DESIGN AND ANALYSIS OF CONCRETE DIAGRID BUILDING AND ITS COMPARISON WITH CONVENTIONAL BUILDING BY USING STADDPRO

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Abstract - *Diagrid buildings are emerging as structurally efficient as well as architecturally significant due to the structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. In present work, concrete diagrid structure is analyzed and compared with conventional concrete building which is governed by lateral loads due to wind or earthquake. Later load resistance of the structure is provided by interior structural system or exterior structural system. A regular ten storey RCC building with plan size 16m*16m located in seismic zone-3 is considered for analysis. This software is used for modelling and analysis of structural members .All structural members are designed as per IS 456:2000 and load combinations of seismic forces are considered as per IS:1893(Part 1):2002.Comparision of analysis results in terms of storey drift, node to node displacement, bending moment, shear forces, area of reinforcement, and also the economical aspect is presented. The major portion of lateral load is taken by external diagonal members which in turn release the lateral load in inner columns in diagrid structure. This cause's economical design of diagrid structure compared to conventional structure. Drift in Diagrid building is approximate half to that obtained in conventional building. In this study, steel reinforcement used in diagrid structureis found to be 33% less compared to conventional building.*

***Key Words*: Diagrid, Inclined columns, Axial action, Gravity Loads, Lateral Forces,Drift.**

1. INTRODUCTION : Construction of multi-storey building is rapidly increasing throughout the world.i.e., in construction technology, materials, structural systems, analysis and design software facilitated the growth of these buildings. Multi storied development involves various complex factors such as economics, aesthetics look, technology, municipal regulations, and politics. For Multi Storied bulidings its structural design is generally governed by its lateral stiffness.Comparing with conventional orthogonal structures for tall buildings such as framed tubes, diagrid structures carry lateral wind loads much more efficiently by their diagonal member's axial actionThe main objective of this project is to investigate the behaviour of buildings, i.e., diagrid and conventional frame under the seismic zone3.The major difference between a conventional building and a diagrid building is that, there are no vertical columns present in the perimeter of diagrid building, whereas in conventional building there are vertical column present in the perimeter of the building. Therefore the diagonal members in diagrid structures act both as inclined columns and as bracing elements, and carry gravity loads as well as lateral forces; due to their triangulated configuration, mainly internal axial forces arise in the members, thus minimizing shear cracking effects. The term "diagrid" is a combination of the words "diagonal" and "grid" and refers to a structural system that is single thickness in nature and gains its structural integrity through the use of triangulation.Shapes of diagrid structures are planar, crystalline or take on multiple curvatures . They often use crystalline forms or curvature to increase their stiffness. Perimeter diagrids normally carry the lateral and gravity loads of the building and are used to support the floor edges.

Base of the module: The base on which the diagrid is formed usually depends on the height and the optimal angle of the diagrid..

member to the gusset plate and stiffener and then from gusset plate and stiffener to the members below the node in pair of compression and tension.Due to this load transfer path, the shear forces developed at the location of bolt connection is very high under the time of lateral loads. This may be the shear zone or weak zone of this structure during the earthquakes, the designing of the bolt connections is to be done carefully.

2. Modelling: In this study regular square plan,is considered. All the plan area of 256m^2 . The structure are modelled in STADD PRO software as shown below.

Regular diagrid structure.

- Plan dimension: 16m×16m.

- Slab: 150mm thick
- Column section: For dia-grid:400x500mm.(For bottom stories) ,500mmx500mm(for top stories)

  for conventional 500x500mm(For Top Stories)
- Beam section: for dia-grid 300x300mm(for bottom stories), 400x400mm(for top stories)

  For conventional:450x450mm
- Typical story height: 4m.
- Number of story: G+10storey.

