Analysis and Design of Diagrid Structural System for High Rise Steel Building

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A B S T R A C T

In the present time, diagrid system structures are being adopted in tall buildings since they have constructional efficiency and flexibility in the field of architectural designing. Diagrids additionally referred to as Diagonalized grid structures have emerged united of the most innovative and convertible approaches to structuring buildings. The study included 5 completely different model structures of Diagrid system frame utilized in buildings together with the traditional moment resisting frame. To perform analysis of diagrid structural system for high rise steel building with completely different floor module.

Keywords:
Diagrid Structural System,
High rise buildings,
Structuraldesign

1. Introduction

Tall building or high rise structures construction are a lot of during this era; because of increase in population, economic prosperity and additionally because of the lack of lands high-rise buildings are most trendy. Height is main criteria during this kind of buildings; demand for tall buildings has enhanced due to increase in demand for business and residential house, advances in constructions, high strength structural components, materials and additionally numerous code like ETABS, STAAD PRO. etc these are analysis and style software's have provided growth of high rise structures. Usually tall buildings are made and used for industrial workplace buildings, residences etc. Construction of tall buildings aren't simple as that of normal standard buildings because of the action of lateral loads, lateral displacement can induces bending and shear lag special effects are further so in order to resist cross loads new systems were developed referred to as lateral load resisting systems.

Fig.1 Design of a Diagrid High rise building

Diagrid are created up diagonal parts they are triangular structures with supporting beams, this technique would supply additional flexibility to interior designing and façade look is also improved as a result of numbers of parts needed are reduced. The diagrid structures are extra conservative than commonplace outside propped frameworks this is regularly simply because most the vertical segments are wiped out, askew matrix module just itself convey all parallel and vertical burdens, yet normal outside supports convey just vertical burdens. One among main advantage of this technique is that up to 20 to 30 minutes of steel are often saved at outer boundary compared traditional typical building. By using this technique the high rise structures are often designed to any form like square, rectangle and curved structures etc.

2. METHOD

Methodology

1. Building details was selected from Khusbhu Jaini et al (2013).
2. The angle of diagrid is decided on the basis of the storey module.
3. Models will be made in Staad pro.

Loads Considered

1. Dead load
2. Live load
3. Seismic load

For the modelling of Diagrid High rise building of structure STAAD Pro software is used.

STAAD.PRO is the Structural analysis and Design Software established by Bentley System Inc. founded by Mr. Keith A. Bentley in conjunction with his brother Mr. Barry J.Bentley in 1984. The present version of STAAD-pro is STAAD-pro V8i is one of the most awaited structural analysis and design software. It has the provision for steel works, concrete design codes. It is used to analyses various structural forms from the traditional static analysis, p-delta analysis and geometrical non-linear analysis.

There are four model is design in STAAD Pro software and analysis is done also this software. After applied the load consideration is discussed in next section.

3. RESULT DISCUSSION

The complete analysis and simulation is carried out on Stadd. Pro tool and the required graphs and renders are obtained as results

Table 1: Geometry and load consideration

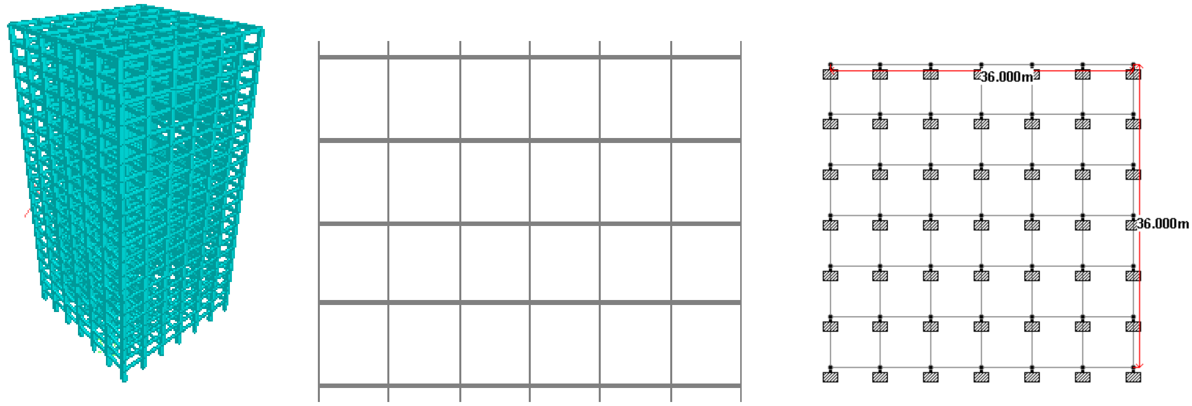
Type of structure	Building details
Plan dimension	36 x 36 m
Total height of building	72 m
Height of each storey	3.6 m
Diagrid section	Steel section
Seismic load (as per IS code 1893 part-1)	Zone IV
Dead load (5 KN/m^2)	875- part 1
Live load (4 KN/m^2)	875- part 2
Thickness of slab	150 mm
Beam size	300 x 800 mm
Column size	800 x 800 mm

