International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-3 Issue-5, October 2013

Analysis of Self-Supporting Chimney

Rajkumar, Vishwanath. B. Patil

Abstract—Chimneys are tall structures and the major loads acting on these are self weight of the structure, wind load, live load due to lining, earthquake load & temperature loads. In this paper a RC chimneys will be designed considering dead load, wind load and earthquake load. The Bureau of Indian Standards (BIS) design codes procedures will be used for the design of chimney. The present paper discusses the parametric study of RC chimney which is made by obtaining the results from software for different heights, diameter, earthquake zones, wind zones, type of soils and various load conditions because of changes in the dimensions of chimney, structural analysis such as response to earthquake and wind oscillations have become more critical to influence on the response and design of chimney. Parametric study on chimney from height 150 meters to 250 meters at an interval of 5 meters, for Zone II, Hard soil & Critical Zone of Zone V, Soft soil with wind speed varying from 33 meters/sec to 55 meters/sec with an internal temperature of 100 Degrees. The response of the chimney is studied & recorded in Tables & Graphs. The analysis is carried out using programming software Microsoft Visual Basic 6.0. The results obtained from the above cases are compared. Finally, the maximum values obtained in wind analysis and seismic analyses are then compared for deciding the design value.

Keywords: - RC Chimney, along & across wind analysis, Seismic analysis, Visual Basic.

I. INTRODUCTION

Chimneys or stacks are very important industrial structures for emission of poisonous gases or smoke from a boiler, stove, furnace or fireplace to a higher elevation such that the gases do not contaminate surrounding atmosphere. These structures are tall, slender and generally with circular cross-sections. Different construction materials, such as concrete, steel or masonry, are used to build chimneys. Steel chimneys are ideally suited for process work where a short heat-up period and low thermal capacity are required. Also, steel chimneys are economical for height up to 45m. They are typically almost vertical to ensure that the hot gases flow smoothly, drawing air into the combustion through the chimney effect. Chimneys are tall to increase their draw of air for combustion and to disperse the pollutants in flue gases over a greater area in order to reduce the pollutant concentrations in compliance with regulatory or other limits. The first industrial chimneys were built in the mid 17th century when it was first understood how they could improve the combustion of a furnace by increasing the draft of air into the combustion zone. As such, they played an important part in the development of refractory furnaces and a coal-based metallurgical industry, one of the key sectors of the early Industrial Revolution.

Manuscript published on 30 October 2013.
***Correspondence Author(s)**
Rajkumar, P G Student, Structural Engineering Department, P.D.A.College of Engineering, Gulbarga-585102, Karnataka, India.
Vishwanath. B .Patil, Professor, Structural Engineering Department, P.D.A. College of Engineering, Gulbarga-585102, Karnataka, India.

Most 18th century industrial chimneys generally located adjacent to a steam-generating boiler or industrial furnace and the gases are carried to it with ductwork. Chimneys with height exceeding 150 m are considered as tall chimneys. However it is not only a matter of height but also the aspect ratio when it comes to classifying a chimney as tall [1]. Wind is essentially the large-scale movement of free air due to thermal currents. It plays an important role in chimney design because of its capacity to transport and disperse pollutants and also because it exerts static and dynamic loads whose effects on a slender structure, such as a chimney, are significant. It is very difficult to predict wind effects precisely by analytical procedures because of winds uncertain variability and therefore a designer is forced to use approximate design techniques.

The enforcement of stricter air-pollution control standards has led to the construction of increasingly tall RC chimneys worldwide. Further due to the availability of advanced construction materials chimney shell is being made with thinner wall. As a result, chimneys have become more slender and sensitive to wind-induced vibrations. The cross-section of the chimney is generally hollow circular, from aerodynamic considerations, and tapered, from considerations of structural economy and aesthetics. The chimney is subject to gust buffeting in the along-wind direction due to drag forces, and also to possible vortex shedding in the across-wind direction.

Tall reinforced concrete (RC) chimneys form an important component of major industries and power plants. Damage to chimney due to wind or earthquake load may lead to shut down of power plants and important industries. However, if chimney is located in higher seismic zone and lower wind speed zone, then, earthquake forces may become comparable, if not more, than the wind loads. In fact, the chimney is designed for the combined effect of along-wind and across-wind loads. Wind is essentially the large-scale movement of free air due to thermal currents. It plays an important role in chimney design because of its capacity to transport and disperse pollutants and also because it exerts static and dynamic loads whose effects on a slender structure, such as a chimney, are significant. It is very difficult to predict wind effects precisely by analytical procedures because of winds uncertain variability and therefore a designer is forced to use approximate design techniques.

K.R.C. Reddy [2] studied on wind and earthquake analysis of tall chimney. In the paper, two RC chimneys are analyzed for earthquake and wind loads as per IS 1893 (Part 4): 2005 and IS 4998 (Part 1): 1992 respectively. The comparison of wind loads with that of earthquake loads are made to decide the most critical loads for the design of the chimney shell. The design wind load is obtained by combination of along and across-wind response of the chimney.

The combination is performed as per the procedure given in ACI 307-98 code. They came to a conclusion as; the wind loads are always governing the design of chimney shell. In the most critical earthquake zone with zone factor of 0.36 and response reduction factor of 1.5, the earthquake response is almost matching with that of wind response but never been crossing the wind response.

