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Study of Telecommunication Tower over Residential building

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ABSTRACT

Basic human needs for living to sustain in various changing environments are one of the main problems in this era of construction world is the problem of vacant and stable land. This lack in urban areas has showed to the vertical construction magnification of low-rise, medium-rise, tall buildings and even sky-scraper. These buildings generally used framed structures exposed to lateral loads along with vertical loads. In these structures, the lateral loads from strong winds and earthquakes are the main concerns to keep in mind while designing rather than the vertical loads caused by the structure itself. These both factors may be inversely proportional to each other as the building which is planned to withstand perpendicular loads or resist the lateral loads.

For seismic loading in this thesis, response spectrum method is used to take part in the response of the earthquake effects. Some work had done previously but the work is still pending to improve the performance of the location of rooftop tower is yet to be implemented.

INTRODUCTION

One of the main problems in this era of construction world is the problem of vacant and stable land. This lack in urban areas has showed to the vertical construction magnification of low-rise, medium-rise, tall buildings and even sky-scraper (over 50 meters tall). These buildings generally used framed structures exposed to lateral loads along with vertical loads. In these structures, the lateral loads from strong winds and earthquakes are the main concerns to keep in mind while designing rather than the vertical loads caused by the structure itself. These both factors may be inversely proportional to each other as the building which is planned to withstand perpendicular loads or resist the lateral loads. The loads mentioned here are lateral are the principal one as they are different against one another as the vertical loads are supposed to increase linearly with height; on the other hand crosswise loads are fairly changeable and rise quickly with elevation.

When lateral loads of a uniform wind or an earthquake load arrives the overturning moment at base of the structure is humongous and varies proportionally to square of the building height. This causes the building to act as cantilever as these lateral loads are especially higher in the topmost storied comparatively different than the bottom storied. These lateral forces from the sideways have a tendency to influence the frame of the structure. The earthquake affected areas where the chances of earthquakes are comparatively higher the buildings collapsed which have not been designed in concern to these seismic loads. All these above stated reactions make it major to study the source and effects of lateral loads and lead us how to erect this.

For elevated buildings having 15 to 20 stories, pure rigid frame system is not adequate because it does not provide the required lateral stiffness and causes excessive deflection of the building. These requirements are satisfied by two ways. Firstly, by increasing the members size above the requirements of strength but this approach has its limitation and secondly, by adding one additional part of structure as tower over it in different parts considering with different cases. This increases the structure's stability and rigidity and also restricts the deformation requirement.

LITERATUREREVIEW

This chapter provides in detail about the previously work done on rooftop tower, its connections with individual member, its basic computations and its influence of host structure, applications of dead load, live load, effects of lateral forces such as wind load and seismic load and combinations of loads which describes the situation in worst case so that how structure will face the particular circumstances and the observation required in the analysis of rooftop tower

In [1] authors presented the seismic response of communication tower which was four – legged for earthquake Zone – IV under the effect of design spectrum according to Indian standard code of practice. Analysis performed on ground tower as well as tower situated on the roof of the building with increasing the stiffness of the building in the both directions (for X direction and for Y direction) by varying positions of tower. By well-known analysis solution, SAP 2000 program was used to simulate the dynamic behavior of the individual as well as whole model. The main parameter considered was axial forces of the tower members and comparison had made between ground and rooftop tower members for considering the height would be same above the ground level. In this, height of the tower was taken as 15 m, having straight portion at the top of the tower was 12 m and slant portion was 3 m. Single storey building was taken into account with 200 mm thick external infill walls and 150 mm internal walls. Their result shows that analytical results obtained from roof top tower cannot be based on results with respect to ground tower. Axial forces increased 2-3 times as compared with ground tower. But when stiffness was increased for X and Y directions, in rooftop towers, the axial forces (both tensile & compressive) were increased by slight amount of 5%. Highest axial values were attained at the leg of the members and torsional modes were unaffected by the location of the rooftop tower.

In **[2]** for finding the seismic factors of amplification, a total of 10 of the existing 4 –legged self-supporting tele-communication towers which are situated in Iran having 18 -67 m of height are selected. After then, a great seismic force was applied to these towers intensively in both horizontal as well as vertical directions. Hence when linear dynamic analysis was performed, the vertical responses along with base shear of the towers are then calculated. The author then divide the required base shears response by the multiplication of the maximum horizontal or vertical acceleration components with tower mass which will result in earthquake amplification factors of horizontal as well as vertical earthquake components. Therefore, by obtaining the value, we have to draw amplification factors with respect to the the fundamental flexural mode to obtain the first axial mode of the towers.

The authors broadly came to following conclusion:

- For first three flexural modes, percent mass participation factor which reaches around 90 %, therefore it is concluded that first three modes are sufficient for the dynamic analysis of the towers. For the participation in dynamic analysis, flexure mode gives only 60 %. The relation obtained in this was whenever first 3 modes are taken into analysis, the % modal mass participation of tower decrease when tower height increases.
- For a more specific and accurate results, the amount of mode shapes needed for concern in a dynamic analysis are at least the first 3 flexural modes. Taking only the first shaking mode will ultimately results in very less base shear standards than what is considered in reality.
- A very strong relationship occurs among the peak horizontal ground acceleration, maximum tower base shear and peak horizontal ground velocity. But, the relation between A/V ratio and tower base shear is week.

- They made a relation which is P = MA (28.96T -0.35);

So, according to the relation achieved for valuing the extreme tower vertical base reaction, as the natural time period of the first axial mode when increases, the tower seismic amplification factor then increases.

In **[**3], the study is performed on time history analyses which are used to explore the relationship among the maximum seismic base shear, the building accelerations and as well as overturning moment from base of the towers mounted on the multistoried building rooftops. In this paper, the authors made the models which include 2 medium-rise multistoried buildings as associated with two lattice steel towers which are subjected to forty five accelero-grams which were horizontal with diverse frequency in content. The results of tower base shear are analyzed and compared with the forecasts based on a formula which was simply projected in building codes for structures. Since data for the isolated type buildings and towers are realistic. The author wants to conclude the following heads:-

- Objective of the research was to provide the data and to study the lattice tower mounted on roof of a building situated at Montreal, Canada. The study shows the response of the structure and ultimate roof acceleration.
- Rooftop acceleration and tower base reaction, overturning moment, shear forces and linear relation between them were determined.
- There were 4 models and out of which 2020 University and GSM 40 model seems maximum tower moment with minimum rooftop acceleration.

