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Telecommunication Tower on Residential Apartment at Jabalpur City with Building Improvement Analysis

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ABSTRACT

Nowadays telecommunication towers are tall structure usually designed for supporting parabolic antennas which are normally used for microwave transmission for communication, also used for sending radio, television signals to remote places and they are installed at a specific height. These towers are self-supporting structures and categorized as three-legged and four-legged space trussed structures. The self-supporting towers are normally square or triangular in plan and are supported on ground or on buildings. They act as cantilever trusses and are designed to carry wind and seismic loads. These towers even though demand more steel but cover less base area, due to which they are suitable in many situations. The availability of land which satisfies ideal installation conditions in urban areas is extremely limited giving no alternative but to adopt roof top towers (with marginal adjustment in position but not in height)..

Keywords: Telecommunication Towers, Seismic Analysis, STAAD-PRO, Building Tower, Response Spectrum.

INTRODUCTION

In this age of communication and networking telecommunication towers plays important role in human society. At times of occurrence of natural disasters, telecommunication towers have the crucial task of instant transmission of information from the affected areas to the rescue centers. In addition, performance of infrastructure such as dams, electric, gas, and fuel transmission stations, depends extensively on the information being transmitted via these telecommunication towers. Military and defence industries in addition to television, radio, and telecommunication industries are other areas of application for such towers and thus create the necessity for further research on telecommunication towers. Telecommunication towers are tall structure usually designed for supporting parabolic antennas which are normally used for microwave transmission for communication, also used for sending radio, television signals to remote places and they are installed at a specific height. These towers are self-supporting structures and categorized as three-legged and four-legged space trussed structures. The self-supporting towers are normally square or triangular in plan and are supported on ground or on buildings. They act as cantilever trusses and are designed to carry wind and seismic loads. These towers even though demand more steel but cover less base area, due to which they are suitable in many situations. The stability of tall structures requires some modifications into it since the scarcity of land generate need of the tall structures such as multistory building and skyscrapers. Since it has been observed that the competition is going on among the countries. Since the loads on the structure such as vertical and horizontal loads itself generate a huge combined load that has somehow generated by structure and that load has to be bear by structure itself. Since the earthquake generates oscillations from the ground which is connected to the structure and the most effective technique used to resist the structure by these combinations is the use of outriggers, belt supported system and outrigger and belt supported system.

Figure 1.1: Tower placed at multistoried building 1

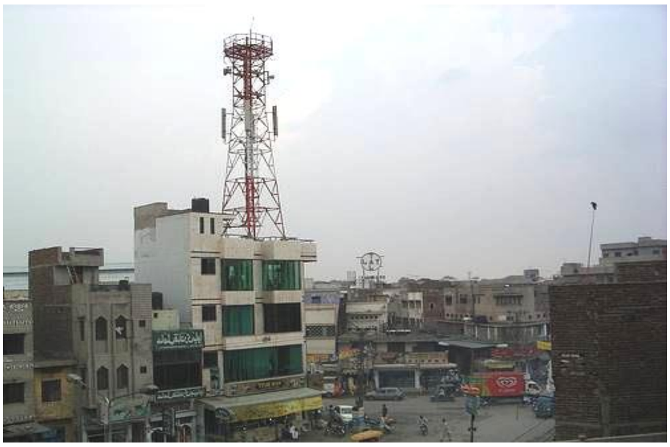

Figure 1.2: Tower placed at multistoried building 2

LITERATURE REVIEW

A review article is an article to gets the current state of a topic and to understand the current demand. A review article examines and shot way to represent past published workbased on study, rather than reporting new facts or analyzes. It is termed as survey articles or, in news release, overview articles. For the current project the review of article is based on the Outrigger Wall, Wall Belt and Outrigger structure Subject area so that it is easy grapes the subject knowledge and implementation and future orientatated work is carried out with the help of the reviews.

NitinBhosale, Prabhat Kumar, Pandey (2012) 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.

G. Ghodrati Amiri, M. A. Barkhordari, S.R. Massah and M.R. Vafaei (2007) 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.

Ghyslaine Mcclure, Laura Georgi And Rola Assi (2004), 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.

C. Preeti, K. Jagan Mohan (2013) 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.

G. GhodratiAmiri, M. A. Barkhordari, S. R. Massah (2004) 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.

Gholamreza Soltanzadeh, Hossein Shad, Mohammadreza Vafaei, Azlan Adnan (2014), 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.

