Selection of Suitable Bracing System for a Communication Tower at Various Wind Zones

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Abstract— Steel Bracing is a structural system which transfers lateral loads (seismic loads and wind loads) into soil bypassing columns, beams which are designed only for gravity loads. Communication towers are very prone to wind loads such that they are need to be designed to resist wind loads to make the structure at least for life safe in the event of natural calamities like HUD-HUD. In the present study communication tower has been modeled and analyzed in STAAD. Pro V8.i. For this model different types of steel bracing systems like X, V, K, Y systems were assigned. These bracing systems were modeled by considering 3 different steel sections like Pipe section, angular section and multi section (pipe section for columns, angular section for beams and bracings) 24 models with bracing system have been developed to run for wind analysis at wind speeds of 33m/s,39m/s,44m/s,47m/s.50m/s,55m/s in STAAD. Pro V8.i. After comparison of various parameters like displacement, axial force, support reactions ,steel quantity between these 24 models it was found that steel angular section with Y bracing system and X-bracing system perform well in the event of selected wind zones. When compared with V-Bracing system 85.97 % of displacement has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/ When compared with Y-Bracing system 57.69 % of Support reaction (FX) has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s , When compared with K-Bracing system 66.58 % of Support reaction (FY) has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s , When compared with K-Bracing system 68.77 % of Axial force has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s, When compared with V-Bracing system 57.14 % of steel quantity has been reduced to the tower with Y-Bracing system along with angular section at wind speed of 55 m/s.

Key words: Modified Root Zone Technology, Colocasia, Disinfection

I. Introduction

A natural disaster is defined as an event of nature that overwhelms local resources and threatens the function and safety of the community. Disasters are the ultimate test of a community's emergency response capability. Planning is very difficult due to the unpredictable character of natural disasters. A thoughtful and well-organized emergency strategy that is flexible and adaptable in face of unforeseen circumstances is crucial. WDs may affect the economic, social, physical, and psychological fabric of any community.

Tall towers are being used by different agencies such as television and radio departments, telecommunication industry, defence, railways and police for their communication network. The microwave towers, which are space structures in steel, carry mainly communication antennae. These towers are mostly square in plan, made of standard steel angles and connected together by means of bolts and nuts. Triangular towers attract lesser wind loads compared with square towers. However they are used only for smaller heights of tower due to difficulties in joint detailing and fabrication using angle sections.

Ultimately, the general availability of a wide range of square, rectangular, and round structural tubing increased. The use of tubular joints greatly improved the aesthetic qualities of the truss, and the higher load carrying capacity of the structural capacity of the structural tube members provided a wide range of applications for a triangular cross section truss. Tubular sections are used for truss members, the range of different standard shapes and sizes produced is much less than wide flange shapes and availability of some standard shapes is still limited. In order to reduce the unsupported length and thus increase their buckling strength, the main legs and the bracing members are laterally supported at intervals in between their end nodes, using secondary bracings or redundant. These secondary bracings increase the buckling strength of the main compression members K X bracing with secondary bracings were commonly using in microwave towers

Optimization is the art of obtaining best results under given conditions. An optimization problem consists of a function, which is to be optimized, and with or without constraints. The constraints are the conditions to be satisfied during optimization. Optimal design methods assist engineers to evolve the best possible designs in terms of cost, weight, reliability or a combination of these parameters. As far as tower and tower like structures are concerned limiting the displacement and stresses to allowable limits optimizes the weight using different sections. Many methods have been developed and are in use for design optimization of structural systems. Structural optimization using mathematical programming was very expensive in the early stages of its development and hence applications to problems were limited in scope. Recent advances in computer hardware have encouraged researches to give a new thrust to structural optimization.

