio
Tilting Lifting with Bracing (Series 2)	Bracing Member	UA120X120X12	0.365
		UB203X133X30	0.666
		UB305X165X46	0.584
		UB356X171X57	0.380
	Column	UC254X254X73	0.228

Table No.4: Unity Ratio of Tilting Lifting with Bracing



Graph No2: Unity Ratio of Tilting Lifting

In Graph No. 2, Series 1 represent the unity ratio of tilting lifting without bracing in that the maximum ratio is 0.843 in that beam member is critical & Series 2 represent the unity ratio of tilting lifting with bracing in that the maximum ratio is 0.666 in that beam is critical in LRFD-H1-1A Members Subject to Flexure and Compression.

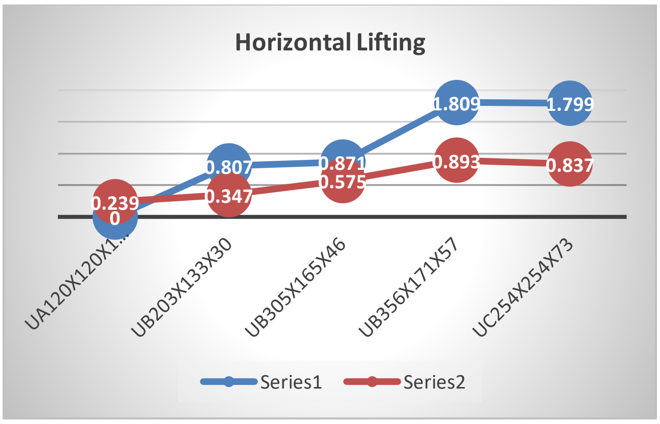
Member Unity Ratio of Horizontal Lifting for Dead load, Equipment load & Wind load combination

	Member Type	Member Size	Utility Ratio
Horizontal Lifting without Bracing (Series1)		UB203X133X30	0.807
		UB305X165X46	0.871
		UB356X171X57	1.809
	Column	UC254X254X73	1.799

Table No. 5: Unity Ratio of Horizontal Lifting without Bracing

	Member Type	Member Size	Utility Ratio
Horizontal Lifting with Bracing (Series 2)	Bracing Member	UA120X120X12	0.239
		UB203X133X30	0.347
		UB305X165X46	0.575
		UB356X171X57	0.893
	Column	UC254X254X73	0.837

Table No. 6: Unity Ratio of Horizontal Lifting with Bracing



Graph No.3: Unity Ratio of Horizontal Lifting

In Graph No. 3, Series 1 represent the unity ratio of horizontal lifting without bracing in that the maximum ratio is 1.809 in that Beam member is Failed in Deflection & Series 2 represent the unity ratio of horizontal lifting with bracing in that the maximum ratio is 0.893 in that beam is critical in Deflection.

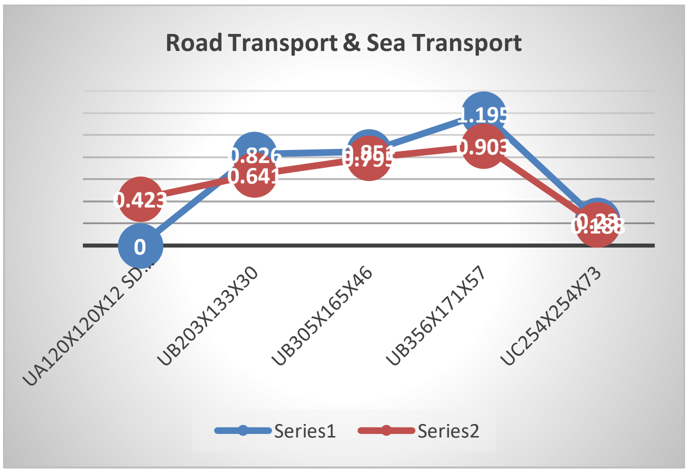
Member Unity Ratio of Road transport & Sea transport

Road & Sea Transport without Bracing (Series1)	**Member Type**	**Member Size**	**Utility Ratio**
		UB203X133X30	0.826
		UB305X165X46	0.851
		UB356X171X57	1.195
	Column	UC254X254X73	0.23

Table No. 7: Unity Ratio of Road Transport & Sea Transport without Bracing

Road Transport & Sea Transport with Bracing (Series2)	**Member Type**	**Member Size**	**Utility Ratio**
	Bracing Member	UA120X120X12	0.423
		UB203X133X30	0.641
		UB305X165X46	0.795
		UB356X171X57	0.903
	Column	UC254X254X73	0.188

Table No. 8: Unity Ratio of Road Transport & Sea Transport with Bracing



Graph No.4: Unity Ratio of Road Transport & Sea Transport

In Graph No. 4, Series 1 represent the unity ratio of Road transport & Sea transport without bracing in that the maximum ratio is 1.195 in that Beam member is Failed in Deflection & Series 2 represent the unity ratio of Road transport & Sea transport with bracing in that the maximum ratio is 0.903 in that beam is critical in Deflection.

CONCLUSION

- The technological structure is found critical/governing for the following load combination 1.2(DS+CTC+PDL+FP+PO+EO+PCL+HDL+CL)-PFX-PFZ-1.2PGL-1.2PAL+1.6L+0.5S with unity 0.981.
- Effects of horizontal loads on structure is reduced/arrested with the help of diagonal bracing pattern.
- Maximum vertical deflection for the structure is found 14.060 mm, and horizontal displacement /storey drift is 32.71mm.
- Total optimized structural Steel Tonnage is 1007 Ton.

As per construction point of view modular structure is best suited for fast construction instead of having higher steel tonnage in comparison to stick built structure. It has less chances of errors due to shop manufacturing.

REFERENCES

- Dhanshree V Damre, Tushar A Jadhav “Structural and Experimental Analysis of Lift Hook Bracket” (IJERT).
- Hosang Hyun, Hyunsoo Kim, Hyun-Soo Lee, Moonseo Park “Integrated Design Process for Modular Construction Projects to Reduce Rework” (MDPI).
- Xiao-Rong Yang, Qiu-Ming Gan, Yan-Hong Wang & Guang-Dong Wang “dynamic response analysis of the lifting load system of a crane ship in irregular waves” (JMST).
- Vasantha Shanmugam “Influence of ICT in Road Transportation” (IJSCM).
- ASCE 7- 10 - American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures
- AISC 360 – 10 - American Institute of Steel Construction, Specification for Structural Steel Buildings
- Noble Denton - Technical Standards Committee-Guidelines for Marine Transportations
- PIP STC01015 Structural Design Criteria