II. INTRODUCTION TO MICROSOFT VISUAL BASIC

BASIC means Beginners All Purpose Symbolic Instruction Code. It is a fairly easy programming language to learn. Different software companies produced different version of BASIC, such as Microsoft QBASIC, QUICKBASIC, GWBASIC, IBM BASICA and so on many of the things that you can do with Visual Basic really aren't very basic at all. The Visual Basic language is quite powerful — if you can imagine a programming task; it can probably be accomplished using Visual Basic.
VISUAL BASIC is a VISUAL and events driven Programming language. These are the main divergence from the old BASIC. In BASIC, programming is done in a text-only environment and the program is executed sequentially. In VISUAL BASIC, programming is done in a graphical environment. Because users may click on a certain object randomly, so each object has to be programmed independently to be able to response to those actions (events).Therefore, a VISUAL BASIC Program is made up of many subprograms, each has its own program codes, and each can be executed independently and at the same time each can be linked together in one way or another.

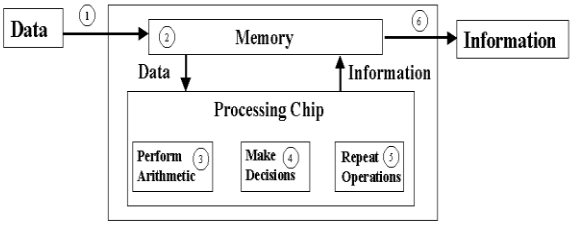


Fig. No.1: Shows the Hierarchy in which Visual Basic works.

III. OBJECTIVE

The main objective of this paper is to get the comparative study of seismic, along wind and across wind effects on a varying height from 150m to 250m at an interval of 5m, for Zone II, Hard soil & Critical Zone of Zone V, Soft soil with wind speed varying from 33 meters/sec to 55 meters/sec with a internal temperature of 100 degree Celsius. The chimney is lined with mild steel and stainless steel whose unit weight is 78.5 KN/m3. The Chimney shell is discretized into 10 segments/zones along the height for calculation purpose. Microsoft Visual Basic 6.0 is used for calculation of the geometry of chimney, seismic analysis, along wind analysis, across wind analysis, natural frequency of the chimney due to self-weight including lining. Program is generated to calculate the wind loads, shear forces and bending moments at different locations in the chimney. The Chimney behavior of Vortex oscillation in fundamental mode & higher modes for different wind speed from 33 meters/sec to 55 meters/sec is also studied & recorded in Tables & Graphs.

IV. ANALYSIS OF RC CHIMNEY

A. Description of Structure

A single flue chimney of 4m diameter at top and multi-flue chimney of 8m diameter at top with a varying height of 150m to 250m with an interval of 5m is considered in this paper. The following are the sample data.

1. Outer diameter of Chimney at top	= 8 m
2. Height of Chimney	= 150 m
3. Taper of Chimney	= 1in 50
4. Top thickness of concrete shell	= 0.3 m
5. Bottom thickness of concrete shell	= 0.45 m
6. Thickness of lining	= 0.12 m
7. Grade of concrete	= M35
8. Seismic zone	= Zone II
9. Type of Soil	= Hard soil
10. Basic wind speed	= 33 m/sec
11. Inside temperature of Chimney	= 100 degree

B. Earthquake Analysis

The earthquake loads are obtained as per IS 1893 (Part-1): 2002. The fundamental time period for stack-like structures, is given by:

$$T = C_T \sqrt{\frac{W_t.h}{E_s.A.g}}$$

Where, C_T = Coefficient depending upon the slenderness ratio of the structure, Wt = Total weight of structure including weight of lining & contents above the base = 59059 kN, h = Height of structures above the base = 150 m, Es = Modulus of elasticity of material of the shell = $3.5x10^{10}$ N/m, A = Area of cross-section at the base of the structural shell = 19.15 m^2, g = Acceleration due to gravity.=9.81sec
Radius of gyration= $\sqrt{MIbase\ /\ Acbase}$ = 4.79
Slenderness ratio= ht/re = 31.31
From table-6 of IS-1893-4-2005,
Ct=56
T = 2.05 Sec
Horizontal Seismic Force:

$$A_h = \frac{\left[\frac{Z}{2}\right]\left[\frac{S_a}{g}\right]}{\left(R/I\right)}$$

Where, Z = Zone factor given, = Zone II = 0.10, I = Importance factor, for RCC chimney = 1.5, R= Response reduction factor, for RCC chimney=3, the ratio of R/ I shall not be less than 1.0 =2.0, Sa / g = Spectral acceleration coefficient for rock & soil sites. For rocky or hard soil
Sa / g = = 0.407
Ah = 0.012175
Design Shear Force & Moment: by Equilateral Static Lateral Force method,
V = Cv. Ah. Wt. Dv
M=Ah. Wt. h. Dm

Where, C_v = Coefficient of shear force depending on slenderness ratio k, table-6=1.35, h = Height of centre of gravity of structure above base = 53.25m, Dv, Dm = Distribution factors for shear & moment respectively at a distance X from the top from table-10, Dv = 1.0, Dm=1.0.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Vbase = Cv. Ah. Wt. Dv = 861.41kN
Mbase =Ah. Wt. h. Dm = 38289.05 kN-m
f_{conc} = (Cumulative wt of lining +concrete)/Ac_{base} + (M_{base}/MI_{base})*D_{outer}/2 = 3.69 Mpa
f_{steel} = m* fconc= 29.94 Mpa

C. Wind Analysis

The wind load on structure depends on gustiness of wind, topography of terrain and also on the interaction of wind with structures. Dynamic wind loads induces along-wind loads and across-wind loads on RC chimney. Here the wind loads are obtained from IS 875 (Part-3):1987 and random response method is used for analysis as given in IS 4998(Part-1):1992.