Table 2: Material properties considered in the modelling

Description	Value
Steel table	Standard I- section (I100012B50016)
Poisson ratio	0.17
Tensile Strength, Ultimate Steel	505 MPa
Tensile Strength, Yeild Steel	215 MPa
Modulus of Elasticity Steel	200 GPa

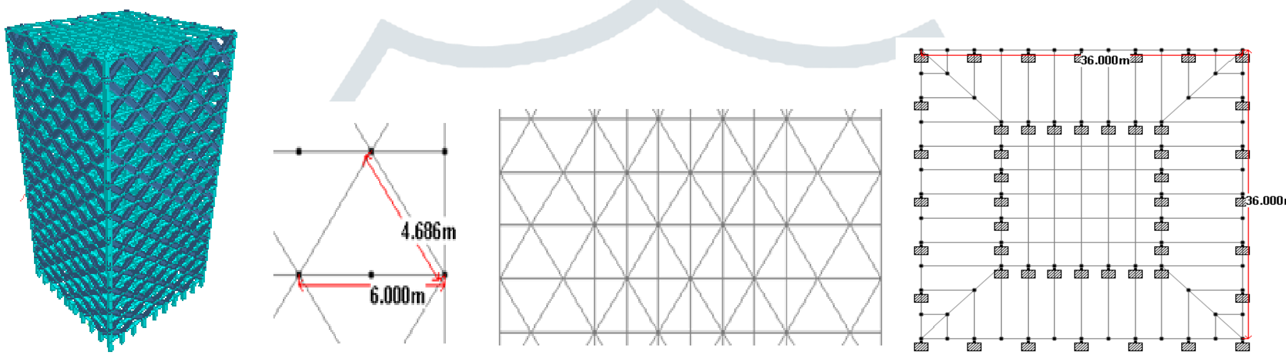
Table 3: Building configurations

Model name	Module per storeys
Model 1	1
Model 2	2
Model 3	4
Model 4	5
Moment resisting frame	-



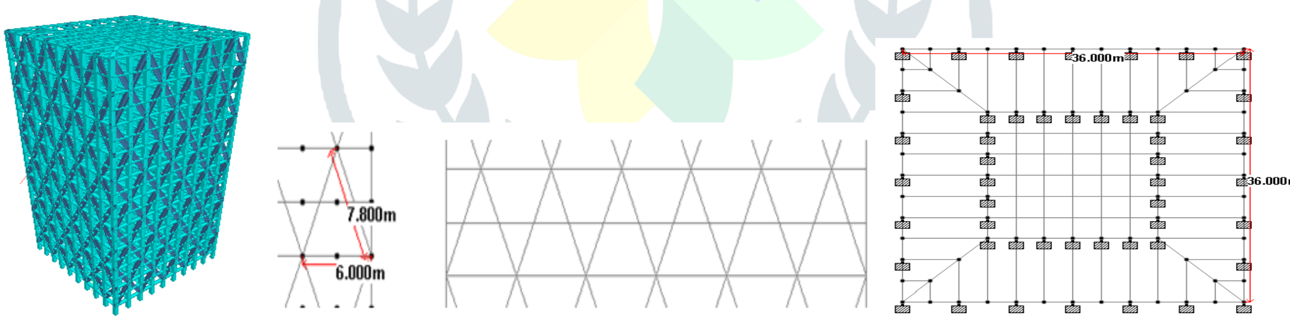
(a) Render view (b) pattern and size (c) floor plan

