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# Comparative Seismic Analysis of Diagrid Structure of Varying Diagonal Angles with X Braced Frame Structure and Conventional RC Structure Using Etabs Software

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**ABSTRACT:**Diagrid structural system have emerged as one of the most innovative and adaptable approaches to structuring buildings in this millennium. Variations of the diagrid system have evolved to the point of making its use non-exclusive to the tall building. Diagrid construction is also to be found in a range of innovative mid-rise steel projects. The structural and architectural design of diagrid buildings falls cleanly between the typical education or experience of the architect and engineer. In this present study, G +23 the building with different frame of structures such as Diagrid frame with different diagonal angles, X braced frame at the periphery and Conventional RC frame is compared and analysed against the seismic lateral load in seismic zone v using ETABS software. The results are tabulated and graphs are plotted for base shear, storey drift and maximum lateral storey displacement, weight of structure. The seismic analysis is done according to IS 1893 :2016 part 1 by using dynamic analysis method.

**KEYWORDS:**Diagrid, X braced frame, Storey drift, storey displacement, Seismic effect, Base shear, Conventional.

## I.INTRODUCTION

As in the modern world we are seeing giant structures which will mesmerize anybody, high rise buildings are also one of them. Around the world we can see a rapid growth of multistory buildings construction in its full swing. In diagrid structure system diagonal member are used to connect the beam and diaphragm and lateral loads and gravity loads are transferred by these members. Diagrid system have become very popular in the complex structures such as curved shape. With the use of diagrid conventional vertical column are not in use and diagonal elements use is rapidly increasing. However different parameters involved in diagrid system needs to figure out to give the structure better optimization, such as optimal angle of diagonal member. A diagrid system in any high-rise building can be analyzed for many things such as for different angle of diagonal elements or a comparative study between Diagrid and conventional building or Braced tube building. Diagrid systems can be 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. In this paper application of four cases of diagrid structure with different diagrid angles, two cases of X braced structure with different location of application and one conventional RC structure are studied and analysed in terms of storey drift, lateral storey displacement, base shear and weight of structure

## II.OBJECTIVES

- To study the performance of RC Frame structure, X braced frame structure and Diagrid structure under the seismic loads (Earthquake loads).
- To perform Response Spectrum analysis of diagrid structure with conventional and X braced frame in ETABS 2019.

- To study the performance of Conventional RC frame, X type bracing frame with Diagrid structure with respect to different parameters such as story drift, story displacement, Storey shear.
- To study the optimum performance of Diagrid under different angles of diagonal.

### III. NODE CONSTRUCTION FOR DIAGRID STRUCTURE

Constructability is a serious issue in diagrid structures because the joints of diagrid structures are more complicated and tend to be more expensive than those of conventional orthogonal structures. In order to reduce jobsite work, prefabrication of nodal elements is essential. Due to the triangular configuration of the diagrid structural system, rigid connections are not necessary at the nodes, and pin connections using bolts can be made more conveniently at the jobsite. If considerately designed using appropriate prefabrication strategy, constructability will not be such a limiting factor of the diagrid structures. Prefabrication of diagrid nodes for conventional rectangular shape buildings can be done relatively easily and economically because many nodes of the same configuration are required in this case. The prefabricated nodes are connected to the large built-up diagonal members by bolts at the jobsite. As building form becomes more irregular, generating appropriate construction modules is critical for better constructability. Though it is possible to produce any complex shape construction module using today's CAD/CAM technology, it is not the most economical solution. Extracting regularity from an irregular building form, and then adjusting the building form following the extracted regularity could be one approach. Another approach could be to make the construction modules relatively regular and design universal connections so that they can accommodate any irregularity.



Figure no.6 : A Diagrid node after fabrication

### IV. PROBLEM STATEMENT

For Parametric results Seven G+23 structural models are taken into consideration for this analysis.

1. A Conventional RC frame building
2. X bracing structural model with Bracing fixed at peripheral
3. X bracing Structure model with bracing fixed at end corner
4. Two storey Diagrid module building
5. Four Storey Diagrid module building
6. Six storey Diagrid module building and
7. Eight storey Diagrid module building.