In **[4],** an attempt has been made on towers to make the transmission line more cost operative by altering the geometry of it and behavior of it such as shape and type structure. Author in this paper chose a 220 kV single circuit transmission line geometrically which having square base and is self-supporting in nature. To conduct an enhancement to the existing geometry, towers are replaced by a triangular base tower. Then, the existing tower is then pushed to make it as a self-supported tower having square base guyed mast. Using STAAD pro software, modal analysis of each of these three towers has been carried out as a 3-D structure. For enhancing member section, the complete wind load calculations have to be repeated. Then, all 3 towers are analyzed and compared.

The author wants to conclude the following heads:-

- There were 3 models and it has been pointed out that all the three towers were of different base width but of same height.
- Wind load definitions and wind case details concluded the result that square tower have greater axial force as compared to guyed mast tower.
- A deflection criterion shows that maximum deflection was seen in square tower and least on guyed mast tower.
- By using the criteria of economic design and cost saving, square tower seems to be the economical one as compared to self-supporting tower and it saves about 39.66% structural steel.

In [**5**], to examine the overall seismic response of the 4-legged self-supporting telecommunication tower is the main objective of this paper. For that, total 10 4-legged self-supporting telecommunication towers in country Iran was studied from the Iranian seismic code of practice in the effects of the normalized spectra and the design spectrum and of Naghan, Tabas along with Manjil earthquakes. It was detected that for the dynamic analysis of such towers for the first three flexural modes are adequate, along with in the case of the more tall towers, bearing in mind the Ist 5 modes would improve the examination accuracy.

From this study, the results obtained are as follows:

- The mode shapes when obtained by investigating the tower, it can be fulfilled that the least of the 3 modes of flexural vibration for the dynamic examination of self-supporting telecommunication towers are sufficient. Even though, when considering the 5 least mode shapes, above all in the case of tallest towers, are going to improve the precision of analysis.
- Since it had been observed that in the towers leg members, the axial forces according to Iranian seismic code of practice, when undergo the propose spectrum, attained the maximum values. Even though, the normalized spectra in the case of low height towers, of Tabas&Manjil were major, except in the horizontal and diagonal members the axial forces shows insignificant variation when values are compared from Iranian seismic code of practice. This shows suggestion of a superior sensitivity of frequency content form leg part to the of earth pressure group.
- When scrutinized allocation along the tower height the shear force when subjected to the proposed spectrum as per Iran design code, the correctness of the relation which is presented

in the equation mentioned in EIA code linking to the allocation of lateral earthquake effects was verified.

In **[6],** this particular study, earthquake effects and performances of about 10 existing 4-legged a kind of telecommunication towers with each of heights ranging from 18 to 67 meter that had been inspected and these towers had planned to installed at Iran. In the beginning, nonlinear static analysis method has been applied to all towers & for that, 3 different upright allocation of lateral load had been operated. After then, the capacity spectrum approach along with target displacement approach and had been considered to compute the earthquake performance point of telecommunication towers. Finally, a total of 3 equations had been obtained to determine tower's base shear for all stated earthquake vulnerability point.

From this study, the results obtained are as follows:

- Concluded all cases for towers, it doesn't have any kind of positive stiffness whenever they passed elastic area.
- Concluded that for the procedure of nonlinear static analysis, lateral load allocation in the part to the first flexural mode was prevail among other sideways load allotment.
- Concluded that for a simple linear equation based on non-linear static investigation was obtained to calculate approximately 4-legged towers to capitulate base shear.

In **[7]**, studying thoroughly the performance of telecommunication tower for diverse arrangement and its examination for seismic effect. In this research, earthquake along with wind examination of telecommunication towers was carried out. These with different arrangements and different configurations such as square plan, with gravity loading check along with different bracing systems are designed. Using STAAD Pro software, the same models are then modeled. These towers are examined by most popular method known as non-linear dynamic method. The consequences obtained from this method are compared on the basis of a range of constraints.

From this study, the results obtained are as follows:

Wind and Response Spectrum Analysis of model had been used by most of the scholars and have done by using changed bracings along with different base plan like triangular and square in most of the plan. SAP analysis software is used by most of them only for the purpose of analysis &

modeling of telecommunication towers. For that, it is necessary it is necessary to find out the dynamic performance of telecommunication tower and to equate a broad number of parameters as well as results of the structure.

In [8], the earthquake effects are considered for diverse types of soils and after that we considered the location of tower at the top most roof top of structure where it had placed and it was detected that the movement at numerous height of the structure that is the displacement was maximum at the top most level of the height of tower and minimum at the building height. The numerous consequences attained from the above examination are then tabulated and then compared and after than conclusions were drawn which were detected the displacement was minutest when we were discussing about soft soil as well as displacement is minimum when we are talking about the position of the tower was at the center of building construction

Research Objectives

The literature review reveals that some work has been done for analysis of multi-storied buildings having transmission tower situated over it under seismic loading. The work to improve the behavior and performance of such buildings are yet to be investigated. For this purpose two cases are used in this study, former is multistoried building when tower is square in shape and multistoried building when tower is triangle in shape are provided. Furthermore, towers of these two cases have to be placed at different positions, in this dissertation; there are total 4 positions at which towers are to be placed in elevated buildings to analyze the response of collapse of the structure under earthquake forces.

From the literature survey, it has been pointed out that very less work had been done for the analysis of the location of the tower which is telecommunication tower. Since no author has done the comparison of the results of such cases. Therefore after summarizing the literature survey, these cases are taken and needed to be studied as per Indian Code of Practice.