The structures like towers and masts are sensitive to dynamic wind load. The need to design a lattice tower considering resonant dynamic response to wind loads arises when their natural frequencies are low enough to be excited by the turbulence structures like towers and masts are sensitive to dynamic wind load. in the natural wind. These types of structures, which are vulnerable to wind induced oscillations, are required to be examined for dynamic effects of wind. Further, the structural loads produced by wind gusts depend of the size, natural frequency and damping of the structure in addition to the inherent wind turbulence.

One of the approaches used for evaluating the dynamic response of lattice towers. Dynamic effects of wind for design of lattice towers are considered in GFM. In this approach, the equivalent wind loading is equal to the mean wind force multiplied by a Gust Factor. This load is applied as an equivalent static loading on structures. This factor is a function of wind, terrain and structural characteristics. The Gust present in strong winds are caused by mechanical disturbance to the flow resulting from the roughness of the ground surface

A. *Objective of the Work*

The main objective of this work is to reduce the displacements to the communication towers in the event of natural calamities by introducing lateral resisting system. By Evolution of response of the structure with various bracing systems subjected to wind loads and to identify the suitable bracing system for resisting wind loads; which gives way in the reduction of property loss sometimes even human loss in the event of drastic winds like HUD-HUD.

B. *Scope of the Work*

This work is restricted to the scope defined in Table1

Type of bracing	33m/s & 39m/s	44 m/s & 47m/s	50 m/s & 55m/s
X	Pipe	Angular	Multi
V	Pipe	Angular	Multi
K	Pipe	Angular	Multi
Y	Pipe	Angular	Multi

Different bracing system like X,V,K,Y have been modeled in STAAD.Pro .These bracing systems modeled for different bracing steel sections like pipe section, angular section multi section, wind analysis have been run in STAAD.Pro to find out better bracing system along with bracing section in the event of selected wind zones. Results obtained by comparing different parameters between these models.

Height of the tower =24 m
Length of the tower (X) = 4m
Width of the tower (Z) = 3m

II. STRUCTURE MODELING IN STAAD.PRO V8I

A. *Step 1*

- Open STAAD.ProV8i software
- Click on new project
- Enter file name and click on next
- Go to snap node edit option give X=4 and Y=24
- Draw the skeleton of the tower as per requirement
- Now select and copy those columns in z- direction (z=3m)

B. *Step-2*

1) *Supports*

- Now click on supports and select bottom nodes to assign pinned supports

C. *Step-3*

1) *Assigning Nodes*

- Click on insert node and select column to add nodes at every mid points to make column into 8 equal bays.
- The height of each bay is 3m

D. *Step-4*

1) *Joining Nodes*

- Click on beam cursor to join all the nodes

E. *Step-5*

Assigning property

1) *Pipe Section*

- Click on Property→ Go to section data base→select Indian→pipe section select Pip 1270 H→Assign to the structure with Pipe section
- Angular Section
- Click on Property→ Go to section data base→select Indian→Angular section IS A 50X50X8→Assign to the structure with Angular section
- Multi Section
- Click on Property→ Go to section data base→select Indian→Angular section IS A 50X50X8(beams and bracings)→ Pipe section select Pip 1270 H(columns) →Assign to the structure with multi section

F. *Step-6*

Load and Definitions

1) *Wind load*

- Click on Load and Definitions→load case details add→give title as wind load→go to definitions wind definitions→wind load dialog box opens→give intensity as 33m/s,39m/s,44m/s,47m/s,50m/s,55m/s for 24 different towers with Pipe section(X,V,K,Y),Angularsection(X,V,K,Y), Multi section(X,V,K,Y).