Shailesh S. Goral, Prof. S. M. Barelikar (2017), 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.

Arpit Chawda, Vijay Baradiya (2015), 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.On the rooftop, the tower was placed at 3 different locations. The investigation was carried out for a total of 4 seismic zones and 3 types of soils.

From this study, the results obtained are as follows:

- Designed for all soil conditions along with all the seismic zones, with the height of structure, the displacement in the rooftop telecommunication tower structure was establish to increase.
- Designed for all the seismic zones, the displacement was found to be supreme in case of hard soil which was monitored by soft along with medium soil.
- Designed for all the seismic zone conditions, least displacement was detected whenever the tower was positioned at the midpoint of the roof which was found in CASE II of the research article. Consequently, the optimal location of the tower was to be at center of the roof.
- On increasing the dimensions of the column by using jacketing can be used for on condition that the present construction, which was not intended to be designed to bear the additional load owing to tower creation and for earthquake.

Sourabh Rajoriya, K.K. Pathak, Vivekanand Vyas (2016), the authors want to express the research that the 4 - legged self-sustaining tower was used over the globe for transmitting electricity supply and as a telecommunication towers. In this article, the transmission tower had to resist in contradiction of all forces like wind and seismic load etc. including the self-weight. Consequently, these towers are commonly constructed for both electrical as well as structural needs. As per IS: 1893 code, authors studied 4 legged transmission tower for all 4 seismic zones which was square in plan and had been studied in this research of practice. In view of 3 heights of tower, (40 m, 50 m and 60 m) by means of STAAD-Pro software. Outcomes of the study were collected based on which the results obtained are as follows:

- **Result 1; Support Reaction**

Support Reactions		
Tower height 40 m	**Tower height 50 m**	**Tower height 60 m**
783 KN to 1217 KN	**971 KN to 1534 KN**	**1167 KN to 1862 KN**
Result **Maximum value of the three**	**For support reactions, maximum value from the above three comes out to be for height 60 m.**	

Table 2.1: Maximum support reactions from total 3 cases.

Hence it was to be clear in mind that the support reaction in seismic zone V for 60 m high transmission tower has larger value as compared to 40m along with 50 m high transmission tower.

- **Result 2; Deflection**

Deflection		
Tower height 40 m	**Tower height 50 m**	**Tower height 60 m**
3.3 to 12.2 mm	**6.2 to 22.3 mm**	**10.3 to 37.6 mm**
Result **Maximum value of the three**	**For Deflection, maximum value from the above three comes out to be for height 60 m.**	

Table 2.2: Maximum deflection from total 3 cases.

Hence it was to be clear in mind that the deflection in seismic zone V for 60 m high transmission tower has larger value as compared to 40 m along with 50 m high transmission tower.

- **Result 3; Axial Stress**

Axial Stress		
Tower height 40 m	**Tower height 50 m**	**Tower height 60 m**
23 N/mm^2 to 33 N/mm^2	**21 N/mm^2 to 27 N/mm^2**	**9 N/mm^2 to 35 N/mm^2**
Result **Maximum value of the three**	**For Axial Stress, maximum value from the above three comes out to be for height 60 m in seismic zone V.**	

Table 2.3: Axial Stress from total 3 cases.

Hence it was to be clear in mind that value of axial stress for 40 m high tower is greater than 50 m high tower for all earthquake zones. In contrast, axial stresses for 60 m high tower in earthquake zone V are larger of all earthquake zones.

- **Result 4; Bending Stress**

Bending Stress		
Tower height 40 m	**Tower height 50 m**	**Tower height 60 m**
13 N/mm^2 to 32 N/mm^2	**20 N/mm^2 to 58 N/mm^2**	**23 N/mm^2 to 22 N/mm^2**
Result Maximum value of the three	**For Bending Stress, maximum value from the above three comes out to be for height 50 m in seismic zone V.**	

Table 2.4: Bending Stress from total 3 cases.

Hence it was to be clear in mind that value of bending stress for 50 m high tower is greater than 40 m as well as 60 m high tower for all earthquake zones. In contrast, bending stresses for 60 m high tower in earthquake zone V seems to be lowest.