Fig. 2: Moment resisting frame



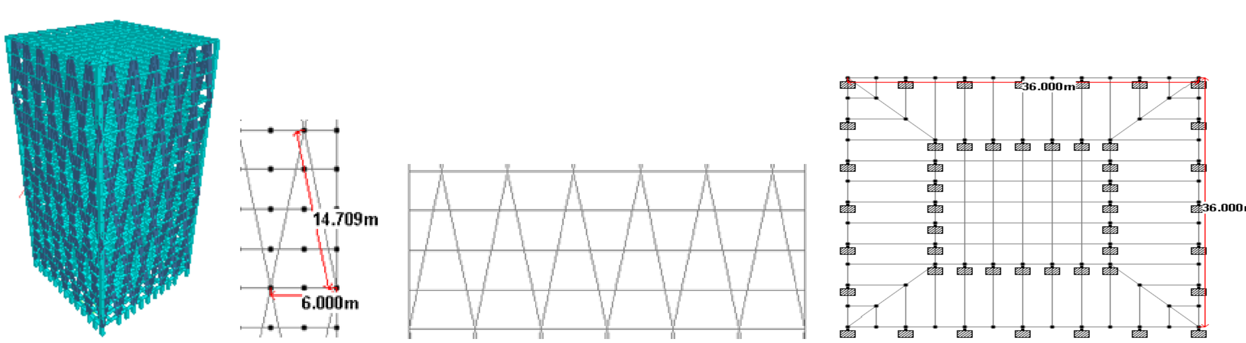
(a) Render view (b) pattern and size (c) floor plan

Fig. 3: Model 1



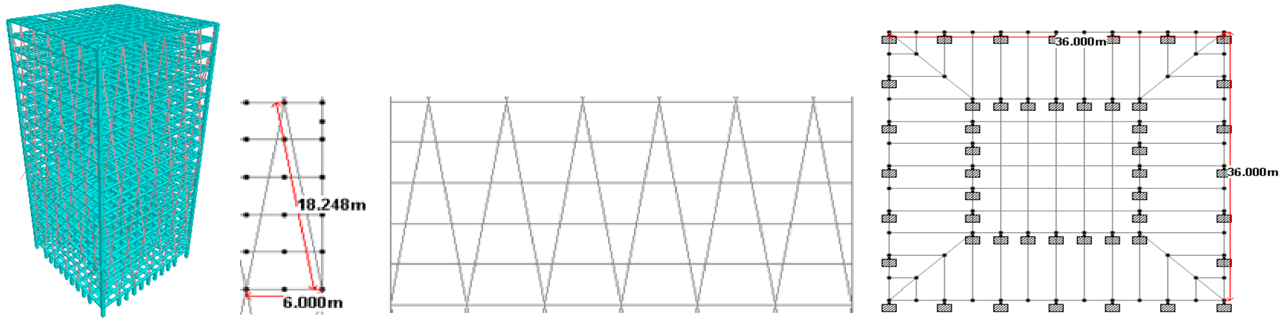
(a) Render view (b) pattern and size (c) floor plan