RESULTS AND DISCUSSION

Maximum Axial Forces: When tower is placed at different positions of the multistory building for square section

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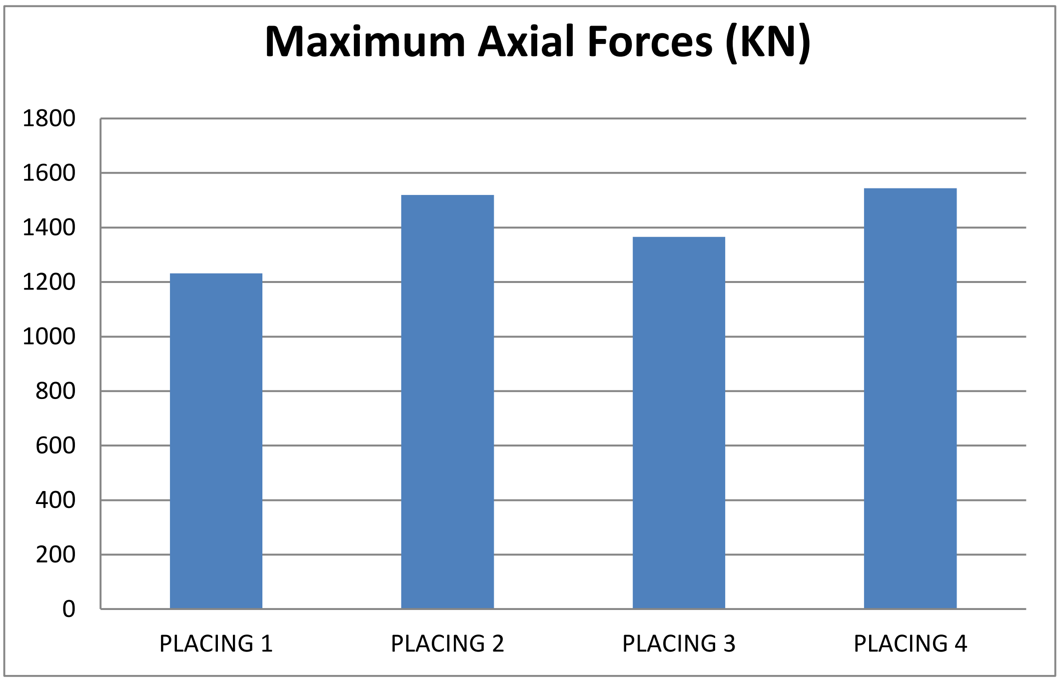
Table 1: Maximum Axial Forces for square section

PLACING ARRANGEMENTS	Maximum Axial Forces (KN)
PLACING 1	1231.293
PLACING 2	1519.950
PLACING 3	1366.201
PLACING 4	1543.603

Graph 1: Maximum Axial Forces for square section



Maximum Axial Forces: When tower is placed at different positions of the

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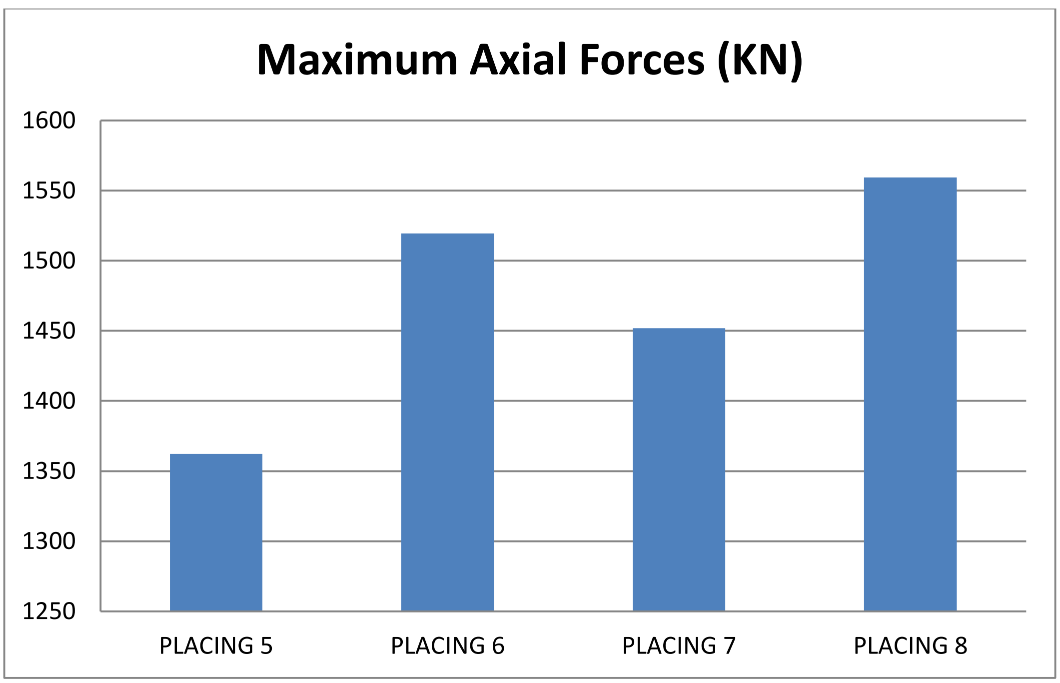
multistory building for triangular section

Table 2: Maximum Axial Forces for triangular section

PLACING ARRANGEMENTS	Maximum Axial Forces (KN)
PLACING 5	1362.315
PLACING 6	1519.397
PLACING 7	1452.025
PLACING 8	1559.473

