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Parametric Study on Asymmetric Diagrid Structures

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Abstract

It is very essential to identify the behavior and Different design parameters of buildings, which initiate at locations of the structural weak planes present in the building systems, due to various asymmetries/Irregularities. The contribution of lateral load resisting system, number of stories, type and degree of asymmetry has to be properly identified and calculated in order to design better and avoid damages which may happen to the structures. The objective of this work is aimed to Study the different parametric behavior of asymmetric buildings by analysis and modeling of different storey buildings using three linear analysis (Response Spectrum Method) procedure using ETABS Software. For this study a Circular Diagrid structure which is Asymmetric in shape With and Without core Shear Walls is modeled and analyzed. All the models / buildings are analysed and compared for the outcomes such as maximum storey drifts, storey displacements, Storey Shear and the conclusions are presented at the end of the paper.

Key words - Dynamic analysis, Etabs, Storey shear, Lateral loads, Storey drift, Maximum storey displacement.

Introduction

The earthquakes are the most unpredictable and devastating among the natural disasters and in recent years, The quick increase of town in habitant's results in high pressure on available town area has a large influence in the expansion of that town. The cost of available property and the need to avoid a non-stop town extension, and the necessity to reserve significant agricultural production and natural territory have subsidized to raise the height of residential structures to greater heights. As the tallness of structure rises, the structural system which carries horizontal force becomes most significant than the structural system that carries the vertical forces. Various horizontal force resisting structural elements are: rigid frame, shear wall, wall-frame, braced tube system, outrigger system and tubular system. In recent times, the Diagrid – Diagonal Grid – structural system is broadly used for high raised steel buildings because of its structural effectiveness and aesthetic prospective by its different geometric arrangement of that building.

Diagrid is a certain arrangement of space truss. It comprises of outside grid consisting of a sequence of triangulated truss system. Diagrid is shaped by interconnecting the diagonal and lateral modules.

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The main objective of these study is to study the effects and behavioral patterns of Asymmetric multi-storied Diagrid Structures against different forces acting on it during the earthquakes. A two dimensional analysis can allow only for an approximate consideration of the stiffness, In a three dimensional analysis we will get total interaction and response of the entire structure all the out coming parameters with these Study Can be done on various buildings with different asymmetries .

This three dimensional analysis can be carried out by using "Etabs".

As per IS code 1893:2002, the irregularities are classified in two types:-

1. Plan Irregularities
   - Torsion Irregularity, Re-entrant Corners, Diaphragm Discontinuity, Out-of-Plane Offsets, Non Parallel Systems
2. Vertical Irregularities
   - Stiffness Irregularity – Soft Storey & Extreme Soft Storey, Mass Irregularity, Vertical Geometric Irregularity, In-plane Discontinuity.

Literature Review

Mir M Ali et al.,(2007)

This paper reviews the evolution of tall building's structural systems and the technological driving force behind tall building developments. For the primary structural systems, a new classification – interior structures and exterior structures – is presented. While most representative structural systems for tall buildings are discussed, the emphasis in this review paper is on current trends such as outrigger systems and diagrid structures. Auxiliary damping systems controlling building motion are also discussed.

Kyoung-sun Moon et al.,(2007)

He presented a simple methodology for determiningthe initial member dimentions.

This method was applied to a set of building heights range from 20 to 60 stories, and parameter for the optimal values of the grid geometry.

K. Moon (2009)

He presented a stiffness-based design methodology fordetermining the initial member sizes of steel diagrid tall buildings. The methodology was useful to obtain the optimal grid configuration within a definite height range of the diagrid structure and also for diagrid structures of various heights and grid geometries.

.***T. M. Boake(2012)***

In this paper attempt as made to demonstrate a dynamic and adaptable structural system that is more adaptable at structuring Contemporary architectural aspirations.

Rajesh Jayarambhai Prajapati et al (2013)

This paper discusses importance of the lateral stiffness of a building on its wind and seismic design. To reduce damage in the event of wind and an earthquake, it is desirable to have large lateral stiffness. They have introduced shear walls at different location on plan of building like aside centre shear wall, corner shear wall, and shear wall at near to centre of building plan. The effect of shear wall on deflection is studied and concluded that there is marginal reduction in deflection, by introducing side centre shear wall, shear wall at centre. But the deflection is reduced drastically by introducing shear wall at corner along both directions.

