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Structural Behaviour of Transmission Tower with Different Bracings under Wind Loading

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Abstract: India has a sizable population that is dispersed throughout the nation, and this population's high need for energy production results in the need for a sizable transmission and distribution system. The present work for the design of transmission towers with foundations for two distinct zones, each with a different basic wind speed and kind of terrain. The requirement of the members has also been optimised. With the aid of Staad.pro and MS Excel's VBA, this present work has completed. Three distinct bracing systems were contrasted based on a number of factors, including deflection, weight, the quantity of joints, and cost. STAAD.pro has used to analyse the tower under various loading conditions, and Excel-VBA interface has used to construct the connections and base. The technological analysis and economic design of transmission line tower constructions have been the main aims of the present work. Under the specified loading conditions scenarios for both zones, the K bracing tower showed the least deflection in terms of the deflection criterion.
Keywords: Transmission tower, Wind load, Optimal, Staad.pro, MS Excel's, VBA.

I. INTRODUCTION

Before the availability of computers and specialized analysis and design programs, towers were often designed by graphical methods. It was considered prudent to test new designs that would be used repeatedly on a transmission line, thereby confirming the design assumptions with a full-scale test. Due to the unparalleled level of design refinement now possible thanks to analysis technologies, many utilities believe testing is unnecessary. Despite significant advancements, there are still discrepancies between analysis results and full-scale tests for latticed steel transmission towers. Modern user interface, visualisation tools, and powerful analysis and design engines with sophisticated finite element and dynamic analysis capabilities are all included in STAAD.Pro. STAAD-Pro is the professional's choice for designing low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles, and much more out of steel, concrete, timber, aluminium, and cold-formed steel. This includes model generation, analysis, and design, as well as visualisation and result verification. The following essential STAAD-Pro tools make previously difficult activities easier: The STAAD-Pro Graphical User Interface incorporates Research Engineers' innovative tabbed page layout. By selecting tabs, starting from the top of the screen and heading down, you input all the necessary data for creating, analyzing and designing a model. Utilizing tabs minimizes the learning curve and helps insure you never miss a step.

The STAAD-Pro Structure Wizard contains a library of trusses and frames. Use the Structure Wizard to quickly generate models by specifying height, width, breadth and number of bays in each direction. Create any customizable parametric structures for repeated use. Ideal for skyscrapers, bridges and roof structures.

II. LITERATURE REVIEW

Gajjar et al. (2011) Investigated, the design of multi-storeyed steel building is to have great parallel load opposing framework alongside gravity stack framework since it additionally administers the plan . They exhibited to demonstrate the impact of various sorts of supporting frameworks in multi storied steel structures. For this reason the 20 stories steel structures display is utilized with same setup and diverse bracings frameworks, for example, knee support, X prop and V prop is utilize. A business bundle STADD Pro is utilized for the investigation and plan and diverse parameters are analyzed.

Amini et al. (2012) studied the effect of bracing arrangement in the seismic behavior of buildings with various concentric bracing by nonlinear static and dynamic analysis. In this study a set of regular multi-story steel building were considered with three kind of x, v and chevron bracing, in two placements of 'two adjacent bays' and 'two non-adjacent bays' along the building height. Results show that in all cases, bracing arrangement in non-adjacent bays leads to lower stiffness but higher strength than in adjacent bays.

Zandi (2013) discussed on comparison between thin steel plate shear walls with dual system of steel moment frame and cross bracing or chevron with a design method based on performance levels. The study focused and discuss on the dual system comprising with thin steel plate shear wall and bracings. In addition, it is based on steel moment resisting frames and approach on performance based design has been arrogated in this research.

Parasiya et al. (2013) has showed a review on comparative analysis of brace frame with conventional lateral load resisting frame in rc structure using software. It has been represented that the parameters of bracings, locations & stiffness of bracings have notable effect on the performance of a building.

Siddiqi et al. (2014) has conducted the comparative study of five different types of bracing systems for the use in tall building in order to provide lateral stiffness and finally the optimized design in terms of lesser structural weight and lesser lateral displacement has been exposed. For this purpose a sixty storey regular shaped building is selected and analyzed for wind and gravity load combinations along both major and minor axes.