Fig. 4: Model 2



(a) Render view (b) pattern and size (c) floor plan

Fig. 5: Model 3



(a) Render view (b) pattern and size (c) floor plan

Fig. 6: Model 4

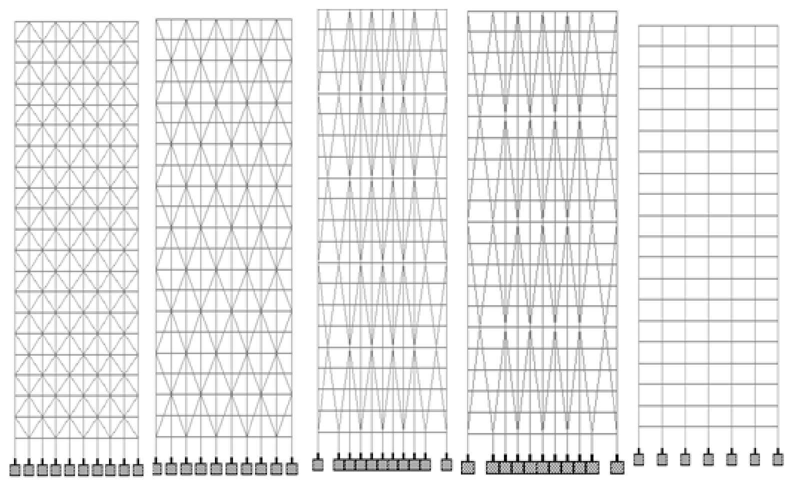


Fig. 7: Elevation plan of different models

Table 4: Maximum Shear force

Shear force, KN	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
	137.15	164.76	901.76	1211.07	605.85

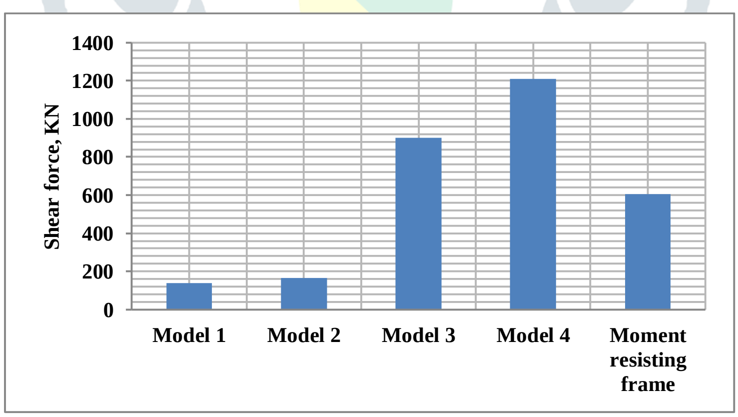


Fig.8 Shear force comparison

BENDING MOMENT

Table 5: Maximum bending moment

BM, KNm	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
	402.01	341.00	2153.55	3076.34	2230.53

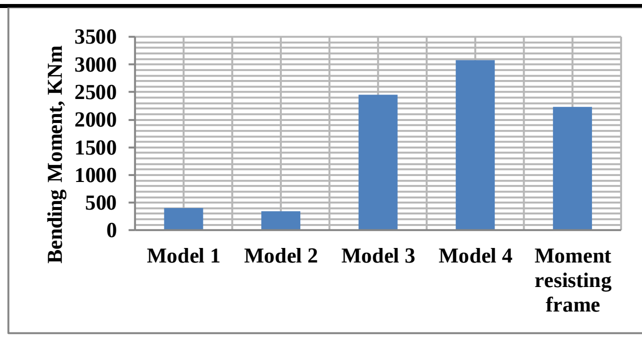


Fig: 9 Bending Moment comparison

DISPLACEMENT

Table:6 Maximum displacement

Displacement, mm	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
	4.323	6.77	206.4	143.62	247.42

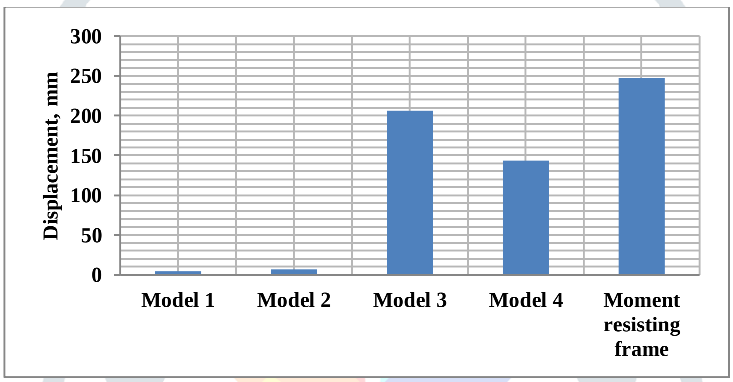


Fig: 10 Displacement comparison

LATERAL DISPLACEMENT

Table 7: Lateral displacement (cm)