Graph 2: Maximum Axial Forces for triangular section



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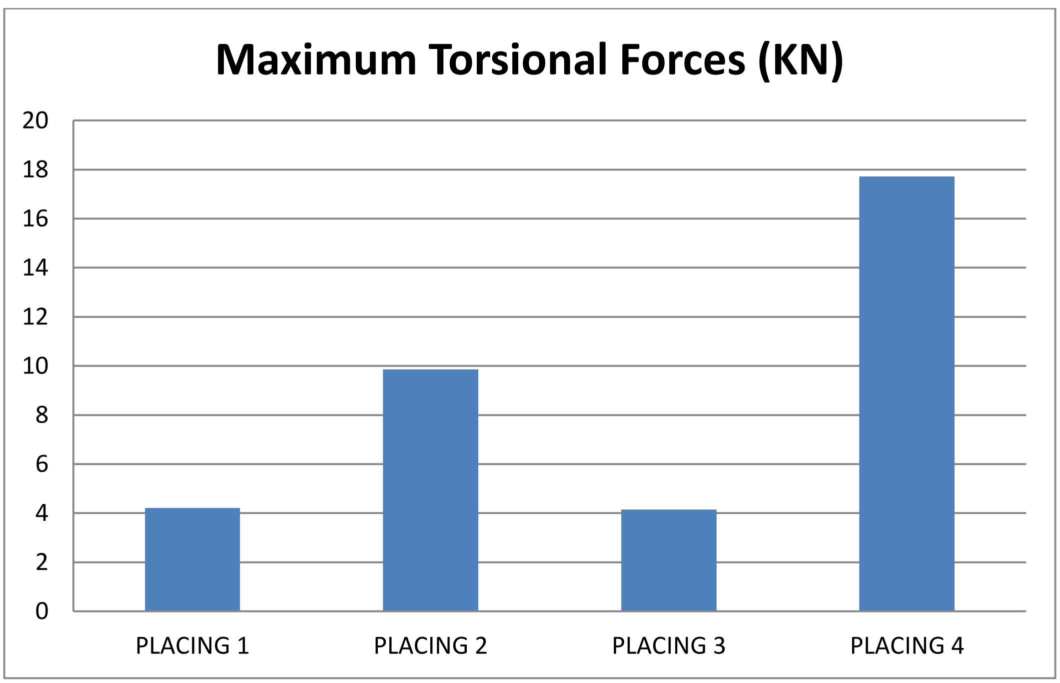
Maximum Torsional Forces: When tower is placed at different positions of the multistory building for square section

Table 3: Maximum Torsional Forces for square section

PLACING ARRANGEMENTS	Maximum Torsional Forces (KN)
PLACING 1	4.213
PLACING 2	9.865
PLACING 3	4.141
PLACING 4	17.729

Graph 3: Maximum Torsional Forces for square section

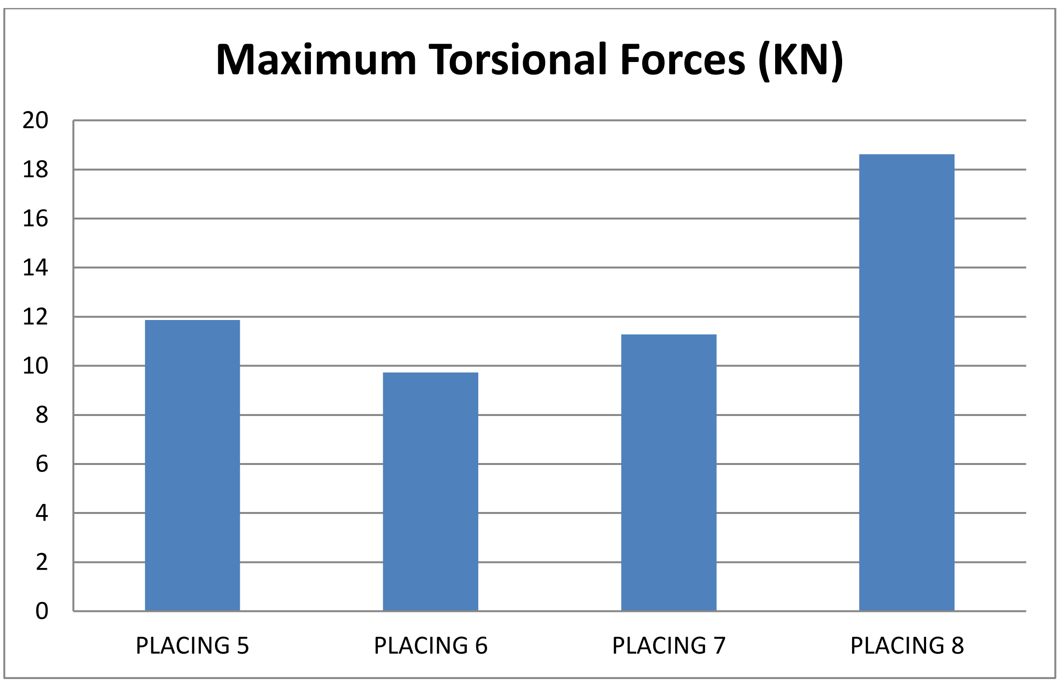


Maximum Torsional Forces: When tower is placed at different positions of the multistory building for triangular section

Table 4: Maximum Torsional Forces for triangular section

PLACING ARRANGEMENTS	Maximum Torsional Forces (KN)
PLACING 5	11.861
PLACING 6	9.731
PLACING 7	11.286
PLACING 8	18.622

Graph 4: Maximum Torsional Forces for triangular section



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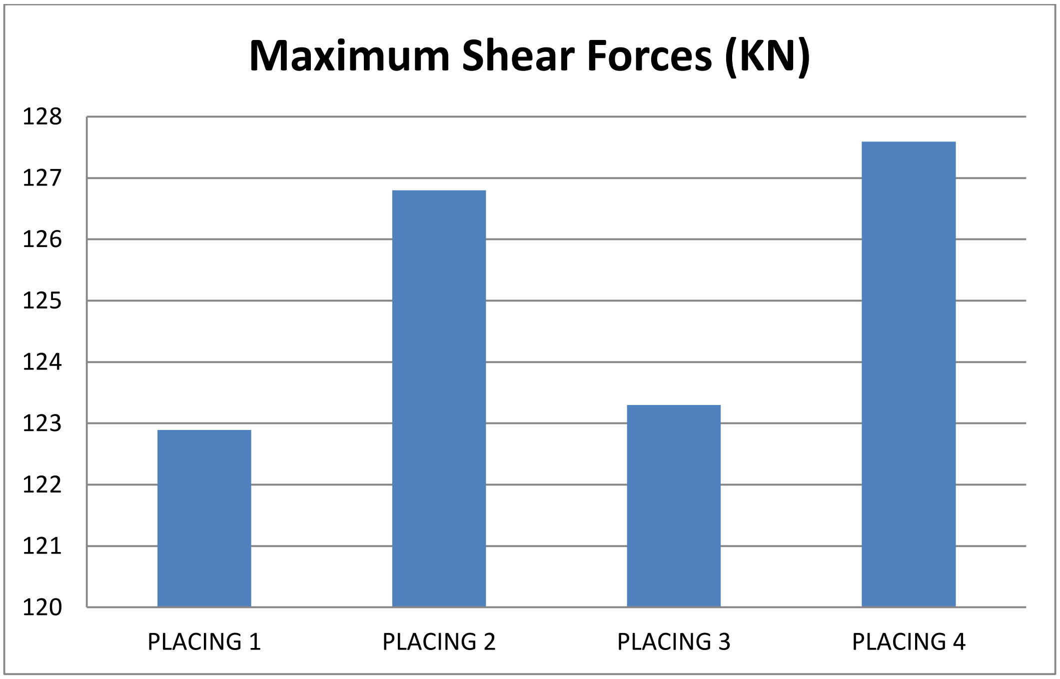
Maximum Shear Forces: When tower is placed at different positions of the multistory building for square section

