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DESIGN AND ANALYSIS OF DIAGRID STRUCTURE USING ETABS

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Abstract:

Construction of multi□storey building is rapidly increasing throughout the world. Advances in construction technology, materials, structural systems, analysis and design software facilitated the growth of these buildings. Diagrid buildings are emerging as structurally efficient as well as architecturally significant assemblies for tall buildings. Recently the diagrid structural system has been widely used for tall buildings due to the structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. Generally, for tall building diagrid structure steel is used. In present work, concrete diagrid structure is analyzed. Structural design of high-rise buildings is governed by lateral loads due to wind or earthquake. Tall commercial buildings are primarily a response to the intense pressure on the available land. Advances in materials, construction technology, analytical methods and structural systems for analysis and design accelerated the development of tall structures. Lateral load resistance of the structure is provided by interior structural system or exterior structural system. Analysis and design of multi storey diagrid RCC frame building is presented. ETABS software is used for modeling and analysis of RCC frame members. All members are designed as per IS 456:2000 considering all load combinations.

INTRODUCTION:

The rapid growths of urban population and consequent pressure on limited space have considerably influenced the residential development of city. The high cost of land, the desire to avoid a continuous urban sprawl, and the need to preserve important agricultural production have all contributed to drive residential buildings upward. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are: rigid frame, shear wall, wall-frame, braced tube system, outrigger system and tubular system. Recently, the diagrid – Diagonal Grid – structural system is widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system Tall commercial buildings are primarily a response to the intense pressure on the available land. Advances in materials, construction technology, analytical methods and structural systems for analysis and design accelerated the development of tall structures. The lateral loading due to wind and earthquake is the major factor that causes the design of high-rise buildings. These lateral loads are resisted by exterior structural system or interior structural system. The lateral load resisting systems that are widely used are mainly rigid frame, shear wall, wall-frame, braced tube system, outrigger system, diagrid system and tubular system. Recent trend shows that the Diagrid structural system is becoming popular in the design of tall buildings due to its inherent structural and architectural advantages. Diagrid is an exterior structural system in which all perimeter vertical columns are eliminated and consists of only inclined columns on the façade of the building. Shear and over-turning moment developed are resisted by axial action of these diagonals compared to bending of vertical columns in framed tube structure.

Fig 1:diagrid structures

• Diagonalized applications of structural steel members for providing efficient solutions both in terms of strength and stiffness are not new, however nowadays a renewed interest in it and a wide spread application of diagrid is registered with reference to large span and high rise buildings, particularly when they are characterized by complex geometries and curved shapes. The diagrid systems are the evolution of braced tube structures.

• The major difference between a braced tube building and a diagrid building is that, there are no vertical columns present in the perimeter of diagrid building.

• The diagonal members in diagrid structures act both as inclined columns and as bracing elements and due to their triangulated configuration, mainly internal axial forces arise in the members.

• Diagrid structures do not need high shear rigidity cores because shear can be carried by the diagrids located on the perimeter. Braced Tube Structure (John Hancock Center, Chicago) Diagrid Structure (Hearst Tower, New York)

•Diagrid has good appearance and it is easily recognized.

• The configuration and efficiency of a diagrid system reduce the number of structural element required on the façade of the buildings, therefore less obstruction to the outside view.

• The structural efficiency of diagrid system also helps in avoiding interior and corner columns, therefore allowing significant flexibility with the floor plan.

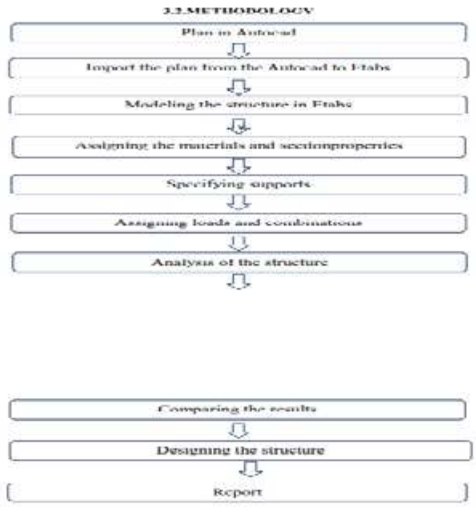
• Perimeter "diagrid" system saves approximately 20 percent structural steel weight when compared to a conventional moment-frame structure.

OBJECTIVES:

1. Evaluate the Design process using ETABS software: One objective is to compare the accuracy and efficiency of the analysis and design process using ETABS software and manual design. This will help determine the advantages and disadvantages of each method and how they can be combined to optimize the design process.
2. Determine the structural loads: The second objective is to determine the structural loads acting on the building, including gravity loads, wind loads, and seismic loads. These loads will be used to design the structural members of the building using both ETABS software and manual design.