1. Along wind analysis (on top of Chimney)

The along-wind loads are caused by the drag component of the wind force on the chimney. This is accompanied by gust buffeting causing a dynamic response in the direction of mean flow.
From, IS 875 (Part-3): 1987,
Design wind speed $V_z = V_b \times k_1 \times k_2 \times k_3$

Where, k_1 risk coefficient (probability) = for 33 m /sec =0.98, table-1 p.no-11, k_2 terrain factor= table-2 p.no-12 =1, k_3 topography factor=1.36
Therefore, Vz = 46.72 m/sec
Design Wind pressure (P_z) = 0.6 x V_z^2 = 1.31 kN/m
The along wind load per unit height at any height z on a chimney shall be calculated from the equation:

$$F_z = F_{zm} + F_{zt}$$

Where,
Fz'= is the wind load in N/m height due to HMW at height z and is given by:
Fzm = pz. Cd. Dz = 7.38 kN
Fzt = is the wind load in N/m height due to the fluctuating component of wind at height z

$$Fzt = 3. (G-1)/H2. (Z/H) \int_H^0 Fzm . z . dz$$

$$G = \text{gust factor} = (1+gr .r. \sqrt{B + SE/Beta})$$

fi = natural frequency of chimney in the first mode of vibration in Hz = 0.48 Cps
V10 = hourly mean wind speed in m/set at 10 m above ground level = vb. K2=33.

Where, Vb and K2, are as defined in IS 875 (Part 3): 1987
S=Size reduction factor = (1+ 5.78 (fi/V10)1.14$H^{.98}$)$^{-.8}$= 0. 173
E = A measure of the available energy in the wind at the natural frequency of the chimney = [123 (fi/ V10) $H^{0.21}$] / [1+ $(330fi/V10)^2$ $H^{.42}]^{.83}$ = .065
B=Back ground factor indicating the slowly varying component of wind load fluctuation = $[1+ (H/265)^{.63}]^{-.88}$ = 0.627
r = Twice the turbulence intensity = 0.622-.178log10H = 0.243
gr = peak factor defined as the ratio of the expected Desk value to RMS value of the fluctuating load

$$VT = 3\ 6OOf,/(\ 1 + B^{\beta}/SE\ )^{1/2} = 1282.48$$

$$gr = \sqrt{2\log VT} + 0.587 \sqrt{2\log VT} = 3.98$$

$$G = (1+gr.r.\sqrt{B + SE/Beta}) = 2.18$$

$$Fzt = 3. (G-1)/H2. (Z/H) \int_H^0 Fzm . z . dz = 13.47 \text{ kN}$$

2. Across wind analysis

The across-wind loads are caused by the corresponding lift component of the wind force on the chimney. This is associated with the phenomenon of vortex shedding which causes the chimney to oscillate in a direction of wind flow.
In this analysis the 1st & 2nd mode shapes & its frequencies are calculated using Rayleigh's method. By adopting trail coordinates & purifying the trails until it converges. Then corresponding frequencies are calculated & corresponding Critical velocities Vcr1 & Vcr2. If the critical velocity is less than10% more than the design wind speed than the chimney is induced vortex oscillations & the corresponding forces are calculated.
Vcr1 = f 1 D / Sn

Where, fi=Natural frequency of the chimney in i^{th} mode of vibration, D=Effective diameter taken as average diameter over top 1/3rd height of chimney, Sn = Strouhal number is taken as 0.20.
Vcr2 = f 2 D / Sn

Ht	Dia	Wt	Mass	Y	Y 2	Y2*dz	M*Y 2	DYdz	F=M*Y* $\omega 2 * q$

Where, dz= Height of each bay,

Potential energy = Kinetic energy to get $\omega 2$

V. VISUAL BASIC PROGRAM OUTPUTS

The flow chart shown below, Illustrates the general procedure adopted for the analysis and design chimney for different load combinations as per IS 4998(Part-1):1992.

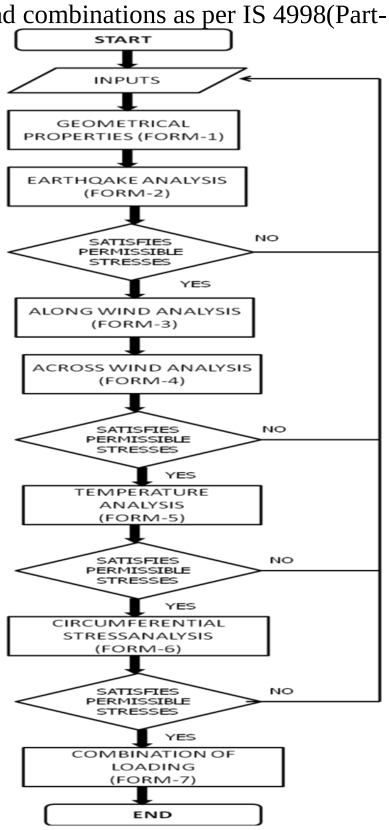


Fig. No.2: Shows the flow chart of Visual Basic.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

A. Analysis of Geometrical Properties (Form-1)

For a specified location and height. The geometrical properties of the chimney such as, inside diameter, outside diameter, area of concrete, area of lining, moment of inertia of concrete, weight of concrete, weight of lining & cumulative weight of concrete are computed for 10 equally spaced sections in Form (1).

