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# SLUMP AND STRENGTH CHARACTERISTICS OF SUPERPLASTICIZED CONCRETE

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## ABSTRACT

Stacks or chimneys are tall, pliable structures consisting of masonry, concrete, and steel. These are used to release waste or toxic gases at greater altitudes so that they cannot contaminate the nearby atmosphere and that they also reach the ground within the acceptable limits authorised by the regular authority for pollution control. A construction like an RCC chimney must successfully fulfil massive functions without interruption for the duration of its anticipated life.It is important to realise that such an assumption is based on the core design's inherent uncertainties and unpredictability in a variety of situations corresponding to a variety of limit states. Several loads, including the self-load, liner load, wind load, earthquake load, and temperature load, are exerting pressure on the chimney. Most industrial RCC chimneys feature tall, elliptical cross-sectional designs. Such light-damped, thin constructions are susceptible to vibration caused by wind, both across and along wind impacts. The geometry of a self-supporting RCC chimney greatly influences its structural behaviour under lateral dynamic loading. Basic criteria for industrial RCC supporting steel chimneys, such as height and exit diameter, are frequently obtained from the local environment.In order to ensure that the intended failure mode design code (IS-6533: 1989 Part 2) was met, the geometry of RCC chimneys had to adhere to a variety of standards, including the top to base diameter ratio and height to base diameter ratio. In order to support the code requirements for the essential dimensions of industrial RCC chimneys, the current study compares self-supporting RCC chimneys under the effects of wind load and seismic activity. In order to calculate the design parameters, the highest values from the seismic and wind assessments are compared. The current study has finished the static and dynamic analysis for seismic zones II, III, and V of a 150 m tall RCC chimney with a foundation resting on moderate soil strata. 50 m/sec is the basic wind speed that affects chimneys. For analysis, we created a chimney model in STAAD Pro.

Keywords:- RCC Chimney, Wind Analysis, Seismic Analysis, Along Wind Effect, Across Wind Effect

## 1.0.INTRODUCTION

In order to release smoke from boilers, thermal plants, and coal plants at a greater elevation where it cannot contaminate the surrounding atmosphere, chimneys or stacks are tall, cylindrical constructions. There are two types of steel chimneys: guyed chimneys and self- supported chimneys. The structural integrity of the chimney is impacted by a variety of loads, including self-weight, wind load, and seismic load. In the design of a chimney, static and dynamic loads are crucial. Because of the chimney's slender design, wind load is taken into consideration during study. When analysing stresses for chimneys, aerodynamic lifts are also a major concern for circular-shaped chimneys. There are two ways to think about wind load: across wind and along wind. Gust bufficating, a type of drag that the wind creates on the chimney, results in a dynamic response to the wind's direction of flow. The chimney structure experiences vortex shedding due to the across-wind effect. As a result, the chimney vibrates in the opposite direction of the wind. The strength of the forces affects the amplitude of vibrations in chimneys. The result is a significant deflection and serious structural damage.After taking into account wind loads, seismic loads are another significant stress operating on the chimney. In accordance with Indian codal rules, quasi-static methods used to evaluate this type of loading suggest amplifying the chimney's normalised response by a factor based on the soil and magnitude of the earthquake. The majority of waste flue gases are released into the sky at high altitudes through chimneys. For the design of self-supporting RCC chimneys, there are numerous standards available, including Indian Standard IS 4998:1992 Part-1. A self-supporting steel chimney's geometry has a significant impact on how it will behave structurally when subjected to lateral dynamic loading. Because the stiffness parameters of the chimney are primarily a result of geometry. However, the fundamental geometrical characteristics of the RCC chimney, such as its height and exit diameter, are linked to the relevant environmental factors. STAAD Pro, a finite element analysis programme, is used to do the analysis. STAAD Pro generates the analysis's output with acceptable graphic and computational quality.