Table 5: Maximum Shear Forces for square section

PLACING ARRANGEMENTS	Maximum Shear Forces (KN)
PLACING 1	122.893
PLACING 2	126.800
PLACING 3	123.301
PLACING 4	127.591

Graph 5: Maximum Shear Forces for square section



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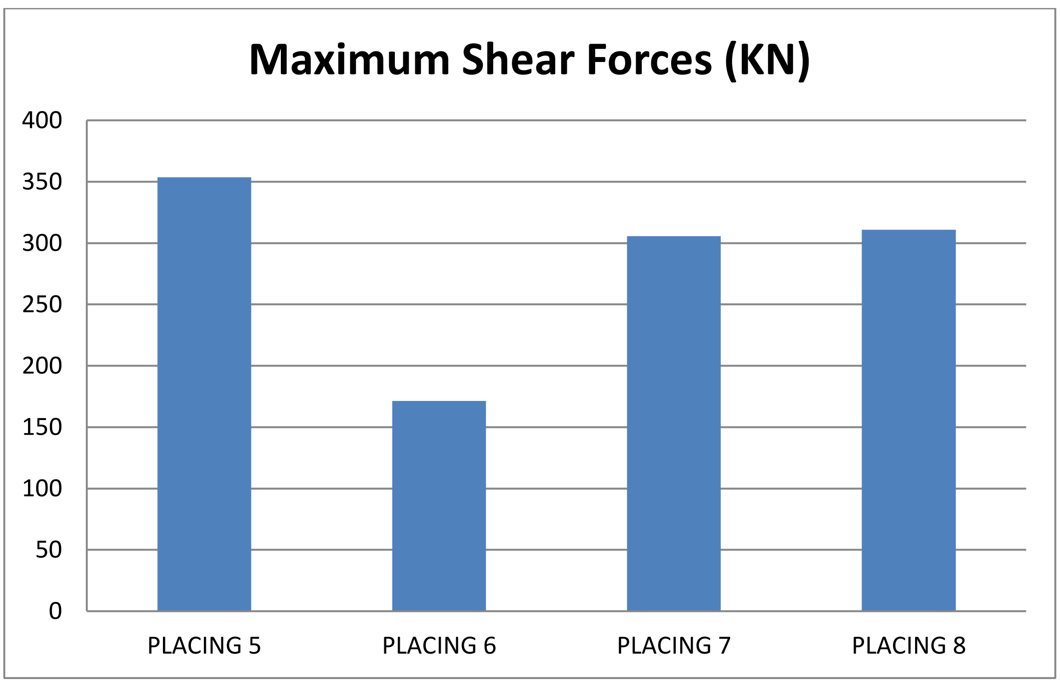
Maximum Shear Forces: When tower is placed at different positions of the multistory building for triangular section

Table 6: Maximum Shear Forces for triangular section

PLACING ARRANGEMENTS	Maximum Shear Forces (KN)
PLACING 5	353.669
PLACING 6	171.461
PLACING 7	305.815
PLACING 8	310.940

Graph 6: Maximum Shear Forces for triangular section

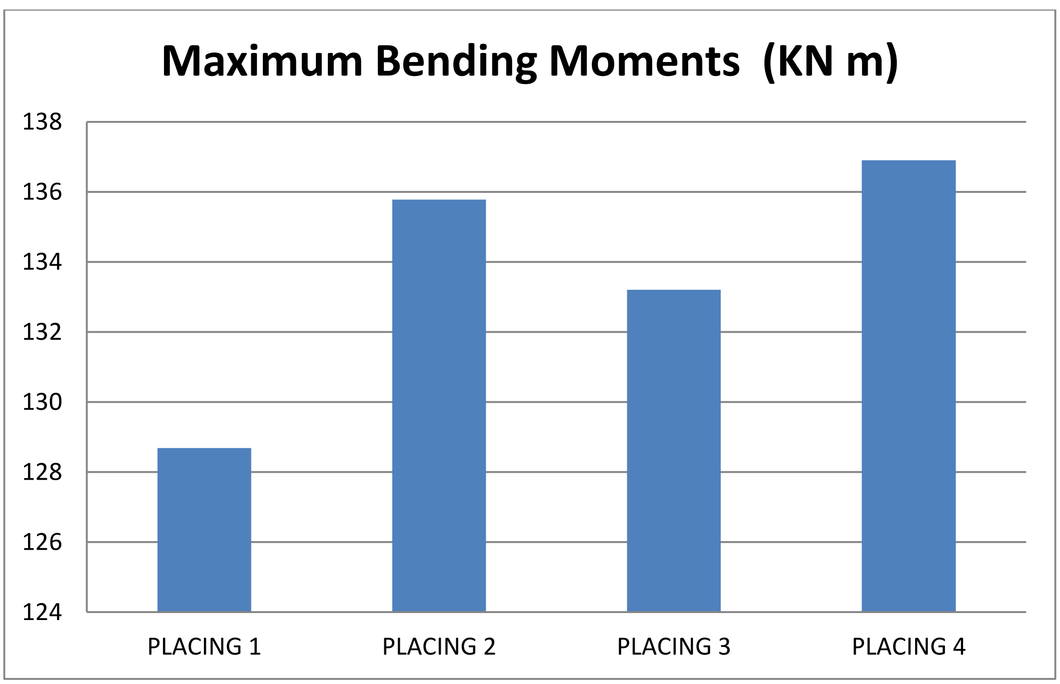


Maximum Bending Moments: When tower is placed at different positions of the multistory building for square section