Floor	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
1st floor	0.0000	0.0000	0.6348	0.0000	0.0000
2nd floor	0.0134	0.1504	1.5266	0.3985	0.0000
3rd floor	0.0140	0.4986	2.5803	1.3932	0.5646
4th floor	0.0131	0.9125	3.7630	2.7630	1.7414
5th floor	0.0216	1.3246	4.9656	4.3460	3.1683
6th floor	0.0192	1.7532	6.1704	5.2188	4.6974
7th floor	0.0184	2.1441	7.3513	6.0147	6.2662
8th floor	0.0178	2.6031	8.4526	6.8701	7.8456
9th floor	0.0181	3.0158	9.4792	7.6765	9.4194
10th floor	0.0185	3.4776	10.7228	9.3275	10.9757
11th floor	0.0135	3.8763	11.8637	10.9126	12.5036
12th floor	0.0139	4.3539	12.8049	12.4085	13.9922
13th floor	0.0187	4.7503	13.6304	13.8279	15.43
14th floor	0.0143	5.2236	14.8899	15.4697	16.8043
15th floor	0.0179	5.5873	16.9654	17.0066	18.1016
16th floor	0.0172	6.0487	17.7295	18.3270	19.3076
17th floor	0.0163	6.3660	18.3186	19.4111	20.4071
18th floor	0.0132	6.7967	19.3520	19.4250	21.3843
19th floor	0.0148	7.0461	19.6606	20.3601	22.2242
20th floor	0.0134	7.4215	19.2431	20.6347	22.9142

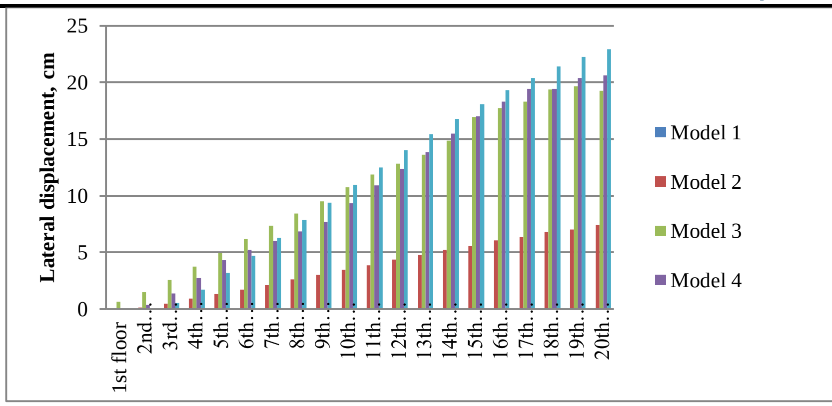


Fig. 11: Lateral displacement of models

STOREY DRIFT

Table 8: Storey drift (cm)

Floor	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
1st floor	0.0000	0.0176	0.0638	0.0000	0.0000
2nd floor	0.0134	0.0190	0.8917	0.3985	0.0000
3rd floor	0.0136	0.0569	1.0538	0.9946	0.5646
4th floor	0.0037	0.0509	1.1827	1.3698	1.1768
5th floor	0.0216	0.0445	1.2026	1.5830	1.4269
6th floor	0.0192	0.0339	1.2048	0.8729	1.5291
7th floor	0.0184	0.0344	1.1810	0.7959	1.5688
8th floor	0.0178	0.0329	1.1013	0.8554	1.5795
9th floor	0.0181	0.0303	1.0266	0.8063	1.5738
10th floor	0.0184	0.0288	1.2436	1.6510	1.5562
11th floor	0.0185	0.0266	1.1409	1.5851	1.5279
12th floor	0.0187	0.0262	0.9412	1.4959	1.4887
13th floor	0.0153	0.0239	0.8255	1.4194	1.4377
14th floor	0.0143	0.0226	1.2595	1.6418	1.3743
15th floor	0.0179	0.0203	1.0860	1.5369	1.2974
16th floor	0.0142	0.0197	0.7181	1.3203	1.2060
17th floor	0.0172	0.0172	1.2563	1.0842	1.0994
18th floor	0.0163	0.0127	0.9541	0.0139	0.9772
19th floor	0.0121	0.0166	0.2515	0.9350	0.8399
20th floor	0.0110	0.0095	0.4175	0.2746	0.6900

