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Cost Optimization of Elevated Circular Water Storage Tank

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ABSTRACT

A computer approach to the optimal design of elevated circular water tank is presented. The resulting optimum design problems are constrained non-linear programming problems and have been solved by SUMT. Parametric study with respect to different type of capacity of tank and grade of concrete have been carried out. The result of optimum design for elevated circular water storage tank have been compared and conclusions drawn. For the minimum capacity and cost design of the elevated circular water storage tank the following design variables are chosen as Thickness of the wall.(X1),Depth of the floor slab (X2)and Depth of the floor beam (X3). constraints for the optimization are considered according to Standard Specifications .The optimization problem is characterized by having a combination of continuous, discrete and integer sets of design variables. The computer program is written in MATLAB.

KEYWORDS: *Optimization, Water tanks, Minimum total cost, Tank capacity.*

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I. INTRODUCTION:

Elevated tanks are supported on staging which may consist of solid or perforated masonry walls, R.C.C columns braced together or a thin hollow shaft. The actual tank portion is designed for water pressure, live load and self-weight of different parts. The staging is to resist wind forces and earthquake forces in addition to the forces transferred from tank proper. The foundation slab in such cases, is generally provided as raft or on piles depending upon the soil conditions. Leakage and seepage is a common problem in water retaining structures. To minimize it, impervious concrete of minimum grade M 20 must be used. The design for water retaining components is based upon no crack theory. The following three factors must be considered while designing a R.C.C tank: Strength, Water tightness, Overall stability

II. STRUCTURAL OPTIMIZATION

Optimization is the act of obtaining the best result under given circumstances. It can be also stated mathematically as "the process of finding the conditions that gives the maximum or minimum value of the function".

The optimum cost design of elevated circular water tank formulated in is nonlinear programming problem (NLPP) in which the objective function as well as Constraint equation is nonlinear function of design variables. The Sequential Unconstrained Minimization Technique (SUMT) is on of the Methods for the solution of the NLPP.

In SUMT the constraint minimization problem is converted into unconstraint one by introducing penalty function. In the present paper the function f (X, r) is the penalty function f (X) and the objective function r is the non negative penalty parameter, and m is the total number of constraints. The penalty function (X, r) is minimized as an unconstrained function of X and r, for a fixed value of r.The present optimization problem is solved by the interior penalty function method. DFP method is used for solving successive unconstrained minimization problems coupled with cubic interpolation methods of on dimensional search. The program developed by S.S. Rao for SUMT is used for the solution of the problem. The program is written in MATLAB language.

III. PREVIOUS RESEARCH

HasanJasim Mohammed (2011) proposed the optimization method to the structural design of concrete rectangular and circular water tanks, considering the total cost of the tank as an objective function with the properties of the tank that are tank capacity, width and length of tank in rectangular, water depth in circular, unit weight of water and tank floor slab thickness, as design variables. A computer program has been developed to solve numerical examples using the indian is: 456-2000 code equations .the results shown that the tank capacity taken up the minimum total cost of the rectangular tank and taken down for circular tank. The tank floor slab thickness taken up the minimum total cost for two types of tanks. The unit weight of water in tank taken up the minimum total cost of the circular tank and taken down for rectangular tank

Samer A. Barakat, Salah Altoubat (2009) proposed evolutionary based optimization procedure for designing concial reinforced concrete water tanks. The material cost of the tank that include concrete , reinforcement and formwork required for walls and floor was chosen as the objective function in the non-linear optimization problem formulation. The wall thickness (at the bottom and top), base thickness, depth of water tank and wall inclination were considered as design variables. Three advanced optimization techniques to solve the nonlinear constrained structural optimization problem were investigated. These method are 1) shuffled complex evolution (SCE), 2) simulated anneling (SA) and genetic alogarithm (GA). Several tests were performed to illustrate the robustness of these techniques and resul were encouraging for SCE method. The SCE method proved to be superior to SA and GA methods in obtaining the best discovered solutions. The concludes that the robust search capability of SCE alogarithmtechiques is well suited for solving the structural problem in hand

IV. FORMULATION

A) Design Variables

For a particular elevated circular water tank, a large number of parameter control the design of the water tank such as capacity of tank, depth of the slab ,depth of the beam,grade of steel etcthe design variables considered in this studies are as follows

Design Variables	
Thickness of the wall(X1)	121≤X1≤300
Floor slab Depth(X2)	200≤X2≤300
Depth of the Floor beam(X3)	300≤X3≤500

B) Objective function

The objective function in the present optimization problem is the cost of the overhead circular water storage tank whose main component arecost of steel and cost of concrete. Its is assumed that the cost of steel launching and casting formwork etc are directly proportational to volume of concrete,hence all the cost are included in the rate of concrete

Objective function can be expressed as:

Total Cost =Concretecost + steelcost

whereas

steelcost= Quantity of steel*Cost of steel

= Scost*TSQ

Concretecost= Quantity of Concrete*Cost of concrete

== Ccost*TCQ

TSQ=Quantity of steel in kg

TCQ=Quantity of concrete in m^3

C).Constraint

These are specified limitation (upper or lower limit) on design variables which are derived from geometric requirements , minimum practical dimension for construction, coderestriction etc. The constraint is defined as

$$XL \leq X \leq XU \quad \text{……} (1)$$

Where

X = Design variable.

XL = Lower limit of the design variable.

XU = Upper limit of the design variable.

The constraints equation used in the study of design of elevated circular water tank are generally the following

G1= Capacity Constraint	$G1 = (Cap/NCT) - 1$
G2=Top slab Depth Constraint	$G2 = dRS/((RSD * 100)) - 1$
G3=Slab Stress Constraint	$G3 = f/ConBenten - 1$
G4=Non Cracking Constraint	$G4 = Fbt/ConBenten - 1$
G5= Floor beam Constraint;	$G5 = MST/Scbc - 1$
G6=Bond stress Constraint	$G6 = BS/conbon - 1$

G7=Pressure Constraint	$G7 = PRS/BEC - 1$
G8=Tensile stress in wall Constraint	$G8 = Ts/ConDiten - 1$
G9=Bending stress in wall Constraint	$G9 = Tbs/ConBenten - 1$
G10=Check for Stress in Wall Constraint	$G10 = IE/1 - 1$
G11=Depth of floor slab Constraint	$G11 = FSDreq/X2 - 1$
G12= Depth of wall thickness constraint	$G12 = dwc/(X1 * 1000) - 1$
G13= Ratio constraint	$G13 = Ratio/16