Rishi et al. (2014) This study's seismic analysis of tall RC building frames was done while taking various bracing techniques into account. A particularly effective and uncompromising lateral load resisting system is the bracing system. In RC structures, bracing systems are one of the components that increase stiffness and strength to protect buildings from damage brought on by natural factors like seismic force. The 10 storey building frame of the suggested problem G+ is examined for various bracing systems under seismic loading. To assess the efficacy of a specific type of bracing system to control the lateral displacement and member forces in the frame, the results of various bracing systems (X bracing, V bracing, K bracing, Inverted V bracing, and Inverted K bracing) are compared with bare frame model analysis. It is discovered that all bracing techniques efficiently control the lateral displacement of the frame. But it's discovered that inverted V bracing is the most cost-effective. The study's key findings are that using steel bracing to resist seismic stresses is helpful. When compared to a bare frame, the bracing system successfully minimises the lateral movement of the structure by up to 80%. The amount of forces in the members is greatly reduced by steel bracing. In comparison to bare frames, the bracing technique is helpful in reducing narrative drift in structures (up to 56%). When bracing members were used as resistive members, the margin of safety against collapse grew.

Chavan and Jadhav (2014) studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bare Page | 10 frame, by use of X-type bracing, indicating increase in stiffness.

Montuori (2014) Perform analysis on high rise steel diagrid building of 351 m high with H/B ratio of 6.62. The analytical model's steel framing members have a floor area of 53 m x 53 m in accordance with the euro steel table. Using SAP 2000 software, a model was created and then examined for three various brace angles, including 600, 700, and 800 with and without a secondary bracing system. A steel diagrid building needs a secondary bracing system, according to analysis. The 600 angle bracing method is determined to have the lowest local inter-storey drifts.

Gowardhan et al. (2015) review of software-based comparative seismic analysis of steel frames with and without bracing. The effectiveness of steel bracings in steel structures has been a key factor in this research. A comparison of structures with and without seismically resistant steel bracing has been considered. It has been discovered that seismic bracings increase stiffness against lateral loads, and using bracings as a retrofitting strategy may be a smart idea.

Bhosle et al. (2015) One of the structural solutions used to resist earthquake loads in multistory structures is the concrete- and steel-braced reinforced concrete frame. Many existing reinforced concrete structures require retrofitting to address flaws and resist seismic loads. An effective way to increase earthquake protection is to use bracing systems

III. ANALYSIS AND OPTIMUM DESIGN OF TOWERS

Analysis and optimum design of towers has been done for the following requirements and configuration:

1) Transmission tower for 220 kV-3 phase-single-circuit.
2) Suspension and Tangent tower (0° – 2°)
3) Height = 28.2 m, Base width = 4.72 m
4) Batter width = 1.5 m
5) Deviation angle= 79° (40°-90°)
6) Shielding Angle = 30°
7) Sag = 8 m

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8) Wind speed = 39m/s and 47m/s(IS-802 (Part 1)-1995)
9) Conductor Wire ACSR ZEBRA (Properties in Table No.3.1)
10) Earth wire (Properties in Table No. 3.2)

Table 1: Conductor wire electrical and mechanical properties

Voltage Level	220kV
Code Name of Conductor	ACSR “ZEBRA”
No. of conductor/ Phase	ONE
Stranding/ Wire diameter	54/3.18mm AL + 7/3.18mm steel
Total sectional area	484.5 mm2
Overall diameter	28.62 mm
Approx. Weight	1621 Kg/ Km
Calculated D.C resistance at 20 0C	0.06915 ohm/Km
Min.UTS	130.32 kN
Modulus of elasticity	7034 Kg/mm2
Co – efficient of linear expansion	19.30 x 10-6/ 0C
Max. Allowable temperature	750C

Table 2 : Earth Wire Electrical and Mechanical Properties

Voltage Level	220kV
Code Name of Conductor	ACSR “ZEBRA”
No. of conductor/ Phase	ONE
Stranding/ Wire diameter	54/3.18mm AL + 7/3.18mm steel
Total sectional area	484.5 mm2
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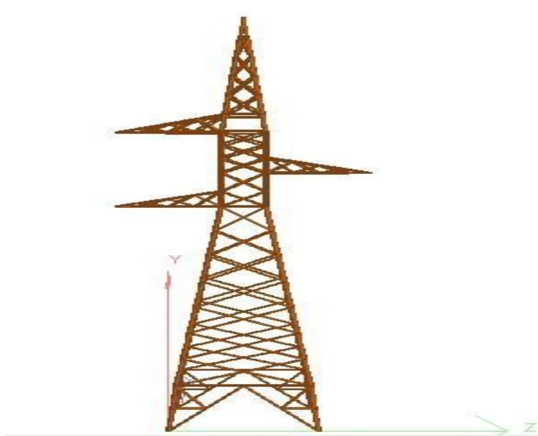

Figure 1: X-X Bracing

IV. CONCLUSION

Based on the above study following conclusions can be made

1) Optimization of tower geometry with respect to member forces. The K-bracing tower with base width 4.72 m is concluded as the optimum tower configuration with respect to geometry for both the zones.
2) As far as the deflection criterion is concerned, the K bracing tower has the least deflection under the same load cases for both the zones.
3) The tower structure with the least weight is directly associated with the reduction of the foundation cost.

