Cost Optimization of Roof Top Swimming Pool

Amol Jadhav[1], Prof. N. G. Gore[2]

[1]ME student, Civil Engineering Department, MGM's college of engineering and technology, Kamothe, Navi Mumbai, Maharashtra, India

[2]Asistaint Professor, Civil Engineering Department, MGM's college of engineering and technology, Kamothe, Navi Mumbai, Maharashtra, India

---***---

Abstract - ***Roof top swimming pools (RCC) are commonly used for storage of water for swimming, wading, diving, recreation or instruction, etc. The vertical wall of such pool is subjected to hydrostatic pressure and the base is subjected to weight of water and it is designed by using IS 3370:2009 Part (I, II). Optimization can be defined as the process of finding the conditions that give the maximum or minimum value of a function. This study focused on the optimum cost design of roof top swimming pools due to effects of unit weight of water, variation in grade of concrete and also for capacity change. The main aim is to achieve the economy. Material saving results in saving in construction cost at the same time the safety is also considered. The model is analyzed and design by using MATLAB software. Optimization is formulated in nonlinear programming problem (NLPP) by using sequential unconstrained minimization technique.***

Key Words: *Roof top swimming pool, Optimum cost design.*

1. INTRODUCTION

The term "swimming pool" means any artificial basin of water constructed, installed, modified or improved for the purpose of swimming, wading, diving, recreation or instruction. The analysis and design of Swimming pool is based on un-cracked section theory, to avoid leakage of stored liquid. In order to ensure impermeability through the walls, rich concrete mix is used. Optimization is the act of obtaining the best result under given circumstances. Slope provided for bottom slab for swimming pool is 5:1

Fig -1: Roof top swimming pool

2. STRUCTURAL ANALYSIS

The vertical wall of such pools is subjected to hydro-static pressure and the base is subjected to weight of water and it is designed by using IS 3370:2009 Part (I, II). This study focused on the optimum cost design of roof top swimming pool due to effects of weight of water, variation in grade of concrete and for same capacity change. The main aim is to achieve the economy. Material saving results in saving in construction cost at the same time the safety is also considered. When the length to breadth ratio is less than two, walls are designed as bottom H/4 or 1m portion of wall designed as cantilever and remaining portion as continuous frame subjected to water pressure and when the length to breadth ratio is greater than two, long walls are designed as cantilever and short walls as slab supported on long wall, bottom portion of short walls H/4 or 1m whichever is more is designed as cantilever.

Considering the total cost of the tank as an objective function with thickness of long wall, thickness of short wall and thickness of base slab panels as design variables a computer program has been developed to solve numerical examples using the Indian IS: 456-2000, IS 3370:2009 (part I,_II) code requirements. The results shown minimum total cost of the rectangular tank for minimum wall and base slab thickness required considering all safety criteria's.

3. DESIGN VARIABLES AND CONSTRAINTS

3.1 Design variables-

The following quantities are chosen as design variables during the procedure of designing and optimizing.
X1= Long wall thickness at base
X2= Short wall thickness at base
X3= Effective thickness of base slab S1
X4= Effective thickness of base slab S2
X5= Effective thickness of base slab S3
X6= Effective thickness of base slab S4
X7= Effective thickness of base slab S5

3.1 Constraint equations--

i. **Constraint for Long wall thickness at base**
X1= Long wall thickness at base
G1= (150/X1)-1

ii. **Constraint for Short wall thickness at base**
D1=Total thickness of wall at base
D2= Total thickness of wall at h1 height
G2= (D2/D1)-1

iii. **Constraint for effective thickness of base slab S1**
dreqs1= Required effective depth for slab S1
X3= Effective thickness of base slab S1
G3= (dreqs1/X3)-1

iv. **Constraint for minimum steel in short wall**
D1=Total thickness of wall at base
Ast1= Area of steel in short wall
G8= (3.5*D1/Ast1)-1

v. **Constraint for minimum steel in long wall**
D2=Total thickness of wall at height h1
Ast7= Area of steel in long wall
G9= (1.2*D2/Ast7)-1

4. DESIGN OPTIMIZATION PROCEDURE

Definition: "The process of finding the conditions that gives the maximum or minimum value of the function". Optimization is the act of obtaining the best result under given circumstances. Primary aim of structural optimization is to determine the most suitable combination variables, so as to achieve satisfactory performance of the structure subjected to functional &behavioral and geometric constraints imposed with the goal of optimality being by the objective function for specified loading or environmental condition. Three features of structural optimization problem are:
1. The design variable.
2. The constraint.
3. The objective function.