2) *Dead load*

- Click on Load and Definitions→load case details add→give title as dead load→click on dead load→assign to view→ Then dead load will be assigned to entire structure

3) *Platform load*

- Click on Load and Definitions→load case details add→give title as plat form load→click on platform load→Add on area load give -1GY→select top members→ Then platform load will be assigned to selected beam

4) *Auto load combination*

- Click on load case details→load cases→select auto load combination→select Indian code→add
- 1.5DL+1.5PL
- 1.2DL+1.2PL+1.2WL
- 1.2DL+1.2LL
- 1.5DL+1.5WL
- 1.5DL
- 0.9DL

G. Step-7

1) Analysis and Design

- Click on design→steel structures→select code IS-800→Define parameters→select FYLD add→select profile ISHB→select Track →go to commands→Add check code→member take off→select optimized→take off→click on add→click on analysis

H. Step-8

1) Post Processing

Go to post processing → select displacement →support reactions → Axial force→steel quantity → record values in tabular form → make bar charts to compare all the required parameters to find better bracing system for communication towers for 33m/s,39m/s,44m/s,47m/s,50m/s,55m/s for 24 different towers with Pipe section(X,V,K,Y), Angular section(X,V,K,Y), Multi section(X,V,K,Y).

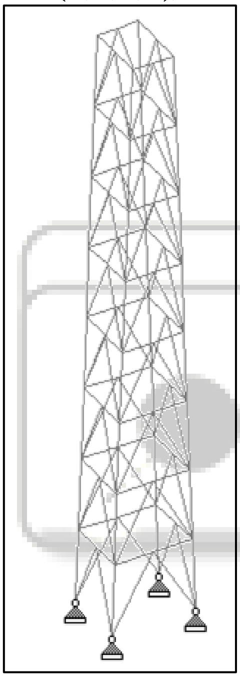

Fig. 2.1: K-Bracingsystem

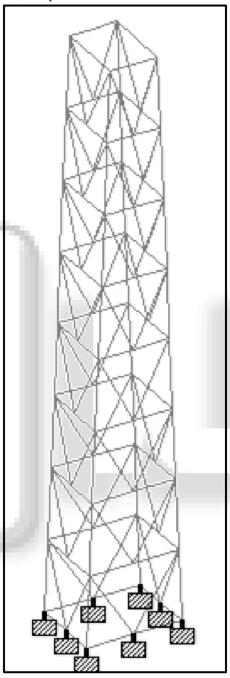

Fig. 2.2: V-Bracing system

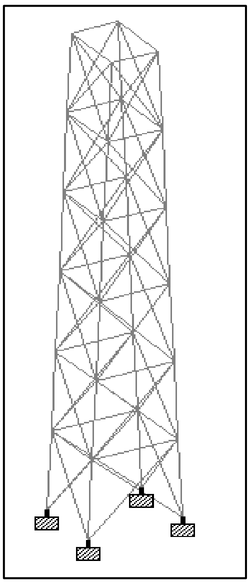

Fig. 1.3: X-Bracing system

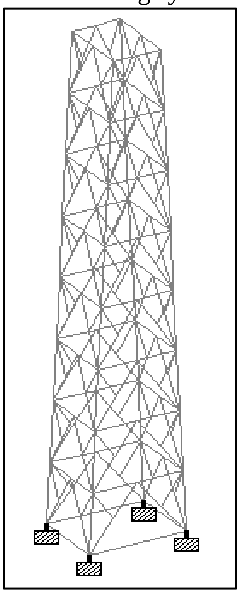

Fig. 1.4: Y-Bracing system

III. RESULTS AND DISCUSSIONS

A. Displacement

1) Pipe Section (Units in mm)

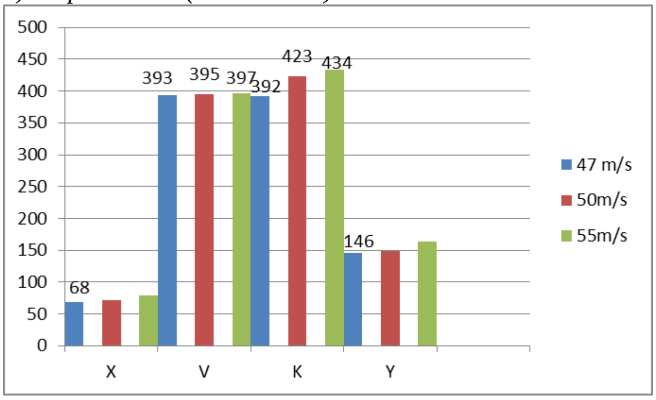

Fig. 5.1: Maximum displacement for Pipe Section

a) V-Bracing System
- 478% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 448% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 402% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 476% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 487% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 449% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 114% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 107% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 107% of displacement has been Increased to the
- structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