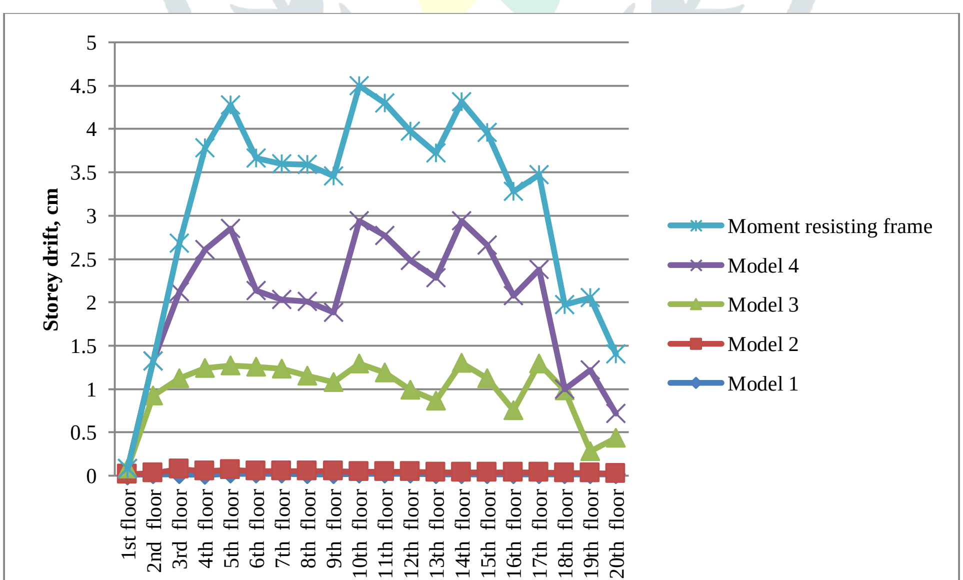


Fig.12: Storey Drift of models

Concept of story drift offers the design of partitions/ curtain walls. To prevent crack it must be carefully designed to bear the storey drift. For structural glazing/ brick walls on external surfaces, this could prove catastrophic.

For earthquake load confirming IS: 1893-2002, clause: 7.11.1, in any storey, storey drift due to lateral force with partial load factor of 1.0 should not be greater than 0.004 times height of storey i.e. H/250, where H = storey height in meter.

Table 9: Concrete take off comparison

Concrete take off, Cu.m	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
	5320	6734.5	4451.5	4107.9	7990.1

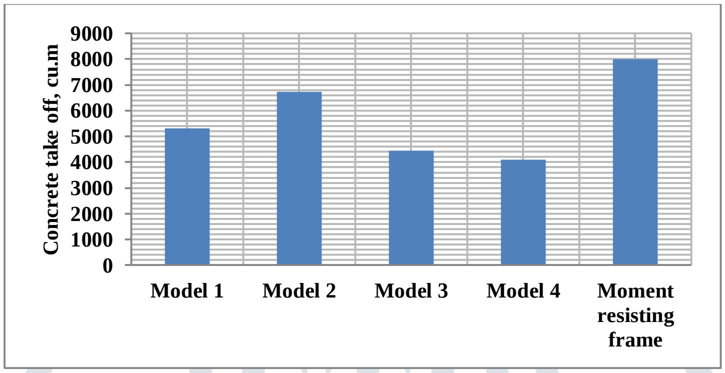


Fig.13: Concrete take off comparison

Concrete consumption in all models is less than the moment resisting frame which makes it more costlier than the diagrid frame.