## 2.0. STUDY AREA

### 2.1. Wind Engineering

In tall freestanding constructions like chimneys, wind is the main source of loads. There are two parts to the impact of wind on very towering structures, which are

- Along-wind effect
- Across-wind effect

The overall wind load exerted on a chimney at any given place can be conceived of as the sum of a quasi-static and dynamic load component. The static-load component refers to the force that wind will exert if it blows persistently at a mean (time-average) speed and tends to induce a steady displacement in a structure. The dynamic component that can cause oscillations in a structure is produced in part by the following factors:

i) Gusts
ii) Vortex shedding
iii) Buffeting

### 2.2. Wind Load Calculation

According to IS 875 (Part 3): 2005 basic wind speed can be calculated,$VZ=VbK1K2K3K4$
Where,$Vz$= design wind speed at any height z m/s

$K1$= probability factor (risk coefficient)

$K2$= terrain, height and structure size factor
$K3$= topography factor

$K4$=Importance factor for cyclonic region

#### 2.2.1.Static Wind Effects

An air stream on a bluff body, such as a chimney, is obstructed by a static force known as drag force. The form and direction of the wind incidence determine how the wind pressure is distributed. This results in circumferential bending, which is particularly severe for chimneys with larger diameters. Along-wind shear forces and bending moments are also produced by drag force.

#### 2.2.2.1. Drag

The drag force on a single stationary bluff body is :$Fd = 1CDA\rho a\bar{U}2$
Here, Fd = drag force, CD = Drag coefficient
A = area of section normal to wind direction, sq. m
The value of drag coefficient depends on Reynolds number, shape and aspect ratio of a structure.

#### 2.2.2.2. Circumferential Bending

Re affects how the wind pressure is distributed radially on a horizontal portion. Normally, the shear force (s) that the structure induces counteracts the along wind's consequent force. It is thought that these shear forces change sinusoidally around the chimney cell.

#### 2.2.2.3. Wind load on linear

Metal liners are employed in single-flue and multi-flue chimneys, however they are not in direct contact with the air or exposed to the wind. However, they are built to withstand the wind stresses that pass through the chimney cell. When the liner is viewed as a beam with a variable moment of inertia that is being loaded transversely at the top and the deflection is determined at the top of the cell, the force's size may be estimated.

### 2.2.3. Dynamic-wind effects

Wind load is a combination of steady and a fluctuating component. Due to turbulence effectthe win load varies in its magnitude.

#### 2.2.3.1. Gust Loading

Due to fluctuations wind load is random in nature. This load can be expressed as$F(t) = K(U + \rho u)2$
$F(t) = K(U2 + 2U\rho u)$, for small value of $\rho u$
Where $K = 1 C D A \rho a$
2
In the above expression ($K \bar{U}$) is quasi-static and $\bar{U}$ is the mean velocity.

#### 2.2.3.2. Aerodynamic Effects

In wind engineering there is a term called "aerodynamic admitance coefficient" which depends on spatial characteristics of wind turbulence. Spatial characteristics relates to structure's response to wind load, at any frequency.

#### 2.2.3.3. Vortex Formation

When wind flows through a circular cross section like chimney vortices are formed. Thesevortices cause a pressure drop across the chimney at regular pressure intervals. Due to this changein pressure, a lateral force perpendicular to wind direction is created. It depends on Reynolds's number which has a range such as sub-critical (Re<3x105), ultra-critical (Re>3x105) and super critical (3x105 to 3x106).

#### 2.2.3.4. Vortex Excitation

The alternate shedding of vertices creates a transverse forces called as lift. According to practical design purpose it is divided into two forms, such as

(i) In sub-critical and ultra-critical Re range

The frequency of lift force is regular, but magnitude is random. When frequency of vortexshedding is close to natural frequency of a chimney (when its motion is near sinusoidal), maximumresponse is obtained. The exciting force should be taken as,
$FL=1\ \rho aAU2\sin v_o \bar{A}L$
2
The response of the structure depends on the time-average energy input from the vortex sheddingforces. In the expression $\bar{A}L$ has the time-average value rms value of the lifting force coefficient with a range of frequencies close to the natural frequency $v_o$ of the structure.