2) Angular Section (Units in mm)

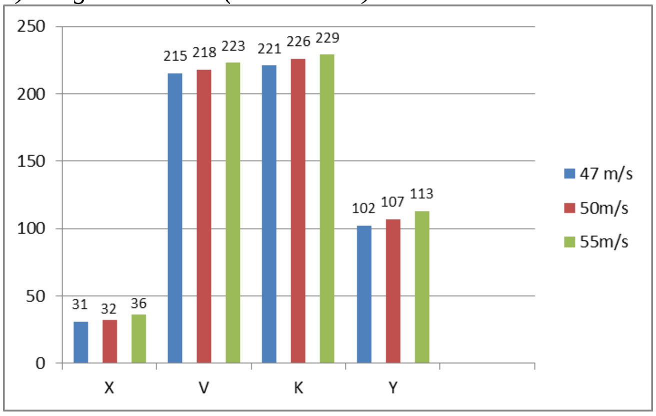

Fig. 5.2: Maximum displacement for Angular Section

a) V-Bracing System
- 593% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 581% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 519% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 613% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 606% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 536% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 229% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 234% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 213% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

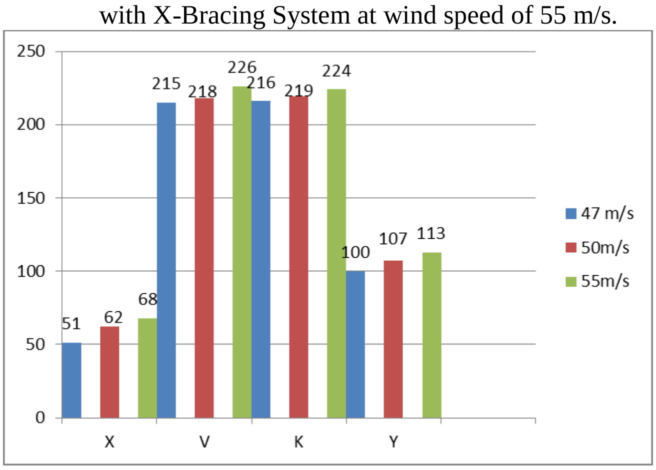

Fig. 5.3: Maximum displacement for Pipe Section

d) V-Bracing System
- 321% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 251% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 232% of displacement has been Increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s

e) K-Bracing System
- 323% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 253% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 229% of displacement has been Increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.
- 3.1.3.3 Y-Bracing System
- 96% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 72.5% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 66% of displacement has been Increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

Support reaction Pipe Section (Units in kN)

3) Support reaction Pipe Section (Units in kN)

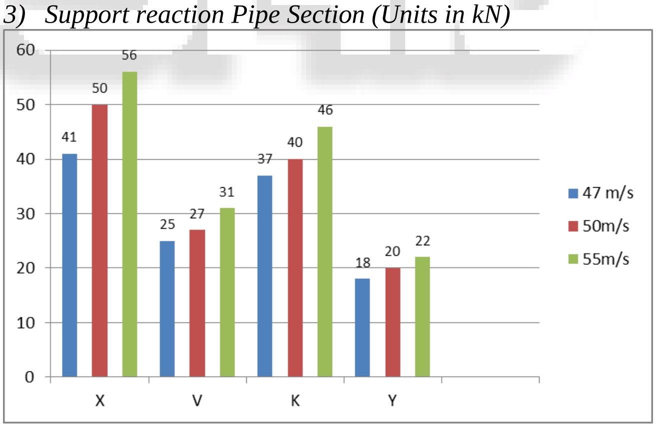

Fig. 5.4: Maximum Support reaction Pipe Section

a) V-Bracing System
- 38% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 36% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 40% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 5% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.