Table 10: Steel reinforcement take off

Steel take off, N	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
	4098538	3521235	3492477	3600942	8988715

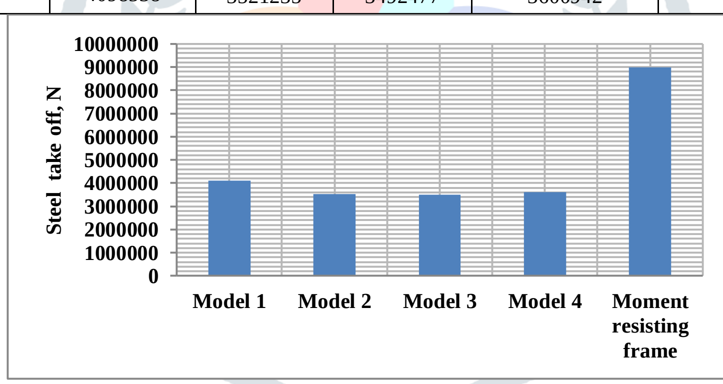


Fig. 14: Steel reinforcement take off

Table 11: Steel member take off

Steel take off, N	Model 1	Model 2	Model 3	Model 4	Moment resisting frame
	14316.88	13834.21	13338.14	13118.26	-

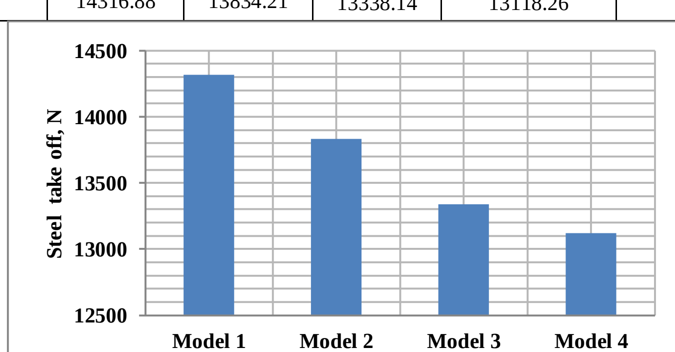


Fig. 15: Steel member take off comparison

4. Conclusion

The rapid increase in population and scarcity of land has increased the demand of taller buildings. Because of their enormous scale, tall buildings require huge amount of resources and consume lots of energy during occupancy, it's important to use various sustainable strategies for tall structures in order to save our limited resources. In this way an auxiliary framework like Diagrid which have productivity as far as quality, articulation, and geometric flexibility is utilized. The job of loads in latertal form for example seismic and wind burdens turns out to be increasingly conspicuous when contrasted with vertical loads in the event of tall structures. The Diagrid framework has notwithstanding quality and style, the additional nature of geometric adaptability, making it the most fit auxiliary framework in this regard.

The 3D modelling and simulation are successfully carried out in Stadd. Pro software tool and the results are obtained. The study included five different model structures of Diagrid system frame used in buildings including the conventional moment resisting frame. Structural parameters such as maximum shear force, maximum bending moment, maximum displacement, lateral displacement, storey drift, concrete take off, and steel reinforcement take off has been calculated. A comparative approach has been done based on the values obtained of the above structural parameters among the five models.

Here the following conclusions:

1. From the results obtained it can be seen that quantity of concrete in a moment resisting frame is higher than in model 1, 2 & 3. It is due to fact in diagrid structure we can replace outer R.C.C. columns by steel sections. However concrete consumption in all models is less than the moment resisting frame which makes it more costlier than the diagrid frame
2. From the results obtained for steel take off it is concluded that steel reinforcement is found more in model 1 and found lowest in moment resisting frame. Similarly steel member take off is found highest in model 1 and lowest in model 4.
3. In the shear force table shear force of model 1 is 77.36% increase from moment resisting frame, model 2 shear force 72.80% increase, shear force of model 3 is -48.84% and model 4 is -99.89.
4. In the bending moment model 1 is 81.97% increase, model 2 is 84.71% increase, bending moment of model 3 is 3.45% increase and model 4 bending moment is -37.91%.
5. In the displacement of model 1 is 98.25% increase, model 2 displacement is 97.26% increase, displacement of model 3 is 16.57% increase and model 4 displacement is 41.95% increase.
6. In the concrete take off of model is 3.33% increase, model 2 is 15.71% increase, model 3 is 44.28% increase and model 4 concrete take off is 48.58% is increase. However concrete consumption in all models is less than the moment resisting frame which makes it more costlier than the diagrid frame.
7. In the model 1 steel take off is 54.4% increase, model steel take off is 60.82% increase, model 3 is 61.14% increase and model 4 steel take off is 59.93% increase.

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