Table 7: Maximum Bending Moments for square section

PLACING ARRANGEMENTS	Maximum Bending Moments (KN m)
PLACING 1	128.685
PLACING 2	135.782
PLACING 3	133.209
PLACING 4	136.906

Graph 7: Maximum Bending Moments for square section



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Maximum Bending Moments: When tower is placed at different positions of the multistory building for triangular section

Table 8: Maximum Bending Moments for triangular section

PLACING ARRANGEMENTS	Maximum Bending Moments (KN m)
PLACING 5	298.253
PLACING 6	146.593
PLACING 7	243.380
PLACING 8	246.779

Graph 8: Maximum Bending Moments for triangular section

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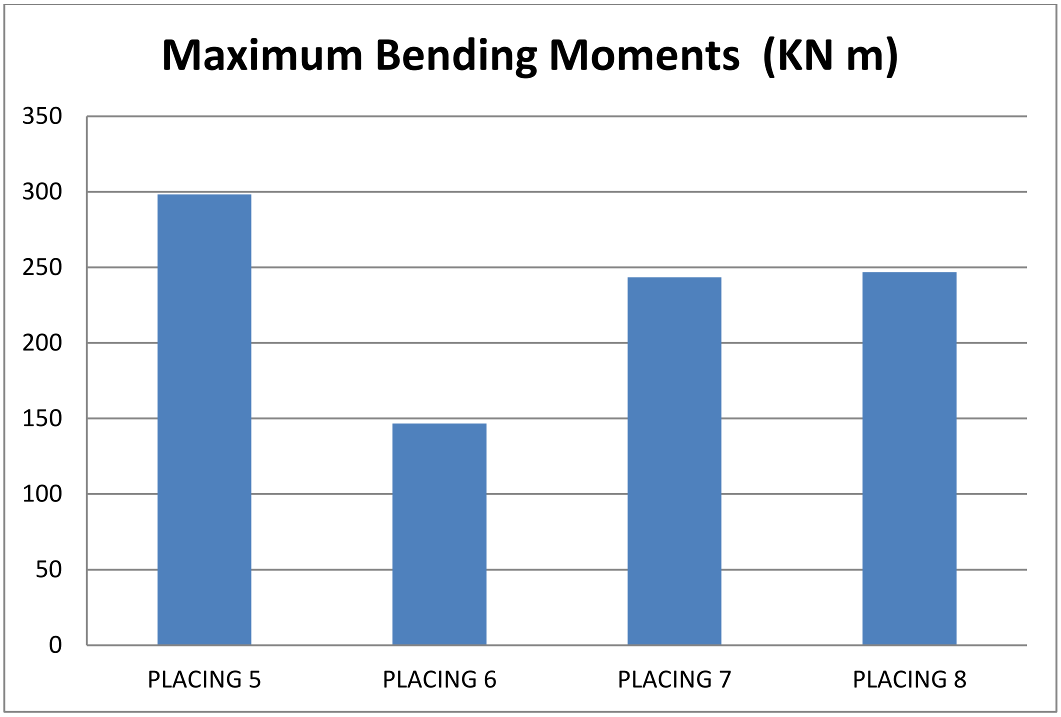


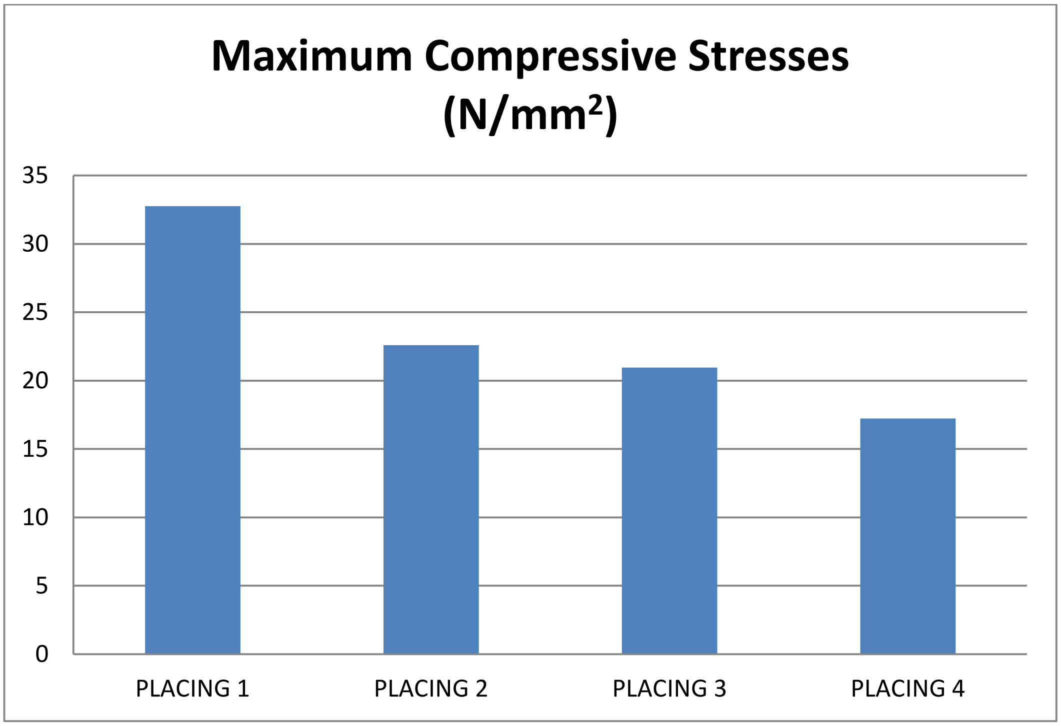
Maximum Compressive Stresses: When tower is placed at different positions of the multistory building for square section