- 4% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 9% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System

- 64% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 63% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 67% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

Support reaction Angular Section (Units in kN)

4) Support reaction angular Section (Units in kN)

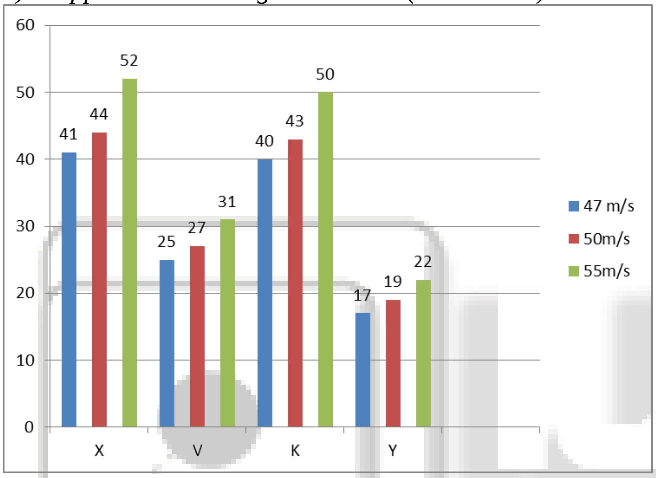

Fig. 5.5: Maximum Support reaction angular Section

a) V-Bracing System

- 39% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 39% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 40% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System

- 3% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 2% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 4% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System

- 56% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 54% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 58% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

5) Support reaction Multi Section (Units in kN)

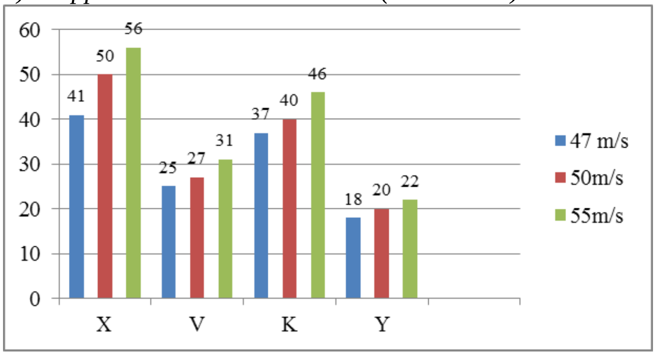

Fig. 5.6: Maximum Support reaction Multi Section

a) V-Bracing System

- 39% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 46% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 45% of support reaction has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System

- 10% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 20% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 18% of support reaction has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.
- 3.2.3.3 Y-Bracing System
- 56% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 60% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 61% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

B. Support Reaction (FY)

1) Support reaction Pipe Section (Units in kN)

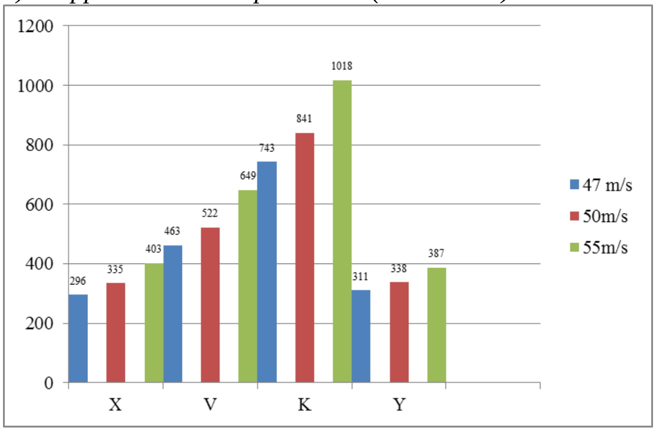

Fig. 5.7: Maximum Support reaction for Pipe Section

a) V-Bracing System
- 57% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 56% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 61% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 151% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 151% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 152% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 5% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 1% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 4% of support reaction has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