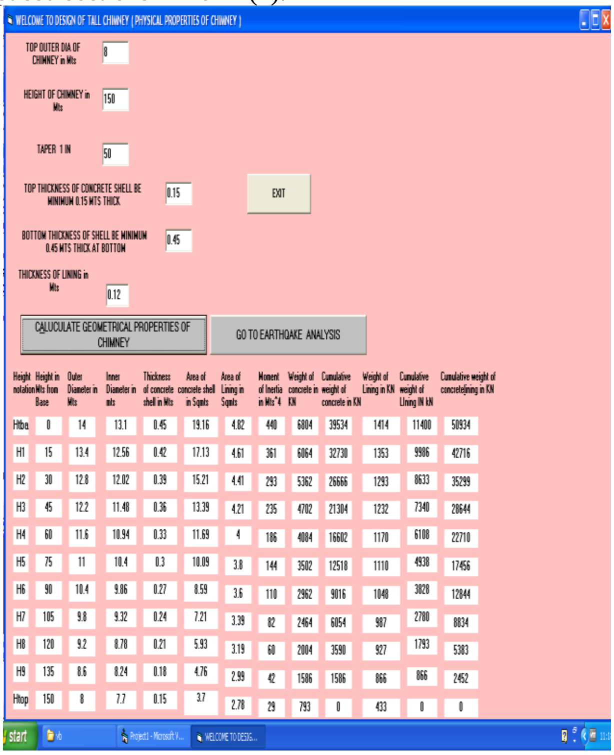


Fig. No.3: Shows the screen short(Form-1) of Visual Basic.

B. Seismic Analysis of Chimney (Form-2)

The form (2) performs the design Shear force & the design bending moments at 10 sections of the chimney & calculates the relative stresses in concrete & reinforcement for the design Earthquake forces & self load of chimney & checks for the permissible stresses.

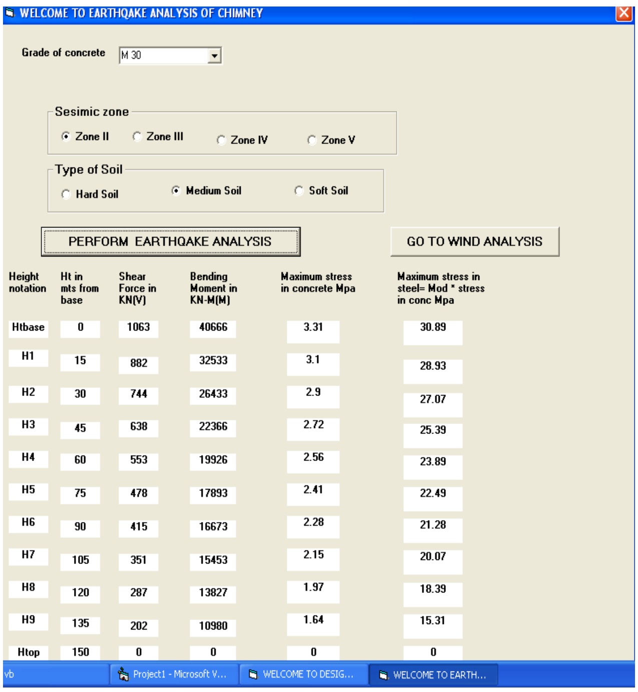


Fig. No.4: Shows the screen short(Form-2) of Visual Basic.

C. Along wind Analysis of Chimney (Form-3)

The form (3) performs the design horizontal forces due to static wind force (Fzm) & the forces due to dynamic effect in terms of gust (Fzt) then both the forces is combined, to get the design bending moments at 10 sections of the chimney & calculates the relative stresses in concrete & reinforcement, for the design bending moment & self load of chimney & checks for the permissible stresses.

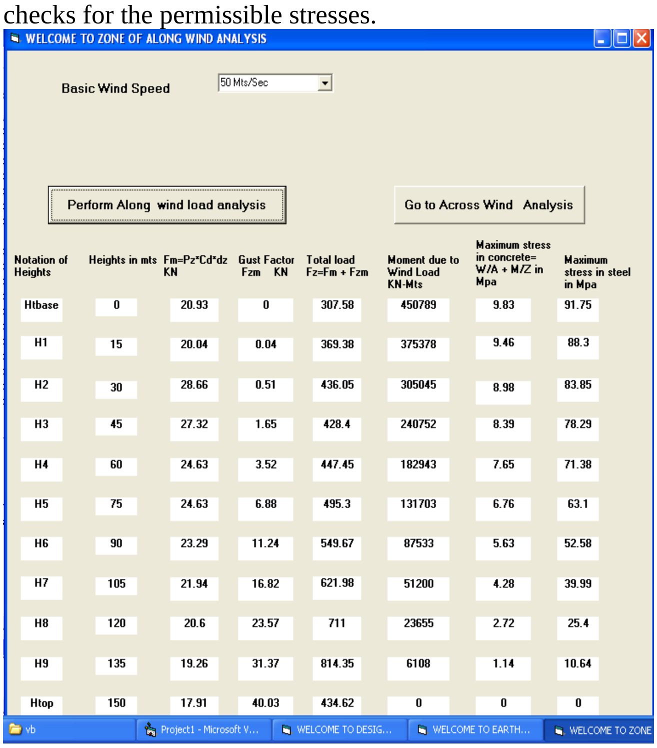


Fig. No.5: Shows the screen short(Form-3) of Visual Basic.