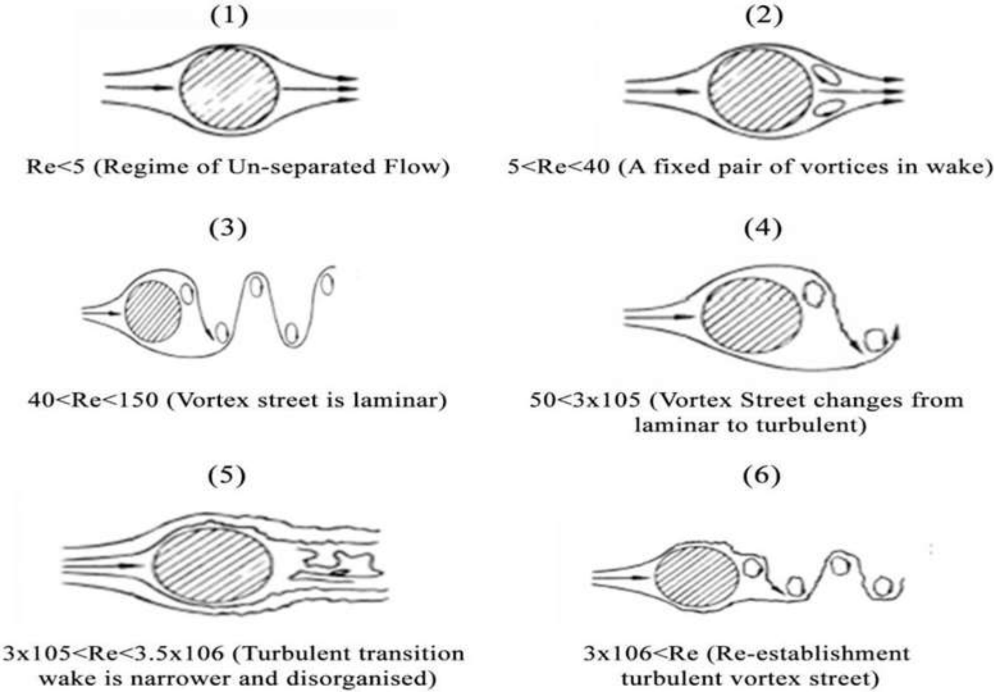

Figure.2.1. Regimes of fluid Flow across circular cylinder

(ii) In super-critical Re range

In this range both frequency and magnitude are random in nature. Here structure's responsedepends on the power input. If we plot power -input density function S / (St) against non- dimensional frequency St, then the power spectrum of the lift-force should be expressed as,

$Sl = [\ 1\rho AU2\sqrt{}CL\ ]Sl\ (St)$

2

According to the IS 6533 Part 2: 1989 ,If period of natural oscillation for the self supportedchimney exceed 0.25 seconds, the design wind load should take into consideration the dynamic effect due to pulsation of thrust caused by the wind velocity in addition to the static wind load.it depends on the fundamental periods of vibration of the chimney.

### 2.3. Seismic effects

Due to seismic action, an additional load is acted on the chimney. It is considered as vulnerable because chimney is tall and slender structure. Seismic force is estimated as cyclic in nature for a short period of time. When chimney subjected to cyclic loading, the friction with air,

friction between the particles which construct the structure, friction at the junctions of structural elements, yielding of the structural elements decrease the amplitude of motion of a vibrating structure and reduce to normal with corresponding to time. When this friction fully dissipates thestructural energy during its motion, the structure is called critically damped. For designing earthquake resistant structures, it is necessary to evaluate the structural response to ground motion and calculate respective shear force, bending moments. Hence ground motion is the important factor for seismic evaluation. To estimate exact future ground motion and its corresponding response of the structure, it depends on soil-structure interaction, structural stiffiness, damping etc. For analysis purpose, chimney is behaved like a cantilever beam with flexural deformations. Analysis is carried out by following one of the methods according to the IS Codal provision,

1. Response-spectrum method (first mode)
2. Modal-analysis technique (using response spectrum)
3. Time-history response analysis.

### 2.4. Analysis & design software

STAAD Pro is a structural analysis and design software programme that was created by research engineers International in 1997.Bentley System acquired Research Engineers International at the end of 2005.

One of the most popular structural analysis and design software tools available today. It supports more than 90 international design regulations for steel, concrete, wood, and aluminium. It can use a variety of analytical techniques, including more modern ones like p-delta analysis, geometric non- linear analysis, pushover analysis, and buckling analysis, as well as more traditional ones like static analysis. It can also leverage a variety of dynamic analytic techniques, including response spectrum analysis and time history analysis. Both user-defined spectra and a variety of international code specified spectra are supported by the response spectrum analysis capability.

It is utilised for structural project analysis and design across the board, including for plants, buildings, bridges, towers, tunnels, metro stations, wastewater treatment facilities, and more.