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V. ACKNOWLEDGMENT

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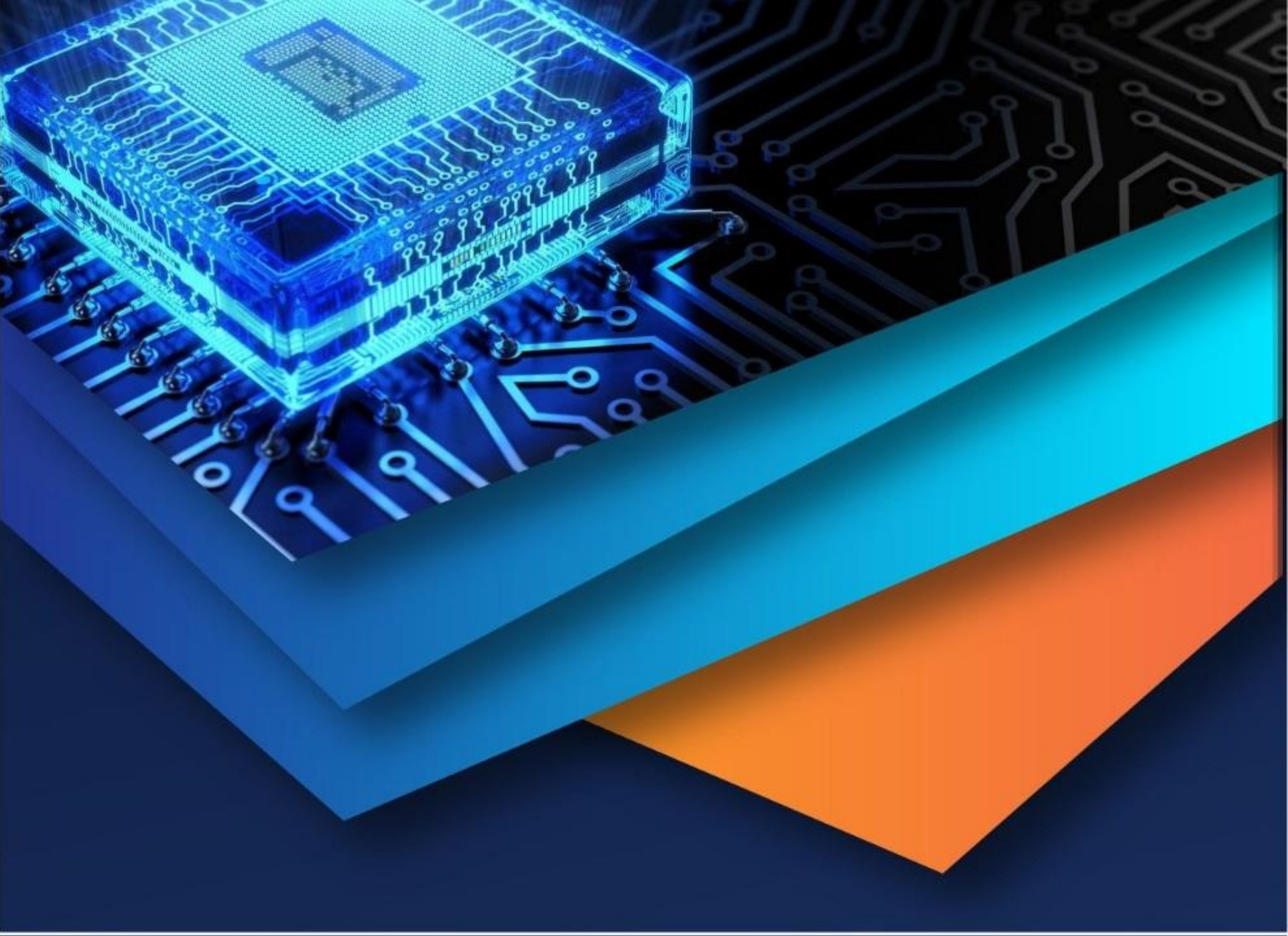

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