Table 9: Maximum Compressive Stressesfor square section

PLACING ARRANGEMENTS	Maximum Compressive Stresses (N/mm^2)
PLACING 1	32.754
PLACING 2	22.588
PLACING 3	20.964

PLACING 4	17.235

Graph 9: Maximum Compressive Stresses for square section



Maximum Compressive Stresses: When tower is placed at different positions of the multistory building for triangular section

Table 10: Maximum Compressive Stresses for triangular section

PLACING ARRANGEMENTS	Maximum Compressive Stresses (N/mm^2)
PLACING 5	37.11

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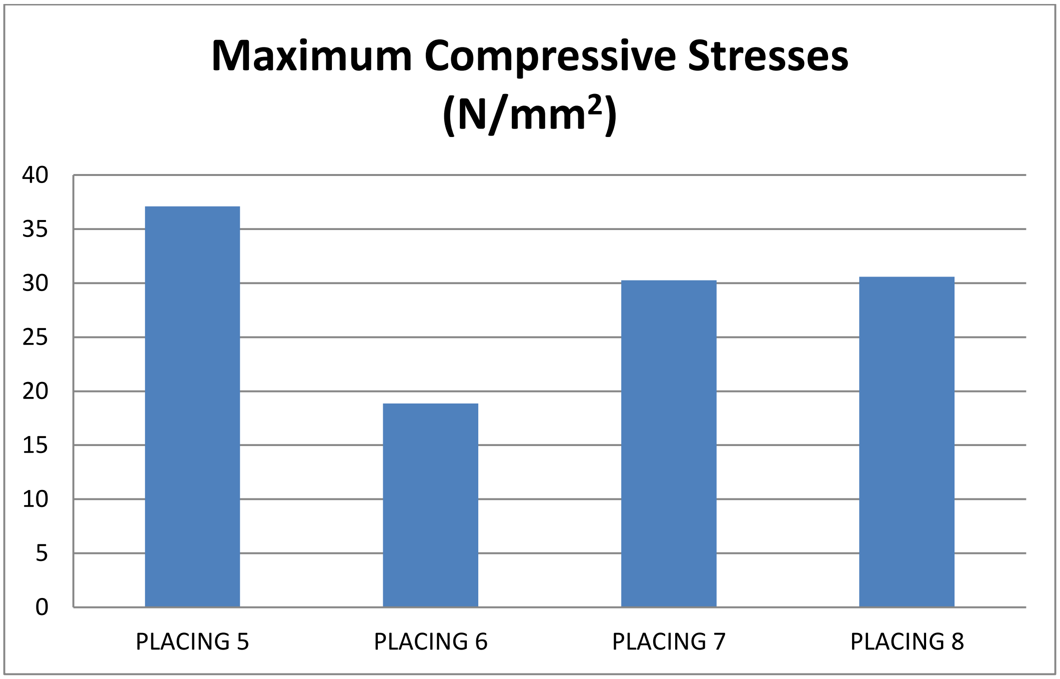
PLACING 6	18.86
PLACING 7	30.274
PLACING 8	30.593

Graph 10: Maximum Compressive Stresses for triangular section



Maximum Tensile Stresses: When tower is placed at different positions of the multistory building for square section

Table 11: Maximum Tensile Stressesfor square section

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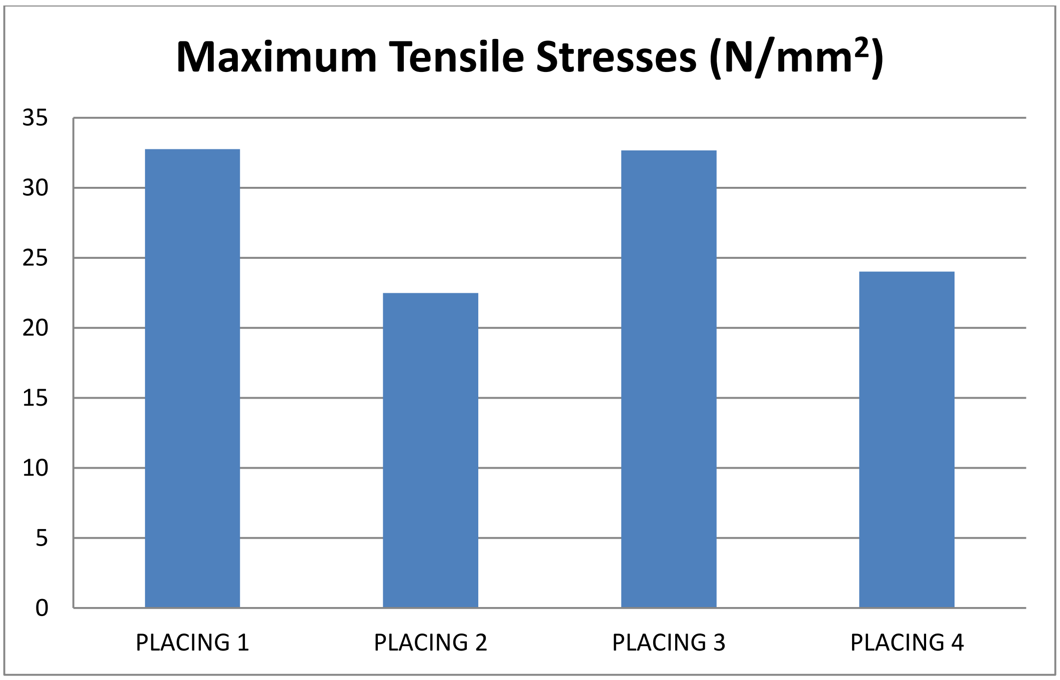
PLACING ARRANGEMENTS	Maximum Tensile Stresses (N/mm^2)
PLACING 1	32.754
PLACING 2	22.481
PLACING 3	32.672
PLACING 4	24.022