The important features of this software are:

- Analytical Modelling
- Physical Modelling
- STAAD Building Planner
- Steel AutoDrafter
- Advanceed Concrete design
- Advanced Slab Design
- Earthquake mode

- OpenSTAAD Macro Editor

## 3.0. METHODOLOGY

### 3.1. Outlay of works

1. The present literature is reviewed by various researchers choice of types of structures.
2. The modeling of RCC chimney is done by using STAAD.PRO.
3. Various load cases are developed.
4. Then the combination of load is done.
5. The static as well as dynamic analysis of reinforced concrete chimney is carried out for windand earthquake load.
6. The critical load combination for model of chimney is identified.
7. The various parameters like bending moments, shear forces, displacement, time period andaxial forces are determined
8. The analysis on selected chimney models is performed and the results of analysis arecompared.
9. The detailing of analysis and graphs are discussed.
10. The conclusions are obtained for the result.

### 3.2. Modelling

1. A chimney model is created using a line or beam element.
2. A 150-meter chimney with fixed support assigned to the base node of the botommost element is shown in the Staad model of chimney employing line or beam elements. In order to allocate cross sections, tapered tube elements were used.

Table.3.1. Geometric Destails of Chimney

| |
|---|
| Height of the chimney |
| Outer diameter at bottom |
| Outer diameter at top |
| Grade of concrete |
| Height to base diameter ratio |
| Top diameter to base diameter ratio |
| Thickness at top |
| Thickness at bottom |
| Foundation type |

### 3.3. Description of loading

(a) Dead Load

Density of various materials considered for design:

(i) Concrete = 25KN/m3
(ii) Insulation = 1KN/m3
(iii) Structural steel = 78.5KN/m3
(iv) Soil = 18KN/m3

(b) Live Load = 5KN/m2

(c) Wind Load

The following wind parameters are followed in accessing the wind loads on the structure:

Table.3.2.Wind Load Parameters

| Chimne No. | Basic Wind Speed (m/sec) | Risk Coefficient ($k_1$) | Terrain height andstructure size factor ($k_2$) | Topographic Factor ($k_3$) | Importance factor ($k_4$) |
|---|---|---|---|---|---|
| 1 | 55 | 1.08 | 1.3 | 1 | 1.15 |

(d) Earthquake load

The following earthquake load parameters as per IS 1893 code:

Table 4-2 Seismic Load Parameters

| Chimney No. | Zone | Soil type | Zone factor | Importance factor | Response reduction factor |
|---|---|---|---|---|---|
| 1 | II | Moderate | 0.10 | 1.5 | 5 |
| 2 | III | Moderate | 0.16 | 1.5 | 5 |
| 3 | V | Moderate | 0.36 | 1.5 | 5 |

### 3.4. Estimation of various load

### 3.4.1. Calculation of Static Wind Load

- According to IS 875 (Part 3): 2005 basic wind speed can be calculated,

VZ=Vb *K1* K2* K3* K4

- The second equation for calculating design wind pressure as per IS 875(part 3):2005:

Pz=0.6* V 2

- To determine the wind force acting at different heights of chimney, the chimney shall bedivided into ten or more sections along its height. The along wind load or drag force per unit height of the chimney at any level shall be calculated from the equation as per Clause No A-4.1 of IS 4998 (Part 1):1992.

Fd = pz*CD* dz

### 3.4.2. Calculation of Dynamic Wind Loads

- The amplitude of vortex excited oscillation perpendicular to direction of wind for any modeof oscillation shall be calculated by the formula:

(a) Across wind load –Simplified method
(b) Across wind load –Random response method

### 3.4.3. Seismic Load Calculation

Analysis procedure for earthquake load as per 1893(part 4): 2005.Seismic action on chimneys are an additional source of natural loads acting on the chimney. Seismic action or the earthquake is a short and strong disruptions of the ground. The steps required for calculation of moment and shear force:

I. Fundamental period
II. Horizontal seismic force
III. Determine design shears and moment

### 3.4.4. Structural analysis in software

- A model is created and modified that numerically defines geometry, properties, loading andanalysis factor for configuration.
- Analysis of model is executed.
- The results of analysis is reviewed.
- The analysis of structure is checked and optimized. This is done in three phases:

Phase I: Pre processing

At first making of the frame model which to be analysed is done and then the properties like density, youngs modulus of elasticity etc. are assigned. Basic model of RCC chimney is completed.Then various loads, load cases are defined and assigned. Now the model is ready for analysis.