Varsha R Harne(2014)

In this paper, the main focus is to determine the solution for shear wall location in multi-storey building. A RCC building of six storey placed in NAGPUR subjected to earthquake loading in zone-II is considered. An earthquake load is calculated by seismic coefficient method using IS 1893 (PART–I):2002. These analyses were performed using STAADPro. A study has been carried out to determine the strength of RC shear wall of a multi-storeyed building by changing shear wall location. Three different cases of shear wall position for a 6astorey building have been analysed. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces.

Ravi K Revankar (2014)

His paper presents a diagrid system which is of 12 storey Diagrid building and the structure was analyzed using SAP2000 by conside ring Dead, Live and Seismic Loads (IS 1893-Part-1, 2002)and designed using IS-800.Afterwards the federal emergency managementagency(FEMA) 356 hinges were assigned and Non-linear Static(Pushover) analysis was used to find out the performance points to know the Immediate Occupancy, Life Safety, and Collapse Prevention of diagrid elements. At the same time Base Shear, Displacements were studied where Spectral Displacement Demand and Spectral Dis placement Capacity was compared to know the adequacy of design.

.***Prashant T G et al., (2015)***

This paper presents a diagrid system which is of 12 storey diagrid building which is an asymmetric plan which was analyzed usi ng SAP 2000 by considering Dead, Live and Seismic Loads as per IS 1893-Part-1, 2002 and designed using IS-800-2007.Afterwards the FEMA 356 hinges were assigned and Non-linear Static (Pushover) analysis was used to find out the performance points of the building. At the same time Base Shear and Displacements were studied and spectrl displacement demand and spectral displacement Capacity were compared to know the adequacy of design.

Objectives of the Study

1. To study the behavioral pattern of structures and their torsional behaviour during earthquakes having irregularities in plan.
2. To study the parameters of storey shear, storey displacements, Maximum storey drift of all models during earthquake.
3. To study the frequencies and periods in different modes.

Modeling and Analysis of Building

In this paper, for analysis and study purpose, Circular Diagrid structure With and Without core Shear Wall building models with plan irregularity which is Asymmetric in nature have been used with constant heights of 10 Stories. The buildings are modeled using finite element software ETABS and dynamic analysis (RSA) is performed

Building Description:-

Building Details		
Sl. No	**Description**	
1	Dimensions of Building (in meters)	12m exterior diameter without core concrete shear wall and with 5m interior core concrete shear wall core.
2	Height of Building (in meters)	360
3	Number of Stories	10 No’s
4	Storey Height (in meters)	3
5	Type of Structure	Diagrid Steel Structure.
6	Type of Analysis	Linear Analysis when the structure is subjected to earthquake load.

Parameter	Type / Value
Structure Type	Steel Structure
Type of Structure	Irregular/Asymetric
Size of the Building	12m
Number of Stories	10
Floor to Floor Height	3m
Density of reinforced concrete(in kN/m^3)	25
Density of Steel (in kN/m^3)	76.9729
Intensity of live load (in kN/m^3)	5
Grade of concrete	M25
Live Load	3 Kn/m^2
Seismic Zone	V (Z=0.36)
Importance Factor	1.0
Soil Condition	Type III
Response Reduction Factor	5 (SMRF)

Building Models:-

The models used are as follows:

Model 1:

Plan of Circular Diagrid without Core Shear Wall

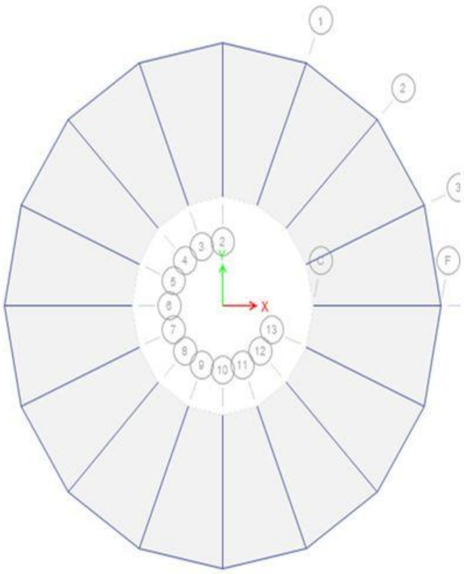

Fig 1: Plan of Circular Diagrid Without Core Shear Wall

Model 2:

Plan of Circular Diagrid with Core Shear Wall

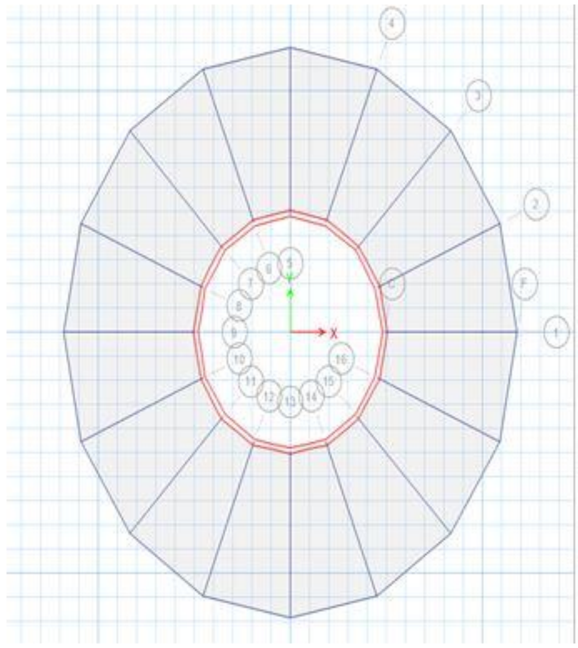

Fig 2: Plan of Circular Diagrid with Core Shear Wall

Analysis Methods:-

Seismic analysis methods are generally classified as two types viz., static analysis and dynamic analysis. In this paper the method of analysis adopted is dynamic analysis i.e., Response Spectrum Method.

The response spectrum method plays an important role in analysis and design of multistory Structures for seismic loads. The maximum response of the building is estimated directly from the elastic and inelastic design spectrums. The building codes are characterized for earthquake motions are based on simplification of the response spectrum method, so this method is extremely significant in the analysis and design procedures. The load combinations will be used for analysis of these models will be according to IS code 800-2000.

Methodology

LITERATURE STUDY

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DEFINIING OBJECTIVES OF THE STUDY

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MODEL GENERATION USING SOFTWARE (ETABS)

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APPLYING LOADS AND SEISMIC PARAMETERS AS ASSUMED FOR THIS STUDY

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ANALYSIS OF BUILDING MODELS TO OBTAIN THE RESULTS

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COMPARISION OF THE RESULTS AND WRITING THE WORK WITH CONCLUSIONS

Analysis And Results

In this study, the results are presented in tabular and graphs form. The results of maximum storey drifts, maximum storey displacements, Storey shears Max bending moment and Max shear force are presented for all the models, simultaneously the results of both the Structures and performance of these models / buildings were observed for seismic loads

Maximum Storey Drifts and Storey Displacements for Respective Stories

Table 1: Max. Storey Drifts

No. of Stories	Model 1	Model 2
10	0.000789	0.000187
9	0.000815	0.000245
8	0.000801	0.0002
7	0.000797	0.000243
6	0.000744	0.000201
5	0.000699	0.000221
4	0.0006	0.000181
3	0.000509	0.000169
2	0.000361	0.000135
1	0.000322	0.000076

Fig 3: Max. Storey Drift for model 1

Fig 3.1: Max. Storey Drift for model 2

These graphs Shows max. storey drift Respective to stories; it has been observed that, the storey drifts values are higher for Circular Diagrid Without Core Shear Wall (Model 1) as compared to the Circular Diagrid With Core Shear Wall (Model 2).