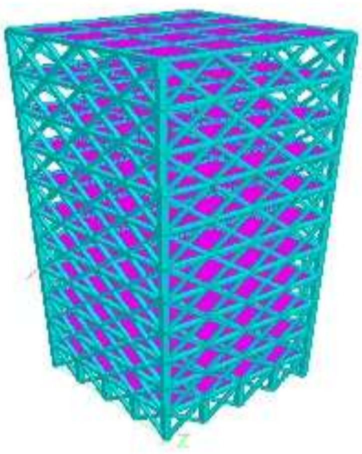

Fig1: 3-D Model For Diagrid building

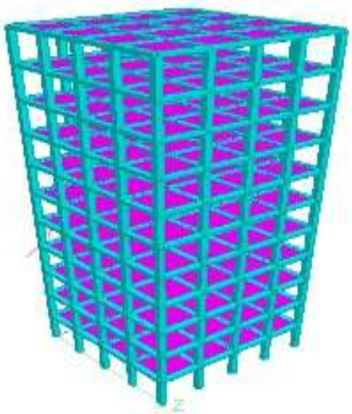

Fig 2: 3-D Model For Conventional Building

Material Properties: Steel Properties:

For Diagrid & Conventional

Grade Of Steel:Fe41500

Modulus Of Elasticity:200GPA

Concrete Properties

For Diagrid Buliding

Grade Of Concrete: M35

Density Of R.C.C: 24 KN/m^3

Poisson's Ratio:0.3

For Conventional Buliding

Grade Of Concrete: M35

Density Of R.C.C: 24 KN/m^3

Poisson's Ratio:0.17

Loading data:

Dead Load 4.5KN/m^2-for Conventional & Diagrid (for all stories)

Live Load 2 KN/m^2- for Conventional & Diagrid (for all stories

Sesimic Load:

- Seismic zone: Zone III
- Zone factor: 0.16.
- Response reduction factor: 3, Special Moment Resisting Frame (SMRF).
- Soil type: Type 1 (medium soil).
- Importance factor: 1

3. Results & Comparison: The results obtained are shown below in form of graphical representation

Table 1- Comparison of maximum shear forces (Fy) and bending moments (Mz) in ground floor beams between conventional building and diagrid building

Beam No	Conventional Building		Diagrid **B**uilding		Ratio	
	Fy(1)	Mz(2)	Fy(3)	Mz(4)	3÷1	4÷2
1	44.777	28.96	81.511	130.275	1.8203	4.4984
2	45.958	14.503	36.504	25.79	0.7942	1.7782
3	44.777	28.96	80.809	129.402	1.8046	4.4683
4	197.969	448.975	144.239	315.431	0.7285	0.7025
5	282.411	687.136	213.804	523.499	0.757	0.7618
6	197.969	448.975	144.212	315.327	0.7284	0.7023
7	29.383	196.259	23.031	150.432	0.7838	0.7664
8	45.958	14.503	36.506	25.774	0.7943	1.7771
9	29.383	196.259	56.247	84.013	1.9142	0.428
10	3.713	348.275	76.279	132.145	20.5437	0.3794
11	282.411	687.136	213.795	523.451	0.757	0.7617
12	3.713	348.275	3.001	278.689	0.8082	0.8001

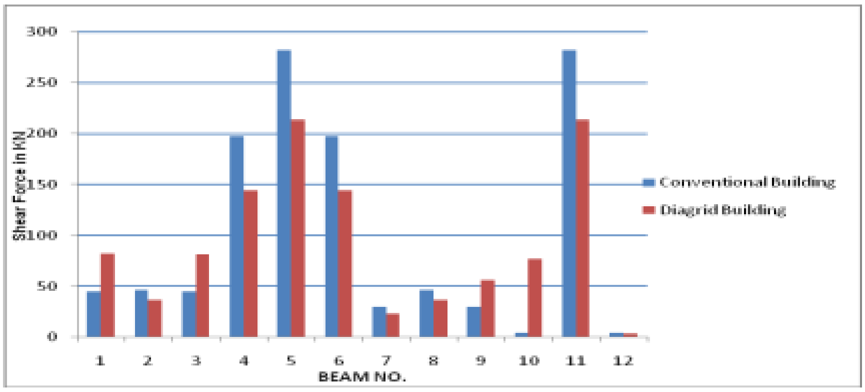

Fig 1:Shear Force(Fy) in Ground Floor between Conventional & diagrid buildings.