Figure.3.1. Self-weight on Chimney

Phase II: Analysis

The next step is to analyse the model. Click on run analysis to perform.Phase III: Post Processing Without any warning and error software displays deformed results for maximum displacement, maximum base shear, deflection, bending stresses etc.

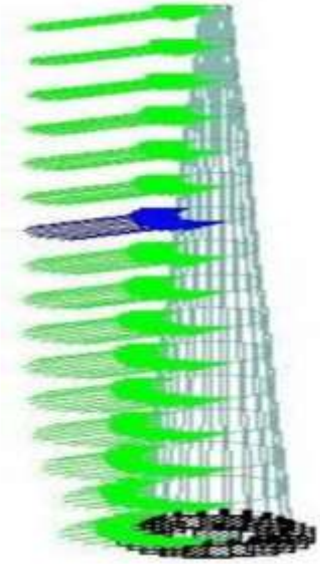

Figure .3.2. Wind load on Chimney

### 4.0. Results and discussions:

Tables and graphs are used to display the STAAD Pro results for several seismic zones and a 50 m/sec wind speed. The analysis has been completed as follows for the sake of continuous discussion.

A formula that takes seismic and wind loads into account has been proposed for an exact solution using IS codal provisions.

Four STAAD models with comparable geometrical properties were used in the analysis, which was done using the analysis and design programme STAAD Pro.In this instance, STAA Pro v8i ss6 is utilised for analysis.

### 4.1. Free vibration of chimney

The wind causes forced, random vibrations in line with the wind to occur on chimneys, while the cross wind causes vortex-induced vibrations. Due to the availability of the real structure, measuring the industrial chimney's free vibration response at full size was the most appropriate way to explore how soil influences affect free vibrations.

Natural frequencies and accompanying time periods for the 150-meter chimney are shown in Table 4.1. These outcomes fit up with the modal analysis of the linear model created in STAAD that was previously mentioned. The wind and seismic analyses employed the acquired mode shapes for each frequency.

Table.4.1. Free Vibration Characteristics of Chimney

| Modes | Frequency (Hz) | Time Period (Sec) |
|---|---|---|
| 1 | 0.475 | 2.10342 |
| 2 | 0.475 | 2.10342 |
| 3 | 1.695 | 0.59006 |
| 4 | 1.695 | 0.59006 |
| 5 | 3.801 | 0.26306 |
| 6 | 3.801 | 0.26306 |
| 7 | 5.974 | 0.16739 |
| 8 | 5.974 | 0.16739 |
| 9 | 6.362 | 0.15718 |
| 10 | 6.690 | 0.14948 |

### 4.2. Base shear, moment & force analysis of seismic zone-ii

Table .4.2. Base Shear in Zone II

| Mode | Base Shear (KN) | | |
|---|---|---|---|
| | X | Y | Z |
| 1 | 0.22 | 0.00 | 137.75 |
| 2 | 137.75 | 0.00 | 0.22 |
| 3 | 16.36 | 0.00 | 224.38 |
| 4 | 224.38 | 0.00 | 16.36 |
| 5 | 79.44 | 0.00 | 58.20 |
| 6 | 58.20 | 0.00 | 79.44 |

Table .4.3. Forces in Zone II

| Mode | Forces (KN) | | |
|---|---|---|---|
| | $F_X$ | $F_Y$ | $F_Z$ |
| 1 | -5.31 | 0.00 | 132.22 |

| | | | |
|---|---|---|---|
| 2 | 143.28 | 0.00 | 5.76 |
| 3 | -44.22 | 0.00 | 163.80 |
| 4 | 284.95 | 0.00 | 76.93 |
| 5 | 147.43 | 0.00 | 126.19 |
| 6 | -9.80 | 0.00 | 11.45 |

### 4.3. Mode shape of chimney in zone II

Figure.4.1. Mode shape 1 ZONE II

Figure.4.2.Mode shape 2 ZONE II

### 4.4. BASE SHEAR,MOMENT AND FORCE ANALYSIS OF SEISMICZONE III

Table.4.4. Base shear in KN in zone III

| Mode | Base Shear (KN) | | |
|---|---|---|---|
| | X | Y | Z |
| 1 | 0.36 | 0.00 | 220.40 |
| 2 | 220.4 | 0.00 | 0.36 |
| 3 | 26.17 | 0.00 | 359.00 |
| 4 | 359.00 | 0.00 | 26.17 |
| 5 | 127.10 | 0.00 | 93.11 |
| 6 | 93.11 | 0.00 | 127.10 |