2) Support reaction Angular Section (Units in kN)

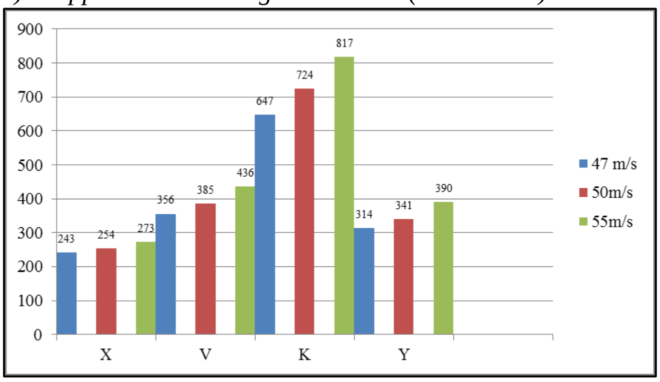

Fig. 5.8: Maximum Support reaction for Angular Section

a) V-Bracing System
- 47% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 52% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 60% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 166% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 185% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 199% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 29% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 34% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 43% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

3) Support reaction Multi Section (Units in kN)

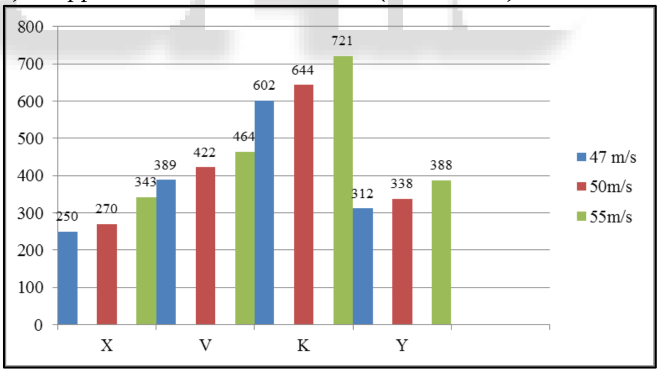

Fig. 5.9: Maximum Support reaction for Multi Section

a) V-Bracing System
- 56% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 56% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 35% of support reaction has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 141% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.

- 139% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 110% of support reaction has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System

- 25% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 25% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 13% of support reaction has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

C. *Axial Force*

1) *Maximum Axial force Pipe Section (Units in kN)*

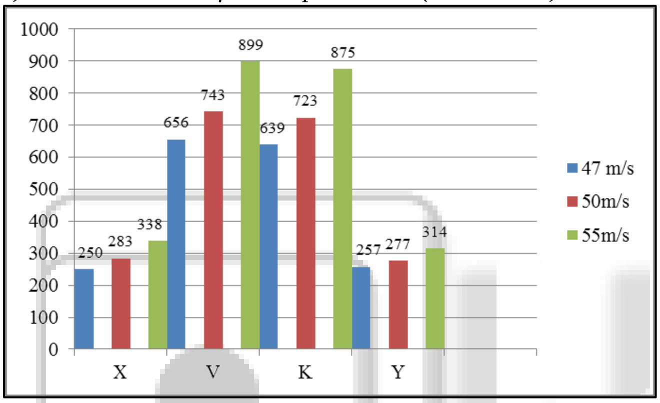

Fig. 5.10: Maximum Axial force for Pipe Section

a) V-Bracing System

- 162% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 163% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 166% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.
- 3.4.1.2 K-Bracing System
- 156% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 155% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 159% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) Y-Bracing System

- 3% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 2% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 7% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