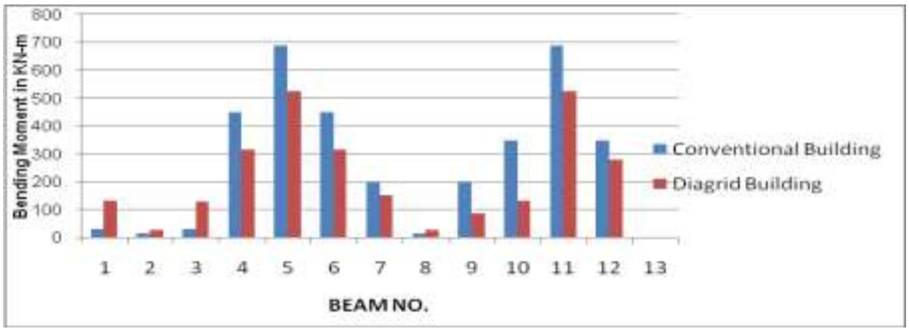

Fig 2:Bending Moment(Mz) in Ground Floor between Conventional & diagrid buildings.

Table2- Comparison of maximum axial forces (Fy) and bending moments (Mz) in columns between conventional building and diagrid building

Beam no.	Conventional Building		Diagrid Building		Ratio	
	Fy(1)	Mz(2)	Fy(3)	Mz(4)	3÷1	4÷2
1	13.152	35.205	6.518	5.319	0.495	0.151
2	13.152	17.404	6.518	20.753	0.495	1.1924
3	13.152	35.205	6.518	5.319	0.495	0.151
4	13.152	17.404	6.518	20.753	0.495	1.1924
5	44.855	91.911	29.089	58.837	0.648	0.6401
6	44.855	87.508	29.089	58.837	0.648	0.6723
7	44.855	91.911	29.089	57.519	0.648	0.6258
8	44.855	87.508	29.089	58.837	0.648	0.6723
9	69.284	159.482	46.614	11.392	0.672	0.0714
10	69.284	117.653	46.614	67.064	0.672	0.57001
11	69.284	159.482	46.614	119.392	0.672	0.7486
12	69.284	159.482	46.614	67.064	0.672	0.4205