Table.4.5 .Moment in KNm in zone III

| Modes | Moment (KNm) | | |
|---|---|---|---|
| | $M_X$ | $M_Y$ | $M_Z$ |
| 1 | 21681.85 | 0.00 | 870.88 |
| 2 | 943.77 | 0.00 | -23496.50 |
| 3 | 11403.18 | 0.00 | 3078.67 |
| 4 | 5355.85 | 0.00 | -19837.70 |
| 5 | 5232.09 | 0.00 | -6112.89 |
| 6 | 474.59 | 0.00 | 406.21 |

Table.4.6 .Forces in Zone III

| Mode | Forces (KN) | | |
|---|---|---|---|
| | $F_X$ | $F_Y$ | $F_Z$ |
| 1 | -8.5 | 0.00 | 211.55 |
| 2 | 229.26 | 0.00 | 9.21 |
| 3 | -70.76 | 0.00 | 262.08 |
| 4 | 455.93 | 0.00 | 123.09 |
| 5 | 235.89 | 0.00 | 201.90 |
| 6 | -15.68 | 0.00 | 18.31 |

### 4.5. Base shear, moment, forces analysis of seismic zone V

Table.4.7 .Base Shear in ZONE V

| Mode | Base Shear (KN) | | |
|---|---|---|---|
| | X | Y | Z |
| 1 | 20.53 | 0.00 | 476.18 |
| 2 | 476.18 | 0.00 | 20.53 |
| 3 | 105.47 | 0.00 | 761.16 |
| 4 | 761.16 | 0.00 | 105.47 |
| 5 | 462.57 | 0.00 | 32.92 |
| 6 | 32.92 | 0.00 | 462.56 |

Table.4.8. Moment in KNm in ZONE V

| Modes | Moment (KNm) | | |
|---|---|---|---|
| | $M_X$ | $M_Y$ | $M_Z$ |
| 1 | 38671.55 | 0.00 | 8028.29 |
| 2 | 12236.08 | 0.00 | -58936.43 |
| 3 | 20790.16 | 0.00 | 7739.15 |
| 4 | 16917.66 | 0.00 | -45446.96 |
| 5 | 4050.72 | 0.00 | -15184.71 |
| 6 | 8789.28 | 0.00 | 2344.66 |

Table.4.9.Forces in Zone V

| Mode | Forces (KN) | | |
|---|---|---|---|
| | $F_X$ | $F_Y$ | $F_Z$ |
| 1 | -78.34 | 0.00 | 377.32 |
| 2 | 575.04 | 0.00 | 119.39 |
| 3 | -177.87 | 0.00 | 477.82 |
| 4 | 1044.50 | 0.00 | 388.82 |
| 5 | 585.96 | 0.00 | 156.31 |
| 6 | -90.48 | 0.00 | 339.17 |

### 4.6. Seismic analysis result

The table below represents shear force and bending moment values obtained from the earthquake analysis for the zones II, III & V. Analysis is carried out using IS 1893 (part4): 2005. It is observedthat there is at least 50% increase in moments in every zone when compared to its previous zone.These are the maximum moments obtained at the base of the chimney.

Table.4.10. Results of Seismic Analysis

| Sl No. | Zone | Zone Factor | Shear Force (KN) | Bending Moment (KNm) |
|---|---|---|---|---|
| 1 | II | 0.10 | 281.58 | 14685.31 |
| 2 | III | 0.16 | 450.52 | 23496.50 |
| 3 | V | 0.36 | 1016.22 | 58936.43 |

### 4.7. Base shear, moment & force analysis for basic windspeed vb 50 m/s

Table.4.11. Forces in KN

| Mode | Forces (KN) | | |
|---|---|---|---|
| | $F_X$ | $F_Y$ | $F_Z$ |
| 1 | -353.98 | 0.00 | 8812.8 |
| 2 | 436.76 | 0.00 | 17.54 |
| 3 | -3867.18 | 0.00 | 14323.78 |
| 4 | -4011.62 | 0.00 | 1083.07 |
| 5 | 4399.18 | 0.00 | 3765.30 |
| 6 | -4316.59 | 0.00 | 5043.27 |