In many practical problems, the design variables cannot be chosen arbitrarily, they have no satisfy certain specified functional and other requirements. The restrictions that must be satisfied in order to produce an acceptable design are collectively called design constraints.
The optimum cost design of swimming pool formulated in is nonlinear programming problem (NLPP) in which the objective function as well as constraint equation is nonlinear function of design variables. In SUMT the constraint minimization problem is converted into unconstraint one by introducing penalty function. In the present work is of the form.

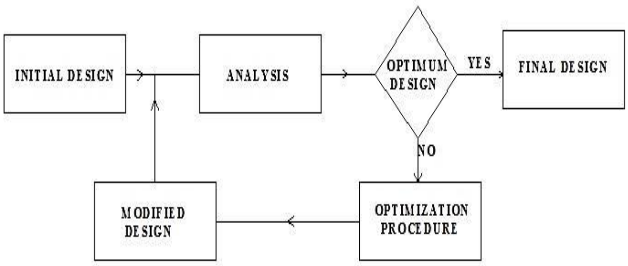

Fig -1: process of optimization

5. ILLUSTRATIVE EXAMPLES

For different conditions and start from starting point and end with optimized point the result shown in graphical form as below. For different dimensions and for various grades of concrete as mention above, optimized points and cost for it, is shown in this graph.
Note:
SP = Starting point.
OP = Optimum point.

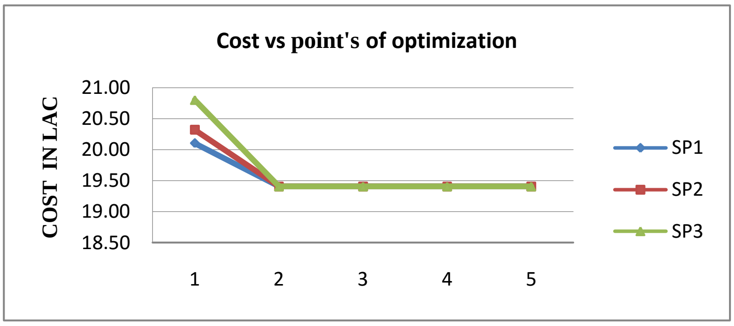

Chart -1: Cost Vs. points of optimization

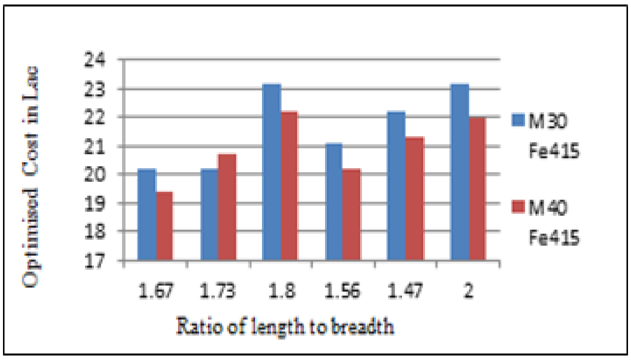

Chart -2: Comparison of cost for M30 and M40

The problem of cost optimization of roof top swimming pool has been formulated as mathematical programming problems. The resulting optimum design problem & constrained non- linear programming problems and have been solved by SUMT. Parametric study with respect to different dimensions and grade of concrete compared and conclusions are drawn.

5. CONCLUSIONS

The conclusion drawn from the results of the illustrative examples given in chapter 8 are presented in the subsequent sections

1) It is possible to formulate and obtain solution for the minimum cost design for roof top swimming pool.
2) Interior penalty function method can be used for solving resulting non-linear optimization problems. For roof top swimming pool the chosen values of initial penalty parameter r0 and reduction factor C worked satisfactorily.
3) Maximum cost savings of 15.23% over the normal design is achieved in case of roof top swimming pool
4) The optimum cost for a roof top swimming pool is achieved in M40 grade of concrete and Fy415 grade of steel.
5) The cost of roof top swimming pool increased rapidly with respect to decrease in grade of concrete.

REFERENCES

[1] Hasan Jasim Mohammed, "Economical Design of Water Concrete Tanks"
[2] G. Manohar and D. S. Prakash Rao, "Optimum Design of Axisymmetric shells and a case study on parabolic water tanks", The Indian Conrete Journal.
[3] Samer A. Barakat, Salah Altoubat, "Application of Evolutionary Global Optimization Techniques In the design of RC Water tanks", engineering structures (2009), Pp332-334.
[4] Kamal C. Sarma and Hojjat Adeli, "Cost optimization of concrete Structures",Journal of Structural Engineering.
[5] Robert Levy and Ovadial E. Lev,"Recent Development in Structural Optimization", Journal of Structural Engineering ,Vol 113, No9 (1987).
[6] R. Livaoglu, A. Dogangun, "Effect of Foundation Embedment On Seismic Behaviour of Elevated Tanks Considering Fluid-Structures Soil Interaction", Soil Dynamics and Earthquake Engineering 27 (2007)855-863.