2) *Maximum Axial force Angular Section (Units in kN)*

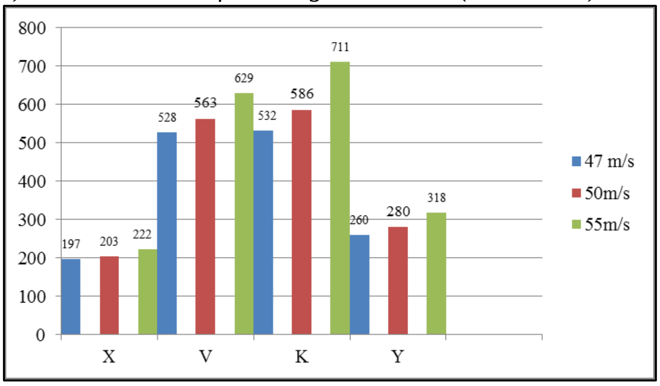

Fig. 5.11: Maximum Axial force for Angular Section

a) V-Bracing System

- 168% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 177% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 183% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System

- 170% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 187% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 220% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System

- 32% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 38% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 43% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

3) *Axial force Multi Section (Units in kN)*

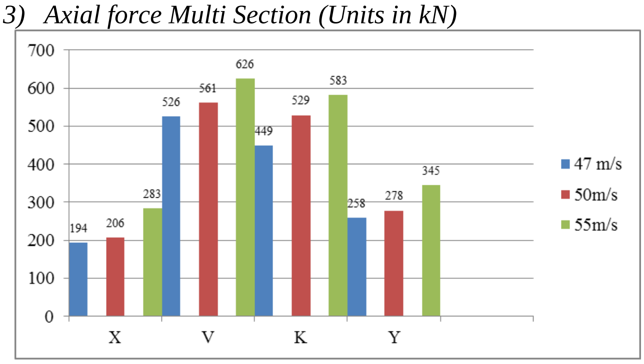

Fig. 5.12: Maximum Axial force for Multi Section

a) V-Bracing System
- 171% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 172% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 121% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 131% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 157% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 106% of axial force has been increased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 33% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 35% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 22% of axial force has been increased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

D. Steel Quantity

1) Steel Quantity Pipe Section (Units in Ton's)

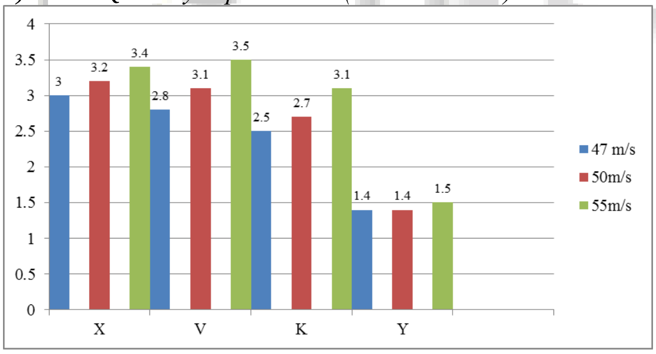

Fig. 5.13: Maximum Steel Quantity for Pipe Section

a) V-Bracing System
- 7% of axial force has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 3% of axial force has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 3% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 17% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 16% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 9% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 54% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 56% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 56% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

2) Steel Quantity Angular Section (Units in Ton's)

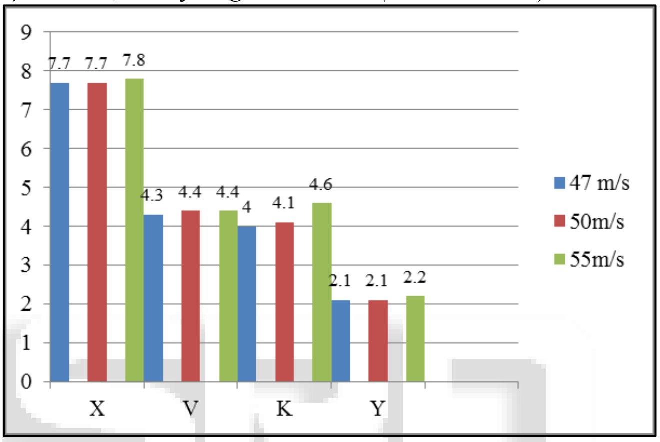

Fig. 5.14: Maximum Steel Quantity for Angular Section

a) V-Bracing System
- 44% of axial force has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 43% of axial force has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 44% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
- 48% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 47% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
- 41% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
- 73% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
- 73% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.