Table 4: Storey Displacements

No. of Stories	Model 1	Model 2
10	18.8	5
9	16.5	4.4
8	14.1	3.8
7	11.7	3.2
6	9.4	2.7
5	7.2	2.1
4	5.2	1.6
3	3.5	1
2	2	0.7
1	1.2	0.2

Fig 4: Max. Storey Displacement for model 1

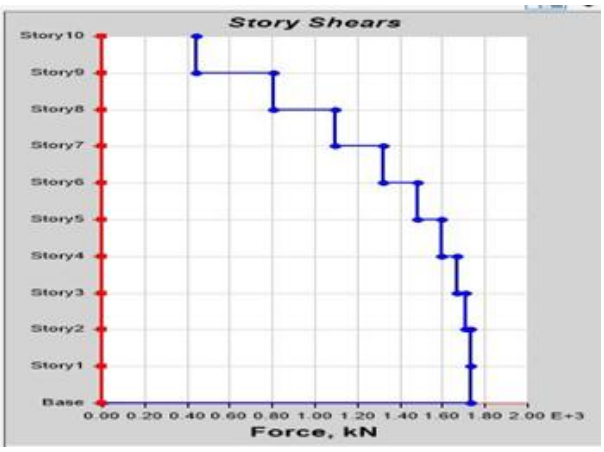

Fig 5: Storey Shear for model 1

Fig 4.2: Max. Storey Displacement for model 2

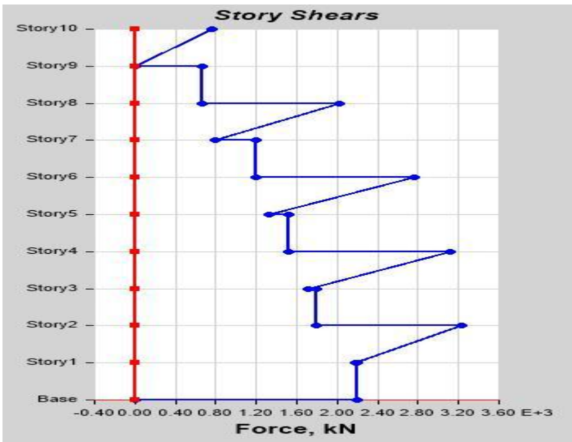

Fig 5.2: Storey Shear for model 2

These graphs Shows max. storey displacement for Respective stories; it has been observed that, the storey displacements values are values are higher for Circular Diagrid Without Core Shear Wall (Model 1) as compared to the Circular Diagrid With Core Shear Wall (Model 2)

Table 5: Storey Shear in Kns

Storey	Model 1	Model 2
10	440.1122	760.6943
9	808.2317	671.988
8	1099.0916	2025.9693
7	1321.7812	1201.5236
6	1485.4092	2766.2289
5	1599.0331	1526.8275
4	1671.7823	3121.9879
3	1712.6872	1792.7568
2	1730.8831	3233.7616
1	1735.4281	2195.9352

These graphs show storey shears at respective storey.

Conclusions

The results obtained for the Above Diagrid structures carried out through dynamic analysis (RSA) method will be near to realistic and the responses of the structure will be very close to actual. In this study, Circular Diagrid structure which is Asymmetric in shape With and Without core Shear Walls have been studied and following conclusions were obtained from the results:

- The Asymmetric structures have significant impact on the seismic/Earthquake response of the structure, especially in terms of displacement and base shear.
- The results show that there is an increase in parameters in model 1 compared to model 2.
- Base shear is maximum at the base of the structure hence it is evident that diagrid structure effectively counters the shear force due to lateral loads.

- Axial forces are found to be maximum at base of the building. From the study it is observed that most of the lateral load is resisted by diagrid columns on the periphery of structure.

- Maximum joint force found to be maximum at exterior bracing of first story and maximum joint displacement is found at top story joints.

- Using shear wall along with diagrid structure reduce the vertical displacement at top and horizontal displacement at middle of the diagrid structure.

- Vertical members are capable of only with standard gravity loads, whereas diagrid is useful for both gravity and lateral loads.

- Diagrid structures are more suitable for aerodynamic shaped buildings, Diagrid is the one which has many advantages such as aesthetic, structural performance, material saving potential.

- Special moment resisting frame is more suitable in severe seismic zones than ordinary moment resisting frame.

Since torsion is the most critical factor leading to major damage or complete collapse of buildings therefore, it is very essential that irregular buildings should be carefully analysed for torsion and the designer should try avoid excess irregularities especially in the multi storied buildings.

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