These models compared and analysed in terms of maximum lateral displacement, Storey drift, Storey shear by response spectrum method in seismic zone V using the same data plan. The plan selected is square in shape. It is not a plan of any existing or proposed building. Analysis and design are carried out using ETABS Software 2019. Concrete of M35 and Steel of Fe 345 is considered.

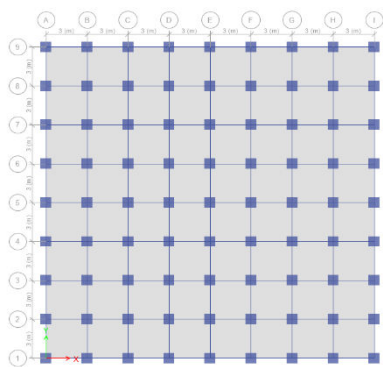
Geometric parameters of building are

Number of Storey G+23, Plan Size 24 m X 24 m, Storey Height 3m, Number of Bays along X axis 6, Number of Bays along Y axis 6, Length of each Bay 3m, Slab Thickness 0.150m, Column Size 0.8m X 0.8m, Beam Size for (Conventional & X braced system) 0.23 m X 0.5 m, Beam size for (Diagrid) is ISMB 500, Diagrid (Hollow steel pipe) 450 mm Dia. & 20 mm Thickness, Ring Beam W 10 x 100, Bracing ISA 200 x 200 x 20, All nodes are pin jointed and all supports are Fixed

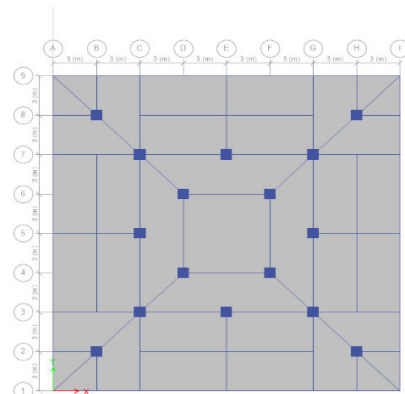


Table 2: Loading parameters

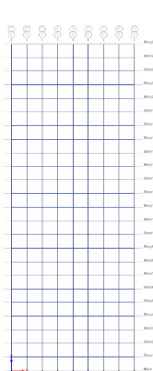
Sr No.	Specification	Data/Values	Reference
1	Floor live load	4 KN/m <sup>2</sup>	As per IS 875(Part 2):1987
2	Roof live load	2 KN/m <sup>2</sup>	
3	Floor Finish Load	1 KN/m <sup>2</sup>	As per IS 875 (Part 1):1987
4	Internal wall load	7.04 KN/m	As per IS 1893(Part 1):2016
4	Seismic Zone Factor	0.36 (Zone V)	
5	Soil Type Factor	II (Medium Soil)	
6	Response Reduction Factor	5 (S.M.R.F.)	
7	Importance Factor	1 (Ordinary Building)	
8	Dead Load	Calculated by ETABS itself	As per IS 875(Part1):2016



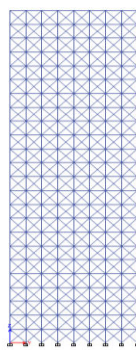
Typical plan of Conventional building and X bracing Structural building



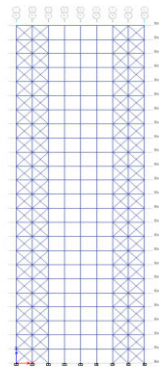
Typical plan of Diagrid Building



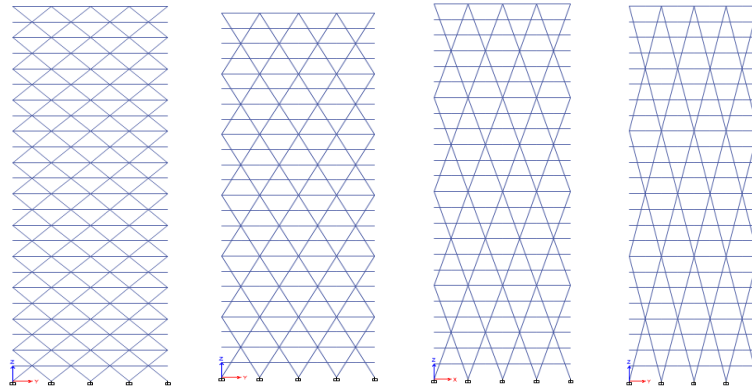
1)Conventional Building



2) X type bracing at Periphery



3)X type bracing at corner end



4) 2 storey module (45 degrees)    5) 4 storey module (63.43 degrees )    6) 6 storey module (71.56 degrees )    7) 8 storey module (76.54 degrees)

