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# DESIGN AND ANALYSIS OF DIAGRID

Prof. Jasmin Tandel[1], Nootan Patel[2], Pooja patel[3], Payal Patoliya[4], Paras Vaghasiya[5]

[1] *Department Of Civil Engineering, BMCET, Surat*
[2,3,4,5] *Gujarat Technological University, Ahmedabad*

***Abstract— 'Diagrid' A supporting framework in building formed with diagonally intersection of ribs of different material like metals, concrete or wooden beams. Diagrid structure is efficient in providing stiffness and strength. In this project regular floor plan of 20 m × 20 m size is considered. ETABS software is used for modelling and analysis of structural members. All structural members are designed as per IS 800:2007 considering all load combinations. Load distribution in diagrid system is also studied. Similarly, analysis and design of 50, 60, 70 and 80 storey diagrid structures are carried out. Comparison of analysis results in terms of time period, top storey displacement and inter-storey drift is presented in this paper.***

***Keywords— Diagrid, Steel structure, Stiffness requirement, Time Period, Strength requirement***

## I. INTRODUCTION

### 1.1. General

Tall buildings have developed in response to the requirements arising from the continuing increase in world population. In recent times, the demand for these buildings is increased enormously, especially driven by environmental considerations. In the resource scarce era, expanding a building vertically to develop a denser city is more energy efficient because the energy consumed for transferring electricity can be minimized, while the land used for building will be reduced and thus saving more green areas. Therefore, through this project an attempt has been made to arrive at a structural pattern which is superior as compared to conventional structural systems.

In the tall structures, structural pattern can be manipulated to optimize the performance. By arranging the structural members in a particular pattern, efficient structure can be produced, whereas the economy can be increased by grouping structural member dimensions according to their arrangement. Moreover, by a high-performance pattern, member sizes can be minimized and thus opening areas can be maximized. In terms of expressiveness, the use of a certain pattern in a tall building can produce a unique architectural appearance. Therefore, the present trend has been for more buildings to employ non-routine structural patterns. With this project we want to present non-routine structural patterns as an alternative to replace the orthogonal pattern.

"DIAGRID (a portmanteau of diagonal grid) is a design for constructing tall buildings with steel that creates triangular structures with diagonal support beams." It is triangulated beam system which may be curved or straight, and horizontal beams that make structural system for high rise structure. The difference in exterior-braced conventional frame structural pattern and the diagrid structural pattern is that these buildings do not use conventional vertical columns.

### 1.2. Selection of plot and study area

Selection of plot is very important for buildings a house. Site should be in good place where their community but service is convenient but not so closed that becomes a source of inconvenience or noisy. The conventional transportation is important not only because of present need but for retention of property value in future closely related to are transportation, shopping, facilities also necessary. One should observe the road condition whether there is indication of future development or not in case of undeveloped area.

The factor to be considered while selecting the building site are as follows: -

- Access to park & playground.
- Agriculture polytonality of the land.
- Availability of public utility services, especially water, electricity & sewage disposal.
- Contour of land in relation the building cost. Cost of land.
- Distance from places of work.
- Ease of drainage.
- Location with respect to school, collage & public buildings.
- Nature of use of adjacent area.

- Transport facilities.
- Wind velocity and direction.

### 1.3 Survey of the site for proposed building

- Reconnaissance survey: The following has been observed during reconnaissance survey of the site.
- Site is located nearly.
- The site is very clear planned without ably dry grass and other throne plats over the entire area.
- No leveling is require since the land is must uniformly level.
- The ground is soft.
- Labor available near by the site.
- Houses are located near by the site.
- Detailed survey: The detailed survey has been done to determine the boundaries of the required areas of the site with the help of theodolite and compass.

### 1.4. Building bye laws & Regulations

- Line of building frontage and minimum plot sizes.
- Open spaces around residential building.
- Minimum standard dimensions of building elements.
- Provisions for lighting and ventilation.
- Provisions for safety from explosion.
- Provisions for means of access.
- Provisions for drainage and sanitation.
- Provisions for safety of works against hazards.
- Requirements for off-street parking spaces.
- Requirements for landscaping.
- Special requirements for low income housing.
- Size of structural elements.

## II. LITERATURE REVIEW

**Paresh V Patel, & Khushbu Jani. (2012)** illustrated that, advances in construction technology, materials, structural systems and analytical methods for analysis and design facilitated the growth of high rise buildings. Structural design of high rise buildings is governed by lateral loads due to wind or earthquake. Lateral load resistance of structure is provided by interior structural system or exterior structural system. Usually shear wall core, braced frame and their combination with frames are interior system, where lateral load is resisted by centrally located elements.