D. Across wind Analysis of Chimney (Form-4)

The form (4) performs the design horizontal forces due to across wind force & the across wind force is combined with the along wind force to get the design bending moments at 10 sections of the chimney & calculates the relative stresses in concrete & reinforcement, for the design bending moment & self load of chimney & checks for the permissible stresses.

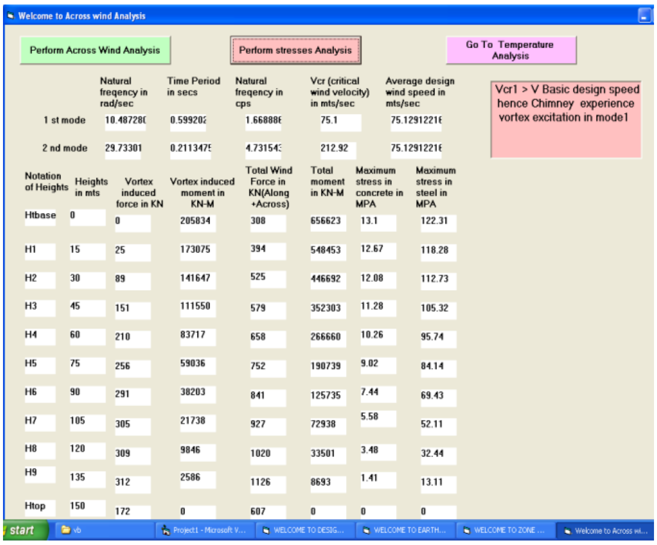


Fig. No.6: Shows the screen short(Form-4) of Visual Basic.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

E. Temperature effect Analysis of Chimney (Form-5)

The form (5) performs the stresses at 10 sections of the chimney, due to combination of the stresses due to dead load & earthquake or the wind loads whichever is critical with the temperature stresses & calculates the relative stresses in concrete & reinforcement, & checks for the relative permissible stresses.

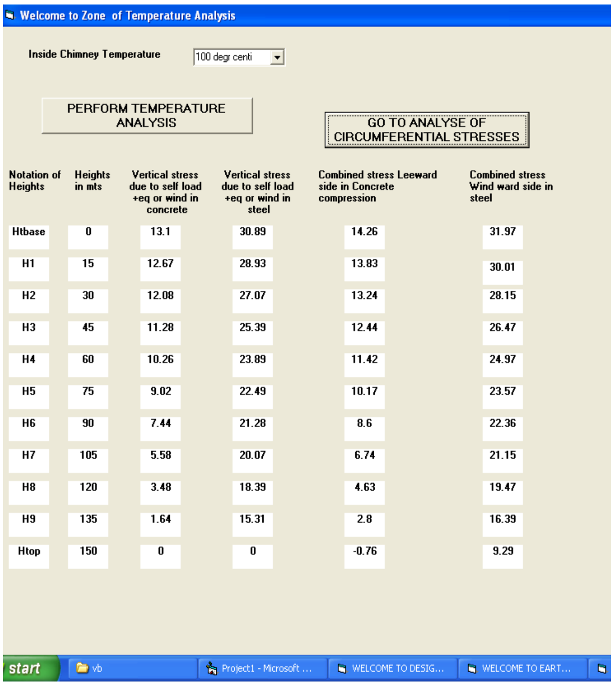


Fig. No.7: Shows the screen short(Form-5) of Visual Basic.

F. Circumferential stress Analysis on Chimney (Form-6)

The form (6) performs the stresses at 10 sections of the chimney, due to combination circumferential stresses due to wind & temperature & calculates the relative stresses in concrete & reinforcement, & checks for the relative permissible stresses.

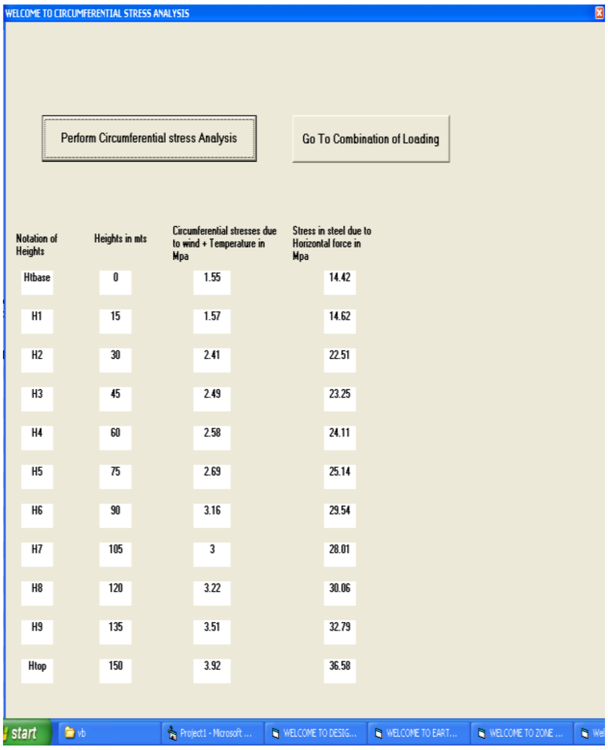


Fig. No.8: Shows the screen short(Form-6) of Visual Basic.

