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STUDY THE WORKING STRESS METHOD AND LIMIT STATE METHOD AND IN RCC CHIMNEY DESIGN

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Abstract – **Every industry focus to build and improve the chimney to create the eco-friend organization as well as to satisfy the strict environmental board.**
IS: 4998 criteria for design of reinforced concrete chimneys is using working stress method for chimney designing. There are some limitations of working stress method. Also the designing is difficult involving lengthy, cumbersome and iterative computational effort.
So we should recognize this problem and we should use some time saving techniques like interaction envelopes to optimize the structural design.
Chimneys with various heights from 65m to 280m are analyzed and designed by working stress method and limit state method for collapse and comparison of results are discussed in this paper. Generation of interaction curves for hollow circular section is also discussed in this paper.

***Key words: R*einforced Concrete Chimneys; Limit State Method; Working Stress Method; P_u-M_u Interaction curves**

I. INTRODUCTION

Chimneys, as we all know today, are hollow, tall and slender vertical structures that carry smoke or steam away from a fire or engine at a high enough elevation so that after dilution due to atmospheric turbulence, their concentration and that of their entrained solid particulates is within acceptable limits on reaching the ground.
IS: 4998 (Part I) CRITERIA FOR DESIGN OF REINFORCED CONCRETE CHIMNEYS [1][2] is using working stress method for chimney designing.
The working stress method, though ensures satisfactory performance at the working loads, is unrealistic and irrational at ultimate load and it does not guarantee the satisfactory performance of the structure at service loads. The working stress method is logically not applicable to concrete structures because this method assumes that the materials of which the structure is made up, namely concrete and steel, both obey Hook's law. The applicability of the Hook's law is rather limited in respect of concrete structures.
Among the advantages claimed for the limit state approach are that the degree of safety of the various parts of a structure is more uniform and also that a probabilistic approach to safety is possible. To ensure satisfactory performance of a structure serviceability check like check for deflection and cracking is also needed which are considered in limit state method.

II. ANALYSIS OF CHIMNEY

The chimney shall be divided in to ten or more sections along its height and the load at any section shall be calculated by suitable averaging the loads above it. The moments are calculated from the sectional forces treating the chimney as cantilever structure.
Analysis consist of calculation of factored dead load (W) which includes Shell weight, Brick lining weight and wind load according to IS: 4998 (Part I)[1] [2], then factored moment (M) because of this wind load is calculated at section.

III. DESIGNING

A. Working Stress Method

Chimney is designed according to IS: 4998 (Part I) [1] [2] and following steps are followed:

1. Determine eccentricity (e) = M/W
2. Determine (eccentricity/radius) at section
3. Assume the *p* (percentage of steel at section) at the section under consideration
4. Select the value of m (modular ratio)for concrete grade to be used
5. Determine α (position of neutral axis)
6. Determine compressive stresses for different values of α and β (β = constant depends on openings in chimneys) in concrete and steel
7. Calculate temperature stresses in steel and concrete
8. Calculate stresses in steel and concrete due to wind induced moment. And check combined stresses

B. Limit State Method for Collapse

1. Calculate the $W/f_{ck} D^2$ and $M / f_{ck} D^3$.
2. Calculate ratio d/D and D'/D
   Where, d=inner diameter of concrete shell
   D=outer diameter of concrete shell
   D'=D - concrete cover

3. Refer the suitable P_u-M_u Interaction curves
4. From selected interaction curve take appropriate value of p/f_{ck}
5. Calculate p percentage of steel required at section for the value of f_{ck} used

IV. GENERATION OF $P_U – M_U$ INTERACTION CURVES

The magnitude of P_u determines the neutral axis. On location of the neutral axis the strain distribution is known. This can then be used to solve for the value of P_u and the ultimate moment M_u. It is therefore obvious that the solution to the above set of equations can be found as a closed form solution. This is because the location of the neutral axis is required for the calculation of the normal force P_u, while the value of P_u is itself required for the location of the neural axis.