Graph 11: Maximum Tensile Stressesfor square section



Maximum Tensile Stresses: When tower is placed at different positions of the

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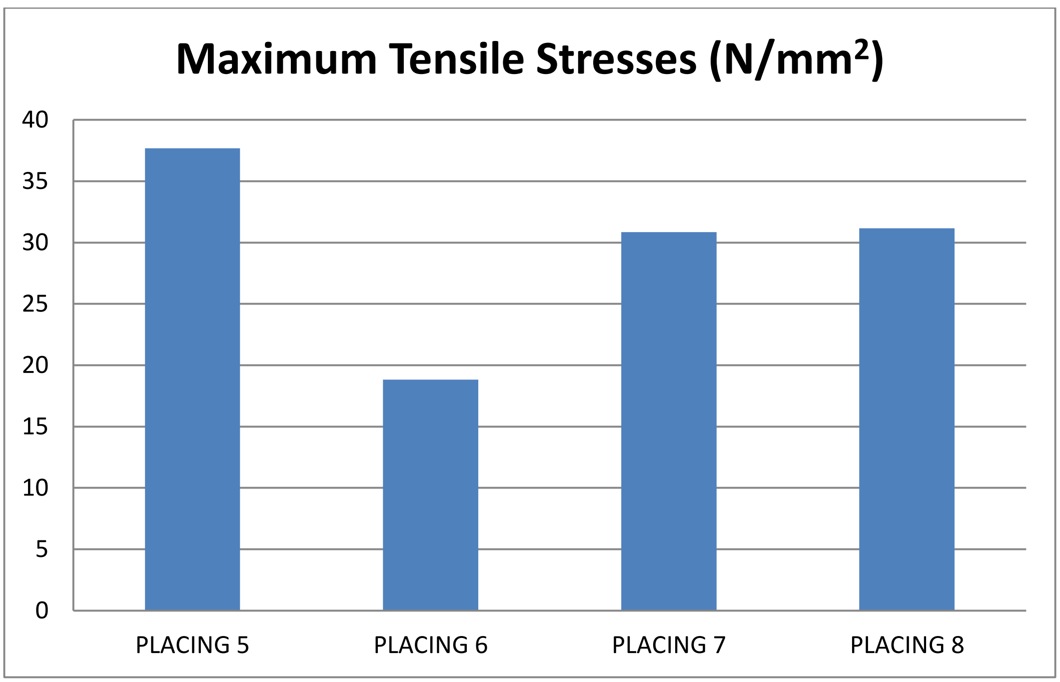
multistory building for triangular section

Table: 12: Maximum Tensile Stresses for triangular section

PLACING ARRANGEMENTS	Maximum Tensile Stresses (N/mm^2)
PLACING 5	37.69
PLACING 6	18.818
PLACING 7	30.839
PLACING 8	31.156

Graph 12: Maximum Tensile Stresses for triangular section



CONCLUSION

As per calculations and results point of view a summary of this examination has been concluded that for conventional R.C.C. building having telecommunication tower present on it carries the effects of building height on the performance under earthquake forces, carries effect of building height along with the tower on the performance under earthquake forces, carries Examination of multistoried building with rooftop triangular tower with different locations, carries dynamic analysis, response spectrum method to be applied on multi-storied building having rooftop triangular tower using Staad pro with varying position of tower along with the study of the optimal location of rooftop triangular tower for multi-storied building keeping other parameters as same.

On the basis of the results following conclusions have been drawn:

- The Horizontal Displacement seems to have maximum in Placing 8, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 35.996 mm. It is also observed that placing 6 and placing 8 have the maximum horizontal displacement and it requires the lateral load resisting system. The optimum placing seems to be in Placing 7.
- The Mass Participation Factor seems to have maximum in Placing 6, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 84.315 %. It is also observed that placing 6 and placing 8 have the maximum percentage of mass participation factor. The optimum placing in this context seems to be in Placing 7.
- The Multiplication Factor (V_B/V_b) seems to have maximum in Placing 8, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 2.1245. It is also observed that placing 6 and placing 8 have the maximum value of multiplication factor. The optimum placing in this context seems to be in Placing 7.
- Average Response Acceleration Coefficient (Sa/g) seems to have single common values in all the placing, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are not comparable and common value seems to be 0.771. The optimum placing for this parameter is not defined.
- Design seismic base shear (Vb) (considering the maximum of SRSS, 10PCT, ABS, CSM) seems to have maximum in Placing 7, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 552.72 KN. It is also observed that placing 5 and placing 7

have the maximum base shear values and it requires the lateral load resisting system. The optimum placing seems to be in Placing 6.

- The Frequency with respect to time period seems to have maximum in Placing 8, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 2.046 Hz for 0.489 seconds. It is also observed that placing 5 and placing 6 have the maximum frequency and it requires the damping system. The optimum placing seems to be in Placing 8.
- The Axial Forces seems to have maximum in Placing 8, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 1559.473 KN. It is also observed that placing 6 and placing 8 have the maximum axial forces and it requires the foundation support. The optimum placing seems to be in Placing 5.
- The Torsion i.e. the applied torque seems to have maximum in Placing 8, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value seems to be 18.622 KN m. It is also observed that placing 6 has the minimum torsional values among all the cases. The optimum placing seems to be in Placing 6.
- The maximum Shear Force seems to be in Placing 5, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value appears to be 353.669 KN. It is also observed that only placing 5, placing 7 and placing 8 have the maximum shear forces and the optimum placing seems to be in Placing 6 which has minimum shear.

- The maximum Bending Moments seems to be in Placing 5, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value appears to be 298.253 KN m. It is also observed that placing 5, placing 7 and placing 8 have the maximum bending moment values and the optimum placing seems to be in Placing 6 which has minimum moment.
- Compressive Stresses seems to be having maximum in Placing 5, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value appears to be 37.11 N/mm^2. It is

also observed that placing 5, placing 7 and placing 8 have the maximum positive stresses values and the optimum placing seems to be in Placing 6.

Last but not the least the important value used in the analysis is the value Tensile Stresses seems to be having maximum in Placing 5, since the values are represented by the help of table as well as graphs, concluding that all the placing in triangular tower cases are comparable and among them, maximum value appears to be 37.69 N/mm^2. It is also observed that placing 5, placing 7 and placing 8 have nearly same maximum negative stresses values and the optimum placing seems to be in Placing 6

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