- **Result 5; Support Moment**

Support Moment		
Tower height 40 m	**Tower height 50 m**	**Tower height 60 m**
22 kN-m to 46 kN-m	**26 kN-m to 49 kN-m**	**76 kN-m to 111 kN-m**
Result Maximum value of the three	**For Support Moment, maximum value from the above three comes out to be for height 60 m in seismic zone V.**	

Table 2.5: Support Moment from total 3 cases.

Hence it was to be clear in mind that value of Support Moment for 60 m high tower is greater than 40 m as well as 50 m high tower for all earthquake zones. In contrast, Support Moment for 40 m high tower in earthquake zone V seems to be lowest.

It is clear from above results when considering all that 60 m height of tower seems to be more dangerous one and when it is to be designed, one should consider all results so that the new structure should be free from design defects in all seismic zones.

Patil Vidya M, Lande Abhijeet C The authors want to express their words by paper which aim to inspect the response of the structure as well as structural members and these special structures when exposed to the effect of lateral forces such as

1. Wind load.
2. Combination of wind load and snow load.

For the activity of research, author had taken a total of 6 types of steel towers, 4 of then are located on the ground and remaining 2 of them are placed over the buildings.

From this study, the results obtained are as follows:

The examination of the steel towers in their report offered the very accurate method of analysis known as Finite element method. 3-D trusses have been taken and with the help of computer software program, it had been used to determine the member forces, joint deflections as well as the support reactions by reason of load generated by equivalent static wind. Most of the outcomes attained at the present study are as follows:-

- At the natural frequencies of the tower, spectral density of displacement shows peak values of the member.
- As stated by the valuation of lattice telecommunication masts steel sample, because of the earthquake analysis the shear forces values are very low when relate to wind loaded structure analysis. Therefore, wind loading has given the main preference in this analysis.
- In case of telecommunication tower with low height, when it was analyzed in the software, the structural performance was not much affected. The earthquake combination origins additional effect as the increment of height.

Siddesha H (2010) the authors wants to show their imagination by this paper. It presents the examination of microwave antenna tower with gust factor method as well as static method. Tower with structural angle as well as square hollow section was taken and made a comparison between them. The main consideration was the displacement at top of the tower was taken into account. For vast configuration, the analysis was also done by eliminating one of the members in the tower at its lower panels.

From this study, the results obtained are as follows:

With the effects of wind loads and with different sections and configurations, the examination of microwave antenna mast was done. The subsequent decisions were drawn.

- By comparative usage of angle sections in tower under static and gust factor method and static method, it is better to be used square hollow sections in leg members more efficiently.
- In bracings besides the leg members not show ample fall when square hollow sections was used and result in terms of displacement as related to tower having hollow sections of square cross section used under static and gust factor method and static method in leg member.
- In Square hollow Sections when using X and M bracing for bracings as well as leg members for 1st lower panel, demonstrates an extreme decline value of displacement when compared under static and gust factor method and static method in leg member with angle sections.
- For bracings and leg members, X and M bracing made according to square hollow cross segments. It had been seen that the lower 1st panel demonstrates a extreme decline value of displacement when compare with square section hollow tower.

Jithesh Rajasekharan, S Vijaya (2014) authors want to demonstrate a study which had been accepted on the basis of models of different bracings as well as different heights for earthquake zones. They used wind forces on the structure too. By using gust factor method, wind effects on the building model were studied & by doing modal analysis as well as response spectrum analysis method, the earthquake response effect on the building was studied.

From this study, the results obtained are as follows:

- As the height increases in earthquake zone V in the range of 30m to 40m stress of the structure was amplified by about 30% in contrast to rise of about 25% when height of 40m to 50m was used and 45% of stresses was there when the height was in the range of 30m.
- For taking loads vertically, the vertical members are hence used to take loads of the transmission tower in vertical plane as compared to horizontal member because there is a criteria is there which tells that when structure height is greater than its width, there is a large effect on the behavior of the tower and vertical members are hence used.
- The joint displacement was very much on tower with Y bracings in wind analysis however for the tower with XX bracing due to the deficiency of horizontal bracing the member stress at bottom leg was extra-large.
- When tower height increases from 30m to 40m, it can be observed that from the wind analysis, raise in joint displacement was nearly 68%. On contrast, when tower height surges from 40m to 50m the displacement is probably increased by 60%.
- It can be seen that the tower with K bracing was having the least on the compared models. The increase in displacement was about 38% in zone II & III when analysis was done by response spectrum analysis method. The tower with Y bracing is having most displacement. While in zone III & IV the decrease was about 28% and in zone IV & V growth in displacement value was about 35%.
- All structural models have been tested & verified by I.S. codal provisions. It can be seen that in the presence of wind of 55 m/s, the tower model with 50 m height made up of XB bracing along with Y bracings. For that, structural member should be redesigned.
- By using dynamic method, i.e. response spectrum analysis, usage of X-X bracings, the stresses generated for tower was more due to the deficiency of horizontal bracing laterally the tower.
- In both cases of wind speeds, when height increases from 30 m to 40 m, the change in stresses was about 45% and from 40 m to 50 m was 39%.

