International Journal of Advance Engineering and Research Development
Scientific Journal of Impact Factor (SJIF): 4.72
Special Issue SIEICON-2017,April -2017
e-ISSN : 2348-4470 p-ISSN : 2348-6406

EARTHQUAKE ANALYSIS OF RCC CHIMNEY AT BHUJ

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Abstract *- Most of the industrial RCC chimneys are tall structures with circular cross-sections. Industrial Chimneys are generally intended to support critical loads produced by seismic activity and Wind. So it is essential to evaluate the dynamic response of chimney to seismic activity & response to Earthquake is more critical as chimney is a slender structure. In the design of tall chimneys, estimation of exact earthquake is very difficult. Empirical as well as analytical approach proposed by different researchers for the estimation of earthquake response of a chimney doesn't give satisfactory results. Parametric study on chimney for height 150m at 15m regular interval is carried out, located at Bhuj in zone V.*

Keywords-*Earthquake analysis, R.C.C Chimney, seismic load.*

I. INTRODUCTION

Man has always been in search of an effective system to dispose off undesirable gaseous products of combustion which leads to the emergence of chimneys in this modern Industrial world. Chimneys are hollow, tall and slender vertical structures that carry smoke or steam away from a fire or engine at a high enough elevation to furnish adequate draft and to discharge the products of combustion without causing local air pollution. Romans used tubes inside the walls to draw smoke out of bakeries but real chimneys appeared only in northern Europe in the 12th century. Industrial chimneys became common in the late 18th century. In India, the well-known example is DAHANU thermal power station, operated by reliance energy ltd. Located near Mumbai has tallest Indian chimney made up of RCC. It's height is about 275.3 m and it was constructed in 1995.Construction of such tall chimneys need the better understanding of loads acting on them and of the of the structural behaviour, so that with the help of modern construction equipment and techniques such as slip form, reinforced concrete, the best material for chimney construction could be used efficiently. Steel ideally suited for height up to 45m, so need of RCC chimney arise.

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. Today, Reinforced Concrete is the dominant material used for the construction of tall chimneys and for short chimneys precast concrete with or without pre stressing, Modern Industrial chimneys consists of a concrete windshield with a number of steel stacks on the inside. RCC can take tension as well as compression, so the tall chimneys are now possible. Also we can reduce diameter and thickness of chimneys. Now tapered chimneys are also possible which saves the construction material and hence save the cost.

II. EARTHQUAKE ANALYSIS OF R. C. C CHIMNEY

A. Description of a Structure:-

1. Height of chimney = 150m, 2. Outer diameter at bottom = 12.5m, 3. Outer diameter at top = 5m, 4. Thickness of shell at bottom = 0.40m, 5. Thickness of shell at top = 0.25m, 6. Grade of concrete = M30, 7. Seismic Zone = V, 8. Basic wind speed = 50 m/sec, 9. Foundation type = RCC circular mat, 10. Type of soil = sandy soil, 11. Thickness of lining = 0.12m, 12. Inside temperature of chimney = 70 degree.

Height	X	Diameter (D)	Thickness (t)	Inner Diameter d = (D-2t)	Base Area	Section Modulus	Exposed Area	Cumulative Area
150	10	5	0.25	4.5	3.73	4.21	80.625	-
135	9	5.75	0.265	5.22	4.56	5.98	91.875	0
120	8	6.5	0.28	5.94	5.47	8.14	103.125	172.5
105	7	7.25	0.295	6.66	6.44	10.75	114.375	275.625
90	6	8	0.31	7.38	7.49	13.84	125.625	390

75	5	8.75	0.325	8.1	8.60	17.44	136.875	515.625
60	4	9.5	0.34	8.82	9.78	21.60	148.125	652.5
45	3	10.25	0.355	9.54	11.03	26.34	159.375	800.625
30	2	11	0.37	10.26	12.35	31.71	170.625	960
15	1	11.75	0.385	10.98	13.74	37.75	181.875	1130.625
0	0	12.5	0.4	11.7	15.20	44.49	93.75	1312.5
-	-	-	-	-	-	-	-	1406.25

Table-1. Calculation of geometric parameter on chimney

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 : $\mathbf{T=C_T}\sqrt{\frac{Wt.h}{Es.A.g}}$

Where, C_T=Coefficient depending upon the slenderness ratio of structure,

W_t=Total weight of structure including weight of lining & contents above the base

h= Height of structure above the base

Es= Modulus of elasticity of material of the shell

A= Area of cross-section at the base of the structural shell

g= Acceleration due to gravity

Radius of gyration= $\sqrt{\frac{MIbase}{Abase}}$

Slenderness ratio=$\mathbf{h/r_e}$

C_T=14.4 (from table-6 of IS-1893-4-2005)

T=0.640 Sec

From IS 1893- 2002 (Part-1): Horizontal Seismic Force: $\mathbf{A_h} = \frac{\left[\frac{z}{2}\right]\left[\frac{Sa}{g}\right]}{\frac{R}{I}}$

Where,

Z=Zone factor given,

I= Importance factor for RCC chimney

R= Response reduction factor, for RCC chimney

S_a/g=Spectral acceleration coefficient for sand soil sites

For sandy soil, S_a/g =2.08

$\mathbf{A_h}$ **=0.19**

- Design Shear Force & Moment: by Equilateral Static Lateral Force method,

$\mathbf{V=C_v.\ A_h.\ W_t.\ D_v}$

M=$\mathbf{A_h.\ W_t.\ h.\ D_m}$

Where,

Cv = Coefficient of shear force depending on slenderness ratio, k =1.02

h = Height of center of gravity of structure above base

Table-2. Values of Ct and Cv (IS-1893-2002)

k= h/re	Co-Efficient Of Ct	Co-Efficient Of Cv
5	14.4	1.02
10	21.2	1.12
15	29.6	1.19
20	38.4	1.25
25	47.2	1.3
30	56	1.35
35	65	1.39
40	73.8	1.43
45	82.8	1.47