For the purpose of developing the interaction curves the location the neutral axis is assumed and the values of the normal force and the moment are calculated. The neutral axis is then changed to calculate a new set of P_u and M_u. This is repeated to get the interaction curves of P_u Vs M_u. Following steps are followed:

1. Select various outer diameter D inner diameter d and cover c to generate various cases of Pu-Mu interaction curves for d/D and D'/D ratios for chimney. Total 27 cases are generated.
2. Assume the location of neutral axis in the cross section for various cases from 0.1d to 1d.
3. Various percentages of steel (*P*%) from 0.25% to 55.5% of steel is taken to generate interaction curves of various cases of p/f_{ck}, Total 1100 cases are taken for designing of chimneys
4. Find strain in concrete (**e_c**).
5. Find stress in concrete according to the strain (**f_c**).
6. Find load carrying capacity of concrete (**P_c**).
7. Find moment carrying capacity of concrete (**M_c**).
8. Find strain in steel (**e_s**).
9. Find stress in steel (**f_s**).
10. Find load carrying capacity of steel (**P_s**).
11. Find moment carrying capacity of steel (**M_s**).
12. Total load carrying capacity **$P_u = P_c + P_s$**.
13. Total moment carrying capacity **$M_u = M_c + M_s$**.
14. Find $P_u/fckD^2$.
15. Find $M_u/fckD^3$.
16. Plot the graphs for different percent of steel.

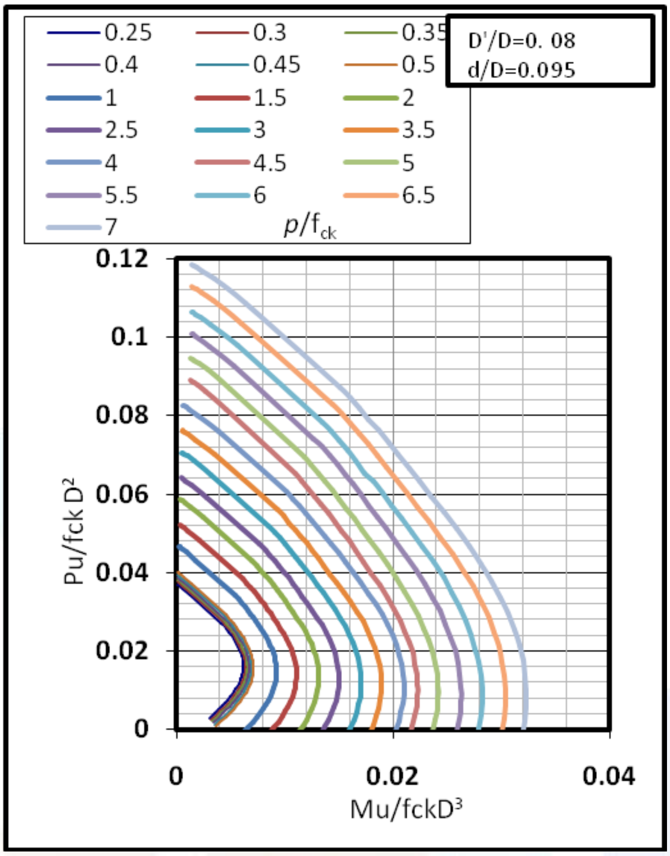

Fig.1 Pu-Mu Interaction curve for d/D = 0.95, D'/D =0.008

V. COMPARISION

Table 1 shows the comparison of working stress and limit state method for collapse for 70m high chimney.
Thickness of shell at top is taken as 0.25m
Thickness of shell at bottom is taken as 0.35m
Shell inner diameter at top is taken as 3m
Shell inner diameter at top is taken as 5.3m

Sectional Height	Working stress method		Limit state method	
	fck	*P*%	fck	*P*%
70-65	20	0.0025	20	0.0025
65-60	20	0.0025	20	0.0025
60-55	20	0.0025	20	0.0025
55-50	20	0.0025	20	0.0025
50-45	25	0.0025	20	0.0025
45-40	30	0.0025	20	0.0025
40-35	35	0.003	20	0.0026
35-30	35	0.0032	20	0.003
30-25	35	0.0033	20	0.003
25-20	35	0.004	20	0.0035
20-15	35	0.0045	20	0.0035
15-10	35	0.0048	20	0.0035
10-05	35	0.0051	20	0.0035
05-00	35	0.0053	20	0.0035

Table 1 comparison of working stress method and limit state method limit of collapse for chimney of height 70m.

Result shows that Limit State method is much more economical than working stress method.

VI. FUTURE SCOPE

Earthquake forces consideration is beyond the scope, also chimneys with openings and chimneys without lining are beyond the scope.

Limit State of serviceability is beyond the scope.

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