Richa Bhatt, A. D. Pandey, Vipul Prakash (2013) The authors wants to demonstrate lateral design of the structure by modeling a total of 2 lattice towers of different heights viz. 18 m & 40 m was analyzed. By three different structural naiveties such as 3D truss, 3D frame & a combination of these was taken into account. By using gust factor method, wind forces was taken as the chief force for the investigation. To discover the effect of the difference in the modeling strategy, comparison were made by getting the result of maximum stresses, member forces & joint displacements performing on a tele-communication tower. The truss model provides typical values of axial forces as well as stresses in all members were found.

Only the consequence comes out of plane bending was considered in it on the other hand, the truss models misjudge the bending stresses. For inspection of the design criteria, either one of the frame model or using the hybrid model may be used to evaluations of combined stresses. The necessity of redesign of base members was found in this study due to combined stresses.

From this study, the results obtained are as follows:

- In truss model, for the middle members and for the leg members at base, the value of axial stresses shows more as compared to prototype model.
- For 18 m high tower, the nonconformities of the displacement values for the rigid frame along with the truss models at the top are 0.72 percent & 0.74 percent. The alterations amongst the frame model along with the truss model from the combined model are 1.4 percent and 0 percent respectively was shown at 3m of height.
- For 40 m high tower, the nonconformities of the displacement values for the rigid frame along with the truss models at the top are 0.07 percent & 0.07 percent. The alterations amongst the frame model along with the truss model from the combined model are 0.46 percent and 0.15 percent respectively was shown at 10 m of height of telecommunication tower.

Hemal J shah, Dr. Atul K Desai (2014), the author wants to show the examination of response of a total of four towers of varying height, each having different bracing systems. Using the most common used software SAP version 2000, dynamic analysis along with static analysis was carried out by them. The time history analysis method was also taken into account with respect of the bhuj earthquake & the analysis of its response was successfully done.

From this study, the results obtained are as follows:

- On comparing static and dynamic method of analysis, the value of base shear by using static analysis was 31 % more than using dynamic analysis. By obtaining this result, author wants to make a note that for earthquake analysis, dynamic methods must be used for accurate result. Because, when earthquake zone changes, there was a linear graph of increment of forces.
- Due to dead load combined with seismic forces, axial forces values were less in K- type bracing for a height of 110 m to 175 m. Hence author wants to conclude a point that for telecommunication towers, K- type of bracings was most economical of all.
- The base shear values which were extreme when 80 m height of tower was used along with the usage of M type of bracing. The author also wants to point out that the weight of the tower was only increase when there was an increment of height of the tower. When comparing all four cases, cross type of bracing system was one of the most uneconomical one.

Using K- type of bracing system in tower of 110 m in height, 150 m in height along with 175 m in height, the author was getting a minimum value of base shear and hence they want to conclude that this kind of bracing was most economical of all of the other system of bracings applied in the towers.

CONCLUSION

Based on the different researchers study there is many type of outcome and theories are carried out which is very important for further research work. some major points are given below-

- Analysis the behavior of Telecommunication Tower on Residential Apartment.
- The maximum research is based on the optimum height, shear wall location and height, variations in outrigger depth etc.

- The belt truss &outrigger system most accepted method for withstanding under lateral loads.
- Study the behavior of Telecommunication Tower on Residential Apartment with outrigger system under seismic loading.
- Location of tower is been analyze in various positions in residential apartment.
- The structural form used by the Outrigger System for High-Rise, Composite Structure ,Multi-Outriggers System, Unsymmetrical Tall Buildings, Steel Structure &braced frame system by different analysis. The bracing &Outriggers System is more priority in it and reduces the effect of laterals loads.
- The checks made by different researches are Seismic performance, Impact in the Cyclonic Region, Guideline adopted under for Optimum Topology concept and Design consideration under sizes.

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