Table.4.12. Moment in KNm

| Modes | Moment (KNm) | | |
|---|---|---|---|
| | $M_X$ | $M_Y$ | $M_Z$ |
| 1 | 903226.61 | 0.00 | 36279.40 |
| 2 | 1798.01 | 0.00 | -44764.03 |
| 3 | 623236.06 | 0.00 | 168236.50 |
| 4 | 47125.10 | 0.00 | -174548.02 |
| 5 | 97574.87 | 0.00 | -114001.21 |
| 6 | 130692.41 | 0.00 | 111861.08 |

Table .4.13. Base shear in KN

| Modes | Moment (KNm) | | |
|---|---|---|---|
| | $M_X$ | $M_Y$ | $M_Z$ |
| 1 | 0.13 | 0.00 | 8816.12 |
| 2 | 82.65 | 0.00 | 14.22 |
| 3 | 9.81 | 0.00 | 14360.12 |
| 4 | 134.63 | 0.00 | 1046.72 |
| 5 | 47.66 | 0.00 | 3724.51 |
| 6 | 34.92 | 0.00 | 5084.06 |

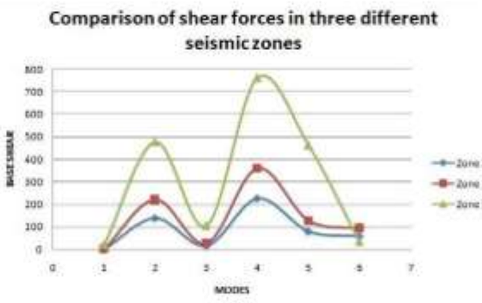

*Figure.4.4. Comparison of shear force*

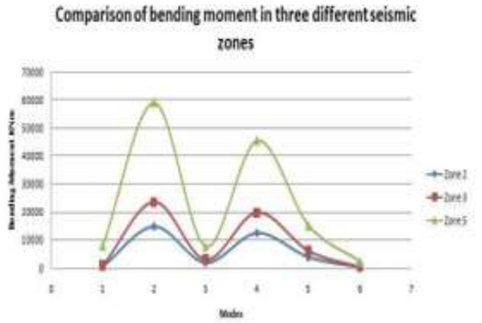

*Figure.4.5Comparison of Bending Moment*

## 4.8. Wind analysis result

According to IS 875(part 3):2005 and IS 4998(part 1):1992, the table below shows the shear force and bending moment values determined from the wind analysis at a wind speed of 50 m/s.The wind analysis is done and reported by individually computing along and across wind effects. When compared to along wind effects, it is seen that across wind impacts are extremely large.

Table .4.14. Results of wind analysis

| Chimney Heightm | Base shear KN | | Base moment KNm | |
|---|---|---|---|---|
| | Along Wind | Across Wind | Along Wind | Across Wind |
| 150 | 168.95 | 18020.89 | 36279.40 | 903226.61 |

## 5.0. Conclusion

The aim of this study is to analyze RCC Chimney subjected to wind and seismic loading. Stress and deflection is studied by considering in different zones. The analysis is carried out by structuralanalysis and design software which is known as STAAD PRO V8i SS6.After a successful completion of analysis the following conclusions are drawn:

- From the above results and discussion it is observed that shear force and bending moment increases with increases in zone factor values.
- The effect of wind force is quite significant as compared with earthquake forces over 150 m RCC Chimney.
- Geometry of chimney has to be chosen in order that deflection produced at top of chimney iswell within permissible limits.
- While comparing loads acting on an industrial RCC chimney, the wind loads are the governingloads for design of chimney shell.

## 6.0. References

- K. Anil Pradeep and C.V Siva Rama Prasad (2014),” Governing loads for design of 60m Industrial RCC Chimney”, International Journal of Innovative Research in Science, Engineering and Technology, vol:03, Issue 08.
- Veena RN, Suresh S (2016),“Analysis and design of RCC Chimney”, International Journal ofMechanical Engineering and Information Technology, vol:04,Issue 01,pp no:1598- 1603,ISSSN-2348-196x.
- Kaluram S.Langhe and Vijaykumar R. Rathi (2016),”Analysis of Self Supported RCC Chimney with Geometric Variation”, International Research Journal of Engineering and Technology,vol:03,Issue:07,ISSN:2395-0056.
- C.V Siva Rama Prasad, Y Vijaya Simha Reddy,J Prashanth Kumar (2018),”Earthquake and wind analysis of a 100m Industrial RCC Chimney”, International Journal of Technical Innovation in Modern Engineering and Science,vol:04,Issue:02,e- ISSN:2455-2585.