– 72% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

3) Steel Quantity Multi Section (Units in Ton's)

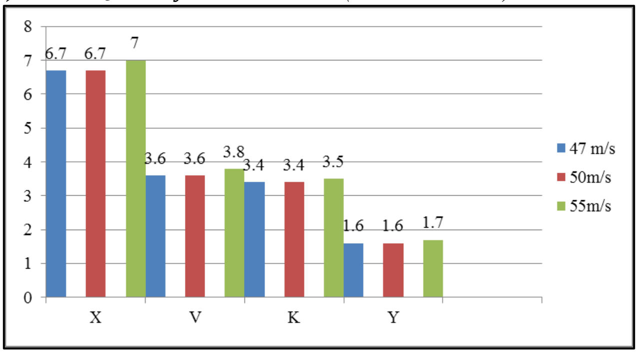

Fig. 5.15: Maximum Steel Quantity for Multi Section

a) V-Bracing System
– 46% of axial force has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
– 46% of axial force has been decreased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
– 46% of axial force has been increased to the structure with V-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

b) K-Bracing System
– 50% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
– 50% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
– 50% of axial force has been decreased to the structure with K-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

c) Y-Bracing System
– 76% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 47 m/s.
– 76% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 50 m/s.
– 76% of axial force has been decreased to the structure with Y-Bracing System when compared with X-Bracing System at wind speed of 55 m/s.

IV. Conclusions

– When compared with V-Bracing system 85.97 % of displacement has been reduced to the tower with X-Bracing system along with angular section at wind speed of 47 m/s
– When compared with V-Bracing system 85.84 % of displacement has been reduced to the tower with X-Bracing system along with angular section at wind speed of 50 m/s
– When compared with V-Bracing system 85.97 % of displacement has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s
– When compared with X-Bracing system 63.82 % of Support reaction (FX) has been reduced to the tower with Y-Bracing system along with angular section at wind speed of 47 m/s
– When compared with X-Bracing system 63.96 % of Support reaction (FX) has been reduced to the tower with Y-Bracing system along with angular section at wind speed of 50 m/s
– When compared with Y-Bracing system 57.69 % of Support reaction (FX) has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s
– When compared with K-Bracing system 62.44 % of Support reaction (FY) has been reduced to the tower with X-Bracing system along with angular section at wind speed of 47 m/s
– When compared with K-Bracing system 64.91 % of Support reaction (FY) has been reduced to the tower with X-Bracing system along with angular section at wind speed of 50 m/s
– When compared with K-Bracing system 66.58 % of Support reaction (FY) has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s
– When compared with K-Bracing system 62.96 % of Axial force has been reduced to the tower with X-Bracing system along with angular section at wind speed of 47 m/s
– When compared with K-Bracing system 65.35 % of Axial force has been reduced to the tower with X-Bracing system along with angular section at wind speed of 50 m/s
– When compared with K-Bracing system 68.77 % of Axial force has been reduced to the tower with X-Bracing system along with angular section at wind speed of 55 m/s
– When compared with X-Bracing system 53.33 % of steel quantity has been reduced to the tower with Y-Bracing system along with angular section at wind speed of 47 m/s
– When compared with X-Bracing system 56.25 % of steel quantity has been reduced to the tower with Y-Bracing system along with angular section at wind speed of 50 m/s
– When compared with V-Bracing system 57.14 % of steel quantity has been reduced to the tower with Y-Bracing system along with angular section at wind speed of 55 m/s

Both X and Y bracing systems performed well at various wind zones while coming to sections angular section performed well in all aspects.

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