**V. RESULTS**

1. SEISMIC WEIGHT OF BUILDING IN TON

FRAME	Seismic Weight of Building (In ton)	% Weight saving (As per Conventional frame)
Conventional	17036.92	
X type bracing at periphery	17605.07	3.3 % increased
X type bracing at corner end	17451.521	2.4 % increased
Diagrid (2 storey module) (45 degrees)	8532.10	51% reduction
Diagrid 4 storey module (63.43 degrees)	7782.92	54% reduction
Diagrid 6 storey module (71.56 degrees)	7090.46	58 % reduction
Diagrid 8 storey module (76.54 degrees)	6625.74	61 % reduction

2. DISPLACEMENT RESULTS IN MM

FRAME	MAXIMUM TOP STOREY DISPLACEMENT (In mm)	% DECREASE IN DISPLACEMENT (As per Conventional frame)
Conventional	73.23	
X type bracing at periphery	24.44	66%
X type bracing at corner end	46.9	36%
Diagrid (2 storey module) (45 degrees)	30.28	58%
Diagrid 4 storey module (63.43 degrees)	27.12	64%
Diagrid 6 storey module (71.56 degrees)	21.29	71 %
Diagrid 8 storey module (76.54 degrees)	23.15	69 %

3. STOREY DRIFT



FRAME	MAXIMUM STOREY DRIFT(unitless)	% DECREASE in DRIFT (As per Conventional frame)
Conventional	0.00213	
X type bracing at periphery	0.000418	80%
X type bracing at corner end	0.000809	62 %
Diagrid (2 storey module) (45 degrees)	0.000534	74%
Diagrid 4 storey module (63.43 degrees)	0.000453	79%
Diagrid 6 storey module (71.56 degrees)	0.000396	81 %
Diagrid 8 storey module (76.54 degrees)	0.000430	80 %

4. BASE SHEAR

FRAME	Base Shear (in KN)	% Variation(As per Convnt.frame)
Conventional	9046.86	
X type bracing at periphery	9523.267	5.2 % increased
X type bracing at corner end	9215	1.9 % increased
Diagrid (2 storey module) (45 degrees)	6703.52	26% reduction
Diagrid 4 storey module (63.43 degrees)	6488.22	28% reduction
Diagrid 6 storey module (71.56 degrees)	6067.23	33 % reduction
Diagrid 8 storey module (76.54 degrees)	5850.89	35 % reduction

Here, Conv. B = Conventional Building, X at corner = X type bracing at the corner of building, X at periphery = X type bracing at periphery of building, D2M = Diagrid 2 storey module, D3M = Diagrid 3 Storey module, D4M= Diagrid 6 storey module, D8M = Diagrid 8 storey module

VI. CONCLUSIONS

Based on the above analytical study carried out on 7 Structural models, it is evident that buildings with Diagrids and X type bracing resist more effectively than Conventional frame building when subjected to lateral seismic loads. Positioning of X type bracing and angle of Diagrid gives different result are as:

- Diagrid Structure performs optimum against lateral force at an angle 71.56 degrees.
- With the increase in the angle of diagonal, Diagrid structure becomes lighter and Stiffer.
- In some cases, X type bracing at periphery outperforms Diagrid structures but providing bracing over the entire face in elevation is practically not desirable for economic and aesthetic reasons.
- X type bracing at the corner end has Shear stress less than the X type at periphery but still more Shear stress than the conventional building.
- Diagrid structure gives around 60 % reduction in weight of building as compared to conventional Building.



## VII. ACKNOWLEDGEMENT

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