**Giovanni Maria Montuori, Elena Mele, Giuseppe Brandonisio and Antonello De Luca (2014)** studied that, The procedures and formulations suggested in literature for the design of diagrid structures start from the assumption that diagonal sizing process is governed by the stiffness requirements, as usually occurs for other, less efficient, structural types, and that member strength demand is automatically satisfied by the cross section resulting from the stiffness requirements.

**Nishith B. Panchal, Vinubhai R. Patel** studied the evolution of tall building structural systems based on new structural concepts with newly adopted high strength materials and construction methods have been towards “stiffness” and “lightness”. Structural systems are become “lighter” and “stiffer”. It is common knowledge that rather than directly standing the forces, it is better to reduce them and dissipate the magnitude of vibrations. Structure design of high rise buildings is governed by lateral loads due to wind or earthquake.

**Harish Varsani, Narendra Pokar, Dipesh Gandhi** studied analysis of diagrid structural system and conventional structural systems are presented. A 36m x 36m size regular floor plan is considered. Modelling and analysis of structure is done by ETABS software. All structural members are as design code IS 800:2007 considering all load combinations.

**Raghunath D. Deshpande, Sadanand M. Patil, Subramanya Ratan(2015)** studied advances in materials, construction technology, analytical methods and structural systems for analysis and design initiated development of tall Structures. Structural design for tall structures is governed by horizontal forces due to earthquake and wind load. Lateral load is resisted by exterior structural system or interior structural system.

## III. ANALYSIS

### 3.1 Building configuration

The five storey building is having 20 m × 20 m plan dimension. The storey height is 3.7 m. The typical plan and elevation are shown in Fig 2. In diagrid structures, pair of braces is located on the periphery of the building. The angle of inclination is kept uniform throughout the height. The inclined columns are provided at four meters spacing along the

perimeter. The interior frame of the diagrid structures is designed only for gravity load. The design dead load and live loads on floor slab are 3.75 kN/m2 and 4 kN/m2 respectively. Terrain category III as per IS 1893 (part 1) : 2002 (Gust factor method). The design earthquake load is computed based on the zone factor of 0.16, medium soil, importance factor of 1 and response reduction factor of 5. Modeling, analysis and design of diagrid structure are carried out using mass & stiffness natural frequency & natural time period method.

TABLE I

| | | |
|---|---|---|
| 1 | Plan dimension | 20 m × 20 m |
| 2 | Height of building | 20 m |
| 3 | Height of each storey | 3 m, 3.25 m, 3.5 m, 3.7 m |
| 4 | Size of column | 500 mm × 500 mm |
| 5 | Size of beam | 230 mm × 450 mm |
| 6 | Grade of concrete | M-20 |
| 7 | Grade of steel | Fe-415 |
| 8 | Density of concrete | 25 KN/m3 |
| 9 | Live load | 4 KN/m2 |
| 10 | Slab thickness: 120 mm | 150 mm |
| 11 | Internal wall thickness | 115 mm |
| 12 | External wall thickness | 230 mm |
| 13 | Number of bays along X-direction | 5 |
| 14 | Number of bays along Y-direction | 5 |
| 15 | Bay width in both direction | 4 m |

**Calculation:**

| Sr. No | Storey height (m) | Mass (kg) | Stiffness,1012 (N/m) |
|---|---|---|---|
| 1 | 3 | 3147145 | 1.667 |
| 2 | 3.25 | 3260940 | 1.31 |
| 3 | 3.5 | 3374669 | 1.05 |
| 4 | 3.7 | 3465765 | 0.85 |

| Sr. No | Natural frequency ωn (Hz) | Constant | Frequency ω (Hz) | Natural time period T (sec) |
|---|---|---|---|---|
| 1 | 727.57 | 0.05149 | 44.44 | 0.141 |
| 2 | 714.76 | 0.0551 | 41.63 | 0.15 |
| 3 | 702.62 | 0.05926 | 39.38 | 0.159 |
| 4 | 693.32 | 0.0641 | 37.46 | 0.169 |

## IV. CONCLUSION

We can conclude that diagrid proved best for time period to conventional structural system. We also conclude that diagrid structural system provides more flexibility in planning interior space and facade of the building. Diagrid provide more resistance in the building which makes system more effective. The optimum angle range of diagrid is 65° to 75° for most economic section. The parameter like base shear, storey drift, time period, storey shear, top storey displacement and steel weight is less as compared it with conventional structural system.

The conclusion drawn from this research work is, as the number of storeys increases natural time period increases although the height of the building remains same.

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