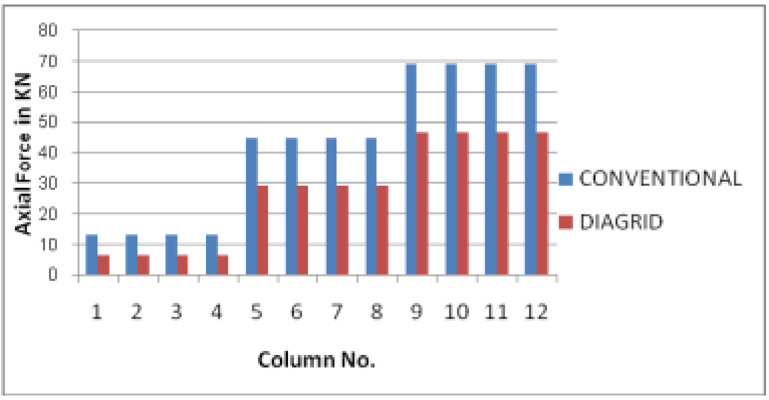

Fig 3: Comparison of Axial force(Fx) in column

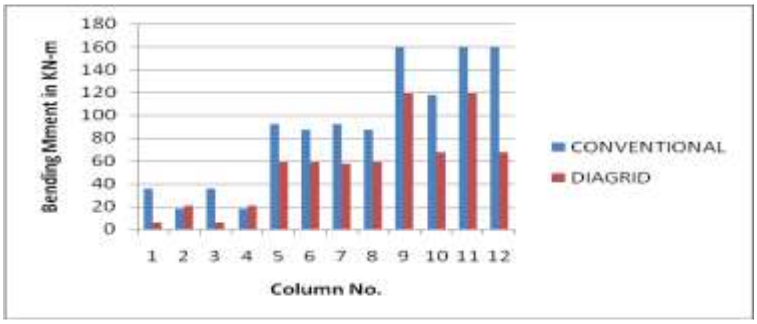

Fig 4: comparison of bending moment(My) in column

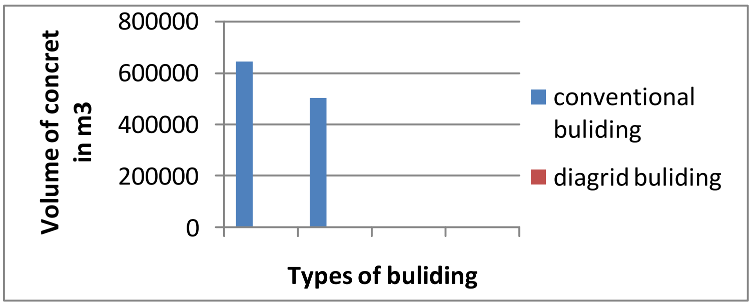

Fig 5: comparison of volume of concrete in conventional & diagrid buildings

Design of Raft Footing for Diagrid Building:

Reactions

NODE NO.	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	-322.127	-6225.376	-323.772	7.899	-0.000	-9.014
5	322.127	-6225.376	-323.772	7.899	0.000	9.014
41	-322.127	-6225.376	323.772	-7.899	0.000	-9.014
45	322.127	-6225.376	323.772	-7.899	-0.000	9.014
301	496.020	-3617.005	129.316	165.987	-14.889	16.636
302	-0.000	-3203.424	168.640	214.933	-0.000	0.000
303	-496.020	-3617.005	129.316	165.987	14.889	-16.636
304	129.424	-3617.229	-496.173	16.540	-14.806	-166.108
305	168.675	-3205.432	-0.000	-0.000	0.000	-214.973
306	129.424	-3617.229	496.173	-16.540	14.806	-166.108
307	-496.020	-3617.005	-129.316	-165.987	-14.889	-16.636
308	-0.000	-3203.424	-168.640	-214.933	0.000	0.000
309	496.020	-3617.005	-129.316	-165.987	14.889	16.636
310	-129.424	-3617.229	496.173	-16.540	-14.806	166.108
311	-168.675	-3205.432	-0.000	-0.000	-0.000	214.973
312	-129.424	-3617.229	-496.173	16.540	14.806	166.108

Design of Raft Foundation for Conventional Building:

Reactions

NODE NO.	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	-13.152	-2521.801	-13.152	-17.404	0.000	17.404
2	-18.781	-4317.401	-85.205	-111.513	0.012	24.703
3	-0.000	-5337.381	-130.560	-170.827	0.000	-0.000
4	18.781	-4317.401	-85.205	-111.513	-0.012	-24.703
5	13.152	-2521.801	-13.152	-17.404	0.000	-17.404
61	-85.205	-4317.401	-18.781	-24.703	-0.012	111.513
65	85.205	-4317.401	-18.781	-24.703	0.012	-111.513
121	-130.560	-5337.382	-0.000	-0.000	0.000	170.827
125	130.560	-5337.381	-0.000	-0.000	0.000	-170.827
181	-85.205	-4317.402	18.781	24.703	0.012	111.513
185	85.205	-4317.401	18.781	24.703	-0.012	-111.513
241	-13.152	-2521.801	13.152	17.404	0.000	17.404
242	-18.781	-4317.401	85.205	111.513	-0.012	24.703
243	-0.000	-5337.381	130.560	170.827	0.000	-0.000
244	18.781	-4317.401	85.205	111.513	0.012	-24.703
245	13.152	-2521.802	13.152	17.404	0.000	-17.404

4. CONCLUSION: In this study, it is observed that due to diagonal columns in periphery of the structures, the diagrid structure is more effective in lateral load resistance. In the above study it is concluded that about diagrid structure.

 In this study, it is perceived that due to diagonal columns at the outer periphery of the structures, the diagrid structure is more effectively resist the lateral load While in conventional frame building, both gravity and the lateral load is restricted by exterior columns.

In our project,

Total volume of concrete used for conventional building =546.4cu.meter

Total volume of concrete used for diagrid building =321.2cu.meter

Diagrid shows more economical in terms of concrete used. Diagrid building saves about 22.5%concrete without affecting the structural efficiency.

from above results and comparison one can adopt diagrid structure for better lateral load resistance.

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