G. Load Combination (Form-7)

The form (7) will perform the required various load combinations cases as per **IS 4998 (Part-1): 1992** provisions.

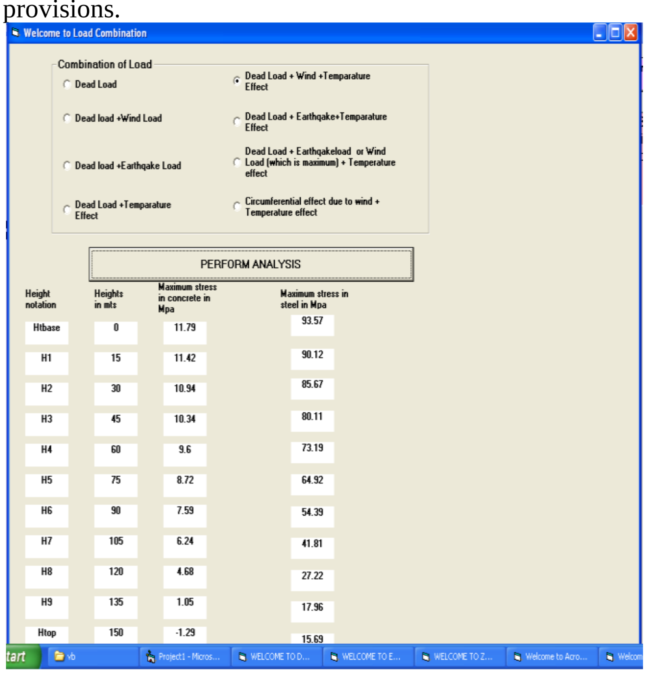


Fig. No.9: Shows the screen short(Form-7) of Visual Basic.

VI. RESULTS AND DISCUSSION

A. Vortex Oscillation in Primary Mode of RC Chimney

The Chimney is studied from 3 meters diameter to 8 meters at the interval of 0.50 meters for wind speed 33, 39,44,47,50 and 55m/sec for M35 grade of concrete. By studying the tabulated results in **Table 1 & Fig. No.10** the conclusion can be drawn, that the vortex oscillation depends upon wind speed, for the same diameter of chimney & all other data to be constant the chimney undergoes vortex oscillation in different heights. Also, the slenderness of the chimney is also an important factor influencing the vortex oscillation of the chimney. The chimney of 3 meter diameter undergoes vortex oscillation at 64 meters, for basic wind speed of 33 meters/sec, whereas, for the same wind speed, the chimney undergoes vortex oscillation at 189 meters for 8 meters diameter of chimney.

Table 1. Primary Mode of Oscillation

SL No	Dia in m	Height at Vortex Oscillation for Wind speed of					
		33m/ sec	39m/ sec	44m/ sec	47m/ sec	50m/ sec	55m/ sec
1	3.0	64	59	55	54	52	49
2	3.5	80	72	68	66	64	61
3	4.0	92	81	78	75	72	69
4	4.5	106	97	91	88	85	82
5	5.0	119	110	101	98	95	90
6	5.5	129	117	110	107	103	98
7	6.0	142	128	121	117	113	107
8	6.5	152	139	130	125	122	116
9	7.0	165	150	140	136	132	125

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

10	7.5	175	160	150	145	140	133
11	8.0	189	172	161	156	150	142

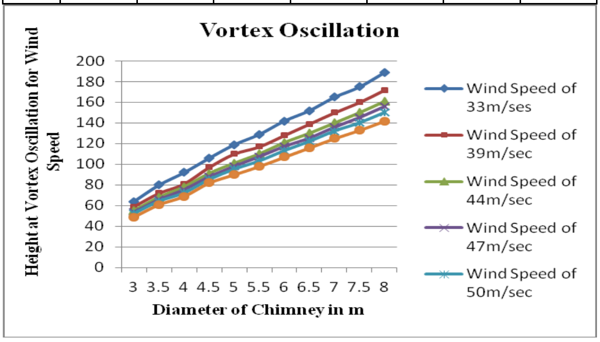


Fig. No.10: Primary Mode of Oscillation

B. Vortex Oscillation in Higher Mode of RC Chimney

This study is made to check chimney for higher modes of Vortex oscillation. For which Chimney of height 150 meter is studied for different wind speed & all other data to be constant. The following **Table 2 & Fig. No.11** gives the response of chimney for higher modes of vortex oscillation for the height of 150 meters & for different wind speed.