Table-3. Calculation for Ct and Cv (IS-1893-2002)

Height	h	M.I	re	k=h/re	Ct	Cv
150	-	10.53	-	-	-	-
135	142.33	17.18	4.28	33.28	61.90	1.38
120	127.35	26.47	4.28	29.77	55.60	1.35
105	112.36	38.97	4.28	26.27	49.44	1.31
90	97.38	55.35	4.28	22.77	43.27	1.29
75	82.39	76.30	4.28	19.26	37.10	1.24
60	67.40	102.58	4.28	15.76	30.93	1.20
45	52.41	135.00	4.28	12.25	24.98	1.15
30	37.41	174.43	4.28	8.75	19.50	1.09
15	22.42	221.80	4.28	5.24	14.4	1.02
0	7.42	278.08	4.28	1.74	14.4	1.02

Table 4. Calculation of Shear Force & Moment

Height	H	X=Distance From Top	Dv	Dm	Weight	V=Cv*Dv*Ah*Wt(KN)	M=h*Dm*Wt*Ah
150	150	0	0	0	36930.34	0	0
135	150	15	0.423	0.127	36930.34	3940.69	131233.98
120	150	30	0.643	0.180	36930.34	5838.74	186500.41
105	150	45	0.835	0.224	36930.34	7451.86	232235.99
90	150	60	1.019	0.268	36930.34	8741.28	278271.90
75	150	105	1.661	0.479	36930.34	13772.67	496438.63
60	150	90	1.419	0.388	36930.34	11294.15	401941.30
45	150	105	1.661	0.479	36930.34	13226.42	496438.63
30	150	120	1.953	0.604	36930.34	14779.86	625863.82
15	150	135	2.309	0.773	36930.34	16282.50	801742.21
0	150	150	2.750	1.000	36930.34	19391.97	1037003.82

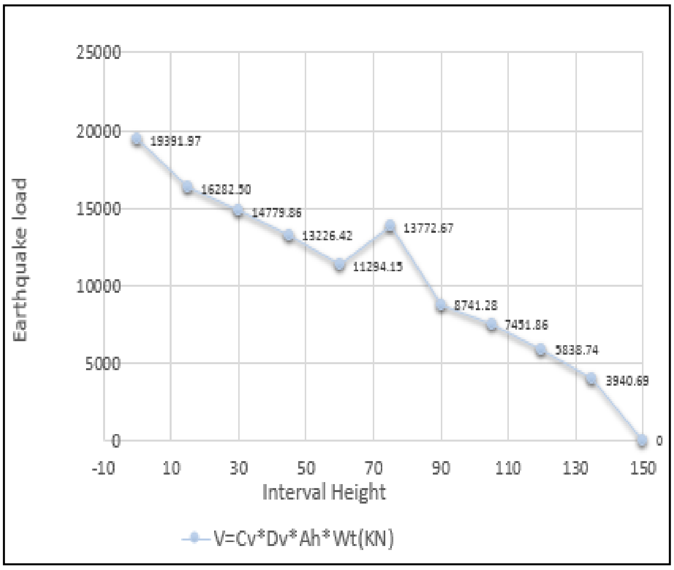

Figure 1. Behaviour of RCC chimney with respect to Earthquake Load

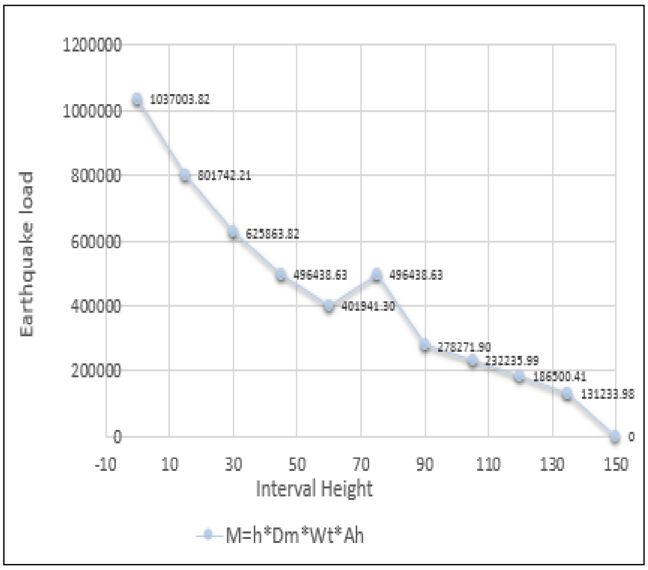

Figure 2. Behaviour of RCC chimney with respect to Moment

Figure 1 and 2 shows the graph of the Earthquake load v/s Interval height and moment v/s Interval height respectively, which shows the behaviour of RCC chimney corresponding to earthquake load and moment for the RCC chimney located at Bhuj in zone v.

III. CONCLUSION

The minimum grade of concrete to be used for chimney should be greater than M25 since lower grades fail in permissible stresses. Wind Analysis and Temperature is also a design criteria. Steel ideally suited for height up to 45m, and above it RCC chimneys are more suitable.

IV. FUTURE SCOPE

Wind Analysis along with the Seismic analysis of RCC chimney can be done and compared for the design load. Also analysis for temperature stresses should be carried out especially on the top of the chimneys. Same way Interaction charts for different locations and different height can be done.

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