- Aneet Khombe, Anand Bagali, Md.Imran IrayyaR, Sachin R Kulkarni (2016),"Seismic Analysis and Design of RCC",International Journal of Advanced Engineering and Research Development,vol:03,Isuue:05,e-ISSN:2348-4470,p-ISSN:2348-6406.
- Shubham Sukla, Mr.Abhishek Kumar and Mohd.Afaque (2016),"Analysis of Self SupportingSteel Chimney as per Indian Standard-A Review", International Research Journal of Engineering and Technology,vol:03,Issue:02,e-ISSN:2395-0056,p- ISSN:2395-0072.
- K Chaithanya Varada Prasad, Dr.K.L Radhika, Mrs P Anuradha, B Santosh Reddy, (2018)"Dynamic Analysis of a Tall Chimney", International Journal for Research in AppliedScience and Engineering Technology,vol:06,Issue:11,ISSN:2321-9653.
- K R.C Reddy, O.R Jaiswal, PN. Godbole (2011),"Wind and Earthquake Analysis of Tall RCC Chimney", International Journal of Earth Sciences and Engineering, vol:04, pp:508- 511,ISSN:0974-5904.
- Kaluram S.Langhe, Vijaykumar R.Rathi (2016),"Analysis of Cantilever Reinforced ConcreteChimney with Variation in Geometry" vol:04,Issue:04,ISSN:2321-0613.
- B. R. Jayalekshmi1,S. V. Jisha1,R. Shivashankar (2015)," Wind load analysis of tall chimneys with piled raft foundation considering the flexibility of soil" Int Journal Advanced StructuralEngineering ,7:95–115 DOI 10.1007/s40091-015-0085-6.
- Anamika K.C and Nithya M.(2018)," Reviews On Wind And Temperature Effects On Rcc Chimneys", International Journal of Engineering Development and Research vol:6, Issue 02,ISSN: 2321-9939.
- Choppalli Kalyani Ramarao and Patil Yogesh D," Effect of Openings in the Analysis of Shellfor a 275m Tall Multiflue RCC Chimney", International Journal of Engineering Innovation &Research, vol 4, Issue 2, ISSN: 2277 – 5668.
- Aniruddhasinh R. Sindha & Jignesh A. Amin (2019)," Assessment of Seismic Response Reduction Factor of RC Chimney According to H/D",Internatonal Journal of Research and Analytical Reviews, volume 06, Issue: 01, e-ISSN: 2348–1269.
- Aneet Khombec, Anand Bagali, Md Imran G, Irayya R and Prof Sachin R Kulkarni (2016),"Dynamic Analysis of RCC Chimney- A Review", International Journal for Scientific Research & Development vol:4, Issue 02,ISSN: 2321-0613.
- IS 875 (Part-lll):1987. Code of Practice for Design Loads for Buildings and Structures, Published by Bureau of Indian Standard, New Delhi.
- Shubham Baghel1, Dr. J.N Vyas,(2019)," Comparative Analysis of RC & Steel Chimney withVarying the Height of Stack", International Research Journal of Engineering and Technology,vol:06, Issue:07, e-ISSN: 2395-0056,p-ISSN: 2395-0072.
- Nagendra Singh and Satish Parthar." Self-supported steel chimney analysis as per Indian standard", International Journal of Advance Research, Ideas and Innovations in Technology,volume: 04, Issue: 03, ISSN: 2454-132x.
- IS 1893 (Part-1):2002, Criteria for Earthquake Resistant Design Concrete of Structure Published by Bureau of India Standard, New Delhi.
- IS 4998(part-1):1992,Criteria for Design of Reinforced Concrete Chimneys published by Bureau of India Standard, New Delhi.
- T.Subramani1, P.Sankar , R.Anbalagan, P.Rama, C.Vijaya (2019)," Design and Analysis of Industrial Steel Structure By Using STAAD Pro", International Journal of Application or Innovation in Engineering & Management,vol:08,Issue:08,ISSN 2319 – 4847.
- T Subramani and P.Shanmuga (2012)," Seismic Analysis and Design of Industrial Chimneys by Using Staad Pro", International Journal of Engineering Research and Applications, vol:02,Issue 04, pp.154-161,ISSN: 2248-9622.