Table 2. Higher Mode of Oscillation

SL No	Dia at Top in m	Top thickness in m	Bottom thickness in m	Height in m	Wind Speed in m/sec	Height /Dia
1	4.0	0.15	0.45	150	33	37.50
2	4.3	0.15	0.45	150	39	34.88
3	4.6	0.15	0.45	150	44	32.61
4	4.8	0.15	0.45	150	47	31.25
5	5.0	0.15	0.45	150	50	30.00
6	5.2	0.15	0.45	150	55	28.85

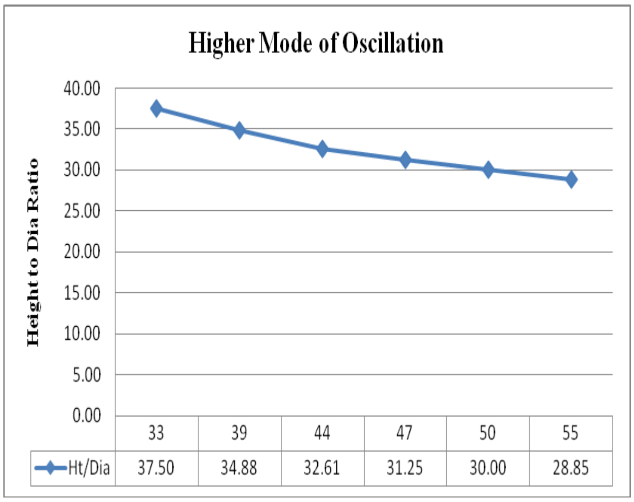


Fig. No.11: Higher Mode of Oscillation

C. Case-I: Considering the Chimney is located in lower seismic zone (Zone-II) and lower wind zone (33m/sec).

By studying the tabulated results for 4 mts & 8 mts diameter of chimney at top. **Fig. No.12 (A)** gives the seismic response of chimney which shows constant increases in stresses due to rise in height of the chimney, & shows no sudden spurt or kink in the graph for any sudden change in stresses depending on increase in height of chimney. **Fig. No.12 (B)** gives the Wind effect response of chimney where 4 meters diameter chimneys experience a constant increase in stresses due to the fact that it has already undergone the vortex oscillation. 8 meter diameter chimney has a constant increase in stress & has a sudden abrupt change in stress at 190 mts due to the chimney entering into vortex oscillation.

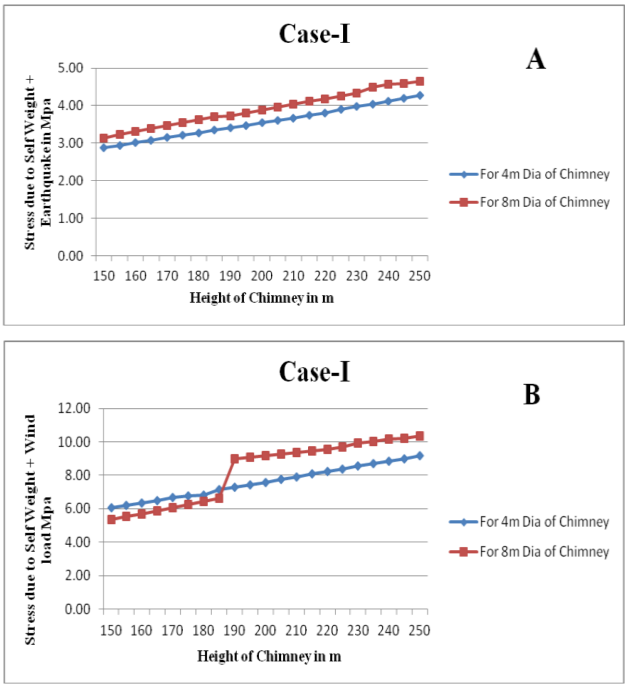
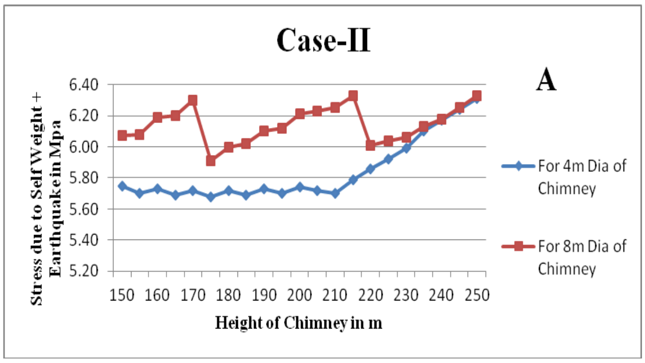


Fig. No.12: Stresses in Concrete Due to Earthquake and Wind.

D. Case-II: Considering the Chimney is located in critical seismic zone (Zone-V) and critical wind zone (55m/sec).

By studying the tabulated results for 4 mts & 8 mts diameter of chimney at top. **Fig. No.13 (A)** gives the seismic response of chimney which shows constant increases in stresses due to rise in height of the chimney. **Fig. No.13 (B)** gives the Wind effect response of chimney where 4 meters diameter chimneys experience a constant increase in stresses due to the fact that it has already undergone the vortex oscillation. 8 meter diameter chimney has a constant increase in stress & has a sudden abrupt change in stress at 160 mts due to the chimney entering into vortex oscillation.



Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

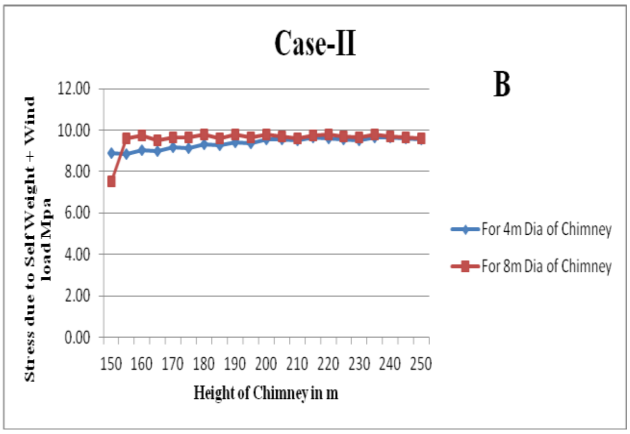
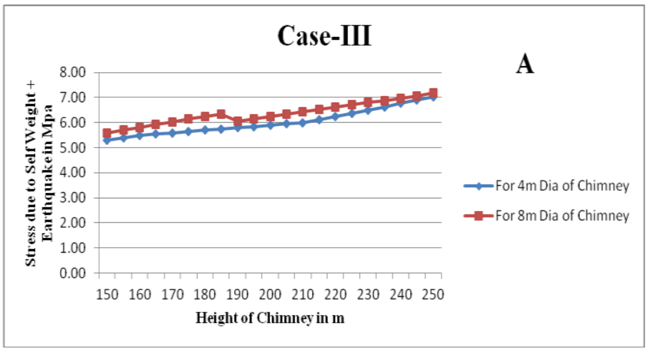


Fig. No.13: Stresses in Concrete Due to Earthquake and Wind.

E. Case-III: Considering the Chimney is located in critical seismic zone (Zone-V) and Lower wind zone (33m/sec).

By studying the tabulated results for 4 mts & 8 mts diameter of chimney at top. **Fig. No.14(A)** & **(B)** gives the stresses induced in chimney due to Earthquake at Critical zone of Zone V, Soft soil is almost equal to the stresses induced by wind at minimum basic speed i.e., 33 meters/sec at lower heights.



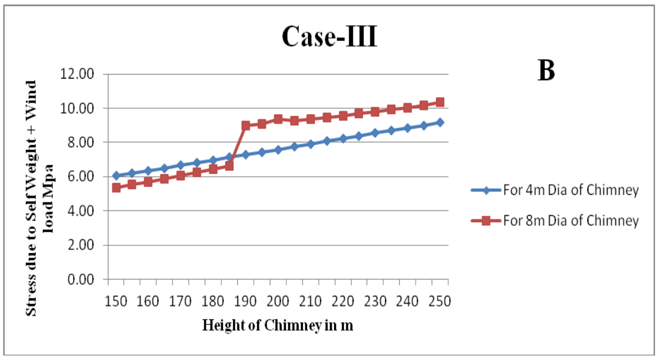


Fig. No.13: Stresses in Concrete Due to Earthquake and Wind.

VII. CONCLUSION

On comparison of the wind loads with that of the earthquake loads, the following conclusions are drown.

- The wind loads are always governing the design of RC Chimney.
- The stresses induced in chimney due to Earthquake at Critical zone of Zone V, Soft soil is almost equal to the stresses induced by wind at minimum basic speed i.e., 33 meters/sec. This concludes that the seismic response even at critical zone is not a design criteria.
- Vortex induced Oscillation depends upon wind speed & Slenderness of chimney.
- If the aspect ratio of the chimney is greater than 28 than the design of chimney is to be checked for higher modes of oscillation.
- The minimum grade of concrete to be used for Chimney should be greater than M25 since lower grades fail in permissible stresses.
- Gust factor "G" accounting for dynamic response of along wind effect on chimney is approximately 2.20. (2.2 times magnified the static wind force to account for dynamic response of along wind effect).
- Temperature is also a design criteria especially near the top of chimney where the stresses induced by moment due to wind & self weight is minimum the temperature stresses predominates.

VIII. ACKNOWLEDGMENT

The authors wish to thank the Management, Principal, Head of Civil Engineering Department of Poojya Doddappa Appa College of Engineering for their encouragement and support.

REFERENCES

1. V. Rohini Padmavathi, B. Siva Konda Reddy and Srikanth "Study of wind load effects on tall RC chimneys", International Journal of Advanced Engineering Technology, Vol.III/ Issue II, April-June 2012, pp.92 - 97.
2. K. R. C. Reddy, O. R. Jaiswal and P. N. Godbole "Wind and Earthquake Analysis of Tall RC Chimneys", International Journal of Earth Sciences and Engineering ISSN 0974-5904, Vol. 04 No 06 SPL, October 2011 pp. 508-511.
3. Manohar, S.N., "Tall Chimneys", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1981.
4. Code of practice for design loads for buildings and structures, IS: 875(Part-III):1987, published by Bureau of Indian standards, New Delhi.
5. Criteria for design of Reinforced concrete Chimneys, IS: 4998(Part-I):1992, Published by Bureau of Indian standards, New Delhi.
6. Criteria for Earthquake Resistant Design of Structures, IS 1893 (Part 1): 2002, Published by Bureau of Indian Standards, New Delhi.
7. T Subramani, P.Shanmugam, "Seismic Analysis and Design of Industrial Chimneys by Using Staad Pro", International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 2, Issue 4, July-August 2012, pp.154-161.
8. M. G. Shaikh MIE, H.A.M.I. khan, "Governing Loads for Design of A tall RCC Chimney", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), ISSN: 2278-1684, pp. 12-19.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)