3. Design an efficient diagrid structure: The third objective is to design an efficient diagrid structure that can withstand the structural loads acting on the building. The design should optimize the use of materials, minimize the structural weight, and maximize the building's stability and safety using both methods.
4. Ensure compliance with building codes and standards: The fourth objective is to ensure compliance with applicable building codes and standards. The design should meet all safety requirements and ensure the structural integrity of the building using both methods.
5. Generate detailed design reports and drawings: The final objective is to generate detailed design reports and drawings that can be used during the construction phase. These documents should provide all the necessary information required for the construction of the building, including the dimensions and specifications of the structural members using both methods. Overall, the objectives of the analysis and design of a diagrid multistoried building using both ETABS software and manual design are to evaluate the accuracy and efficiency of each method, ensure the building's safety and stability, optimize the design process, and comply with building codes and standards while minimizing the building's weight and maximizing its efficiency.

METHODOLOGY:



General The diagrid structure is designed, analyzed using ETABS software mainly focusing on seismic and wind analysis parameters. As per IS 456:2000 and the Linear Static Method all the structural members of the diagrid model are designed and IS 1893 (PART 1): 2002 is considered for load combination of seismic analysis. The structures is carried out on the basis of lateral force assumed to act along with the gravity loads. The base shear which is the total horizontal force on the structure is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode of shape. The base shear is distributed along the height of the structure in terms of lateral forces according to codal provisions (Kazuhiro, 1987). In this study, a multi storied RC building has been analyzed using the equivalent static method in E-Tabs. 3.4.Types of Loads Acting on theStructure In an advancement of building two essential issue considered are security and economy. If the piles are adjusted and taken higher then economy is affected. In case economy is considered and stacks are taken lesser then the security is bartered. So the estimation of various weights acting is to figured unequivocally. Indian Standard code IS: 875-1987 and American Standard Code ASCE 7: Minimum Design Loads for Buildings and Other Structures decides distinctive layout loads for structures.Elevation Figures represent the proposed elevation of building. It shows the elevation of a multi stored building representing the front view which gives the overview of a building block. Each floor consists of height 3 m which is taken as per municipal corporation rules for single column buildings. The building is not designed for increasing the number of floors in future. So the number of floors is fixed for future also for this building due to unavailability of the permissions of respective authorities. Inputting the job Information: Firstly the information of the project is written after opening the E-Tabs. As the name of the project/job, Client's name and the date when project started and the name of the Engineer as well and much more information is inputted. Generating the 3d model geometry: There are two methods of creating a structure data in E-TABS. a. Using the command file also called "The E- TABS editor method". b. Using the graphical user interface (GUI). We have done our whole of the programming with the help of GUI method because it is easier and much advance tool of E-TABS. The model of the framed structure is generated in ETABS by Snap

EXISTING MODEL AND PROPOSED MODEL:

Fig:-2

Location : Hyderabad
Clients : I-Labs HTC Pvt Ltd
Architect : Uday joshi ,
Mumbai Year of commencement : Jan -2008 Year of completion : Dec -2009 This prominent shell (55m x 23m x 21m) design is characterized by the use of a unique diagrid structure used effectively to provide visual lightness and barrier-free usable office spaces inside. The self supporting form with minimal vertical supports lends the building an innovative look and reduces low life cycle costs further. This five-storied pre-fabricated light weight structure took eight months for construction. The skin of the building is a network of circular hollow M.S. sections with nodes that are welded during assembly. Steel floor beams are spanned between the peripheral nodes and central ring beam and these floor beams support the composite floor slabs. The core that houses the services has columns of reinforced concrete with optimal and varying thickness of structural steel usage. The dia-grid shell is clad with hard-coated glass that ensures a high level of visual comfort with a good level of reflection-free sunlight. The central portion of roof top floor, which is the roof of the board room, is covered with water resistant composite construction that reflects partial direct sunlight. The I-

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Lab building has become an icon in its class – and it owes this status to the unique approach towards the structure and architectural expression

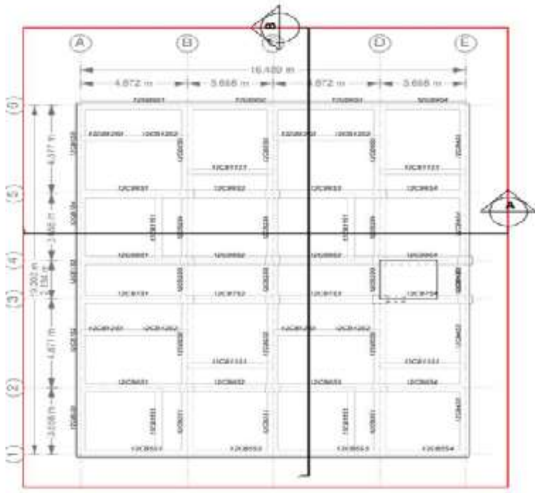

Fig:-3 Loads and Combinations:

S. No.	Particular	Details of Multi-column building structure
1	Type of construction	R.C.C framed structure
2	Dead Load	Self weight : -1 Outer wall load:-13.8 KN/m Inner wall load: -6.9 KN/m Pampet wall load: -5.52 KN/m Floor load : -4.75KN/mm^2
3	Live load	3 KN/m2 at typical floor, 1.5KN/m2 on terrace
4	Wind load	As per IS 875 – Not designed for wind load, since earthquake loads exceed the wind loads
5	Earthquake Load	Select Zone II (as per IS-1893 (Part 1) – 2002)
6	Number of stories	G+10(11 storeys)
7	Depth of foundation below ground	1.5m
8	Slab Thickness	150mm
9	Type of soil	Type II, Medium as per IS:1893
10	Storey height	Floor to Floor – 3m Floor to Ground Floor – 1.5m
11	Plan size	16 m X 16 m
12	No. of bays in X direction	4
13	No. of bays in Y direction	5
14	Grade of concrete	M-30
15	Grade of steel	Fe 415 Structural Steel
17	Column size	0.45m x 0.6m
19	Beam size	0.45m X 0.45m
20	Diagrid size	0.4m dia
21	Building importance factor	1
22	Response reduction factor for concentric and eccentric respectively	5
23	Height of building	31.5m

Fihg:-4

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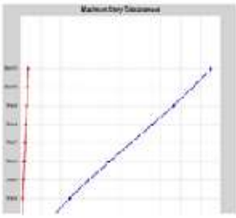
RESULTS:

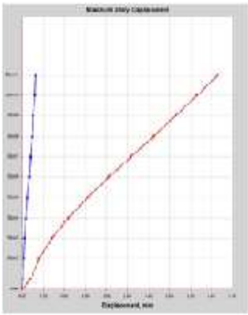
DISPLACEMENT IN -X DIRECTION FOR (G+10) STOREY



Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
Story11	[illegible]	Top	[illegible]	[illegible]
Story10	28.5	Top	3.421	0.385
Story9	25.5	Top	3.024	0.36
Story8	[illegible]	Top	2.606	[illegible]
Story7	[illegible]	Top	2.177	[illegible]
Story6	[illegible]	Top	1.75	[illegible]
Story5	[illegible]	Top	1.329	[illegible]
Story4	[illegible]	Top	0.956	[illegible]

Maximum Displacement of the building seismic Y direction:

DISPLACEMENT IN +Y DIRECTION FOR (G+10) STOREY.



Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
Story11	31.3	Top	0.118	1.842
Story10	28.5	Top	0.291	[illegible]
Story9	25.3	Top	0.23	1.644
Story8	22.3	Top	0.127	1.413
Story7	19.3	Top	0.192	[illegible]
Story6	16.5	Top	0.155	[illegible]
Story5	13.5	Top	0.121	1.41
Story4	10.5	Top	0.067	1.294
Story3	7.5	Top	0.057	0.702
Story2	4.5	Top	0.032	0.394
Story1	1.5	Top	0.018	[illegible]
Base	0	Top	0	0

CONCLUSION:

1. The design horizontal seismic force on the building structure is 2.385 KN/m2 . The diagonal forces on a diagonal member AB of the diagrid are 27 KN. ` 59
2. The column is safe as the design load on the column (19975.04 KN) is much lower than the ultimate axial load capacity of a single column (6.7 KN).
3.. The ultimate moment capacity of the beam is 0.739 KN-m, while the design moment on the beam is 1219.29 KN-m. The design shear force on the beam is 9984 KN.
4. Assuming a distribution steel of 0.15% and a main steel of 1.5%, the area of distribution steel is 0.0000762 m2 , and the area of main steel is... (the calculation is not completed in the given text, so it is not possible to conclude this point).
5. Both the manual and ETABS calculations have provided similar results for the beam design, with minor differences in values.
5. The manual calculations provide a more detailed and thorough approach to beam design, taking into account all the necessary factors such as load combinations, shear, moment, deflection, etc. However, the manual calculations are time-consuming and require a high level of expertise.
6. ETABS is a powerful software that can quickly and accurately perform structural analysis and design. It can handle complex geometries and load combinations, which can be challenging to perform manually.
7. While ETABS can provide quick and accurate results, it is essential to understand the software's assumptions and limitations. It is also crucial to verify the results using manual calculations to ensure accuracy.
8.. In conclusion, the manual calculations provide a more comprehensive understanding of the beam's behavior and design ETABS can be used as a tool to perform quick and accurate structural analysis and design, but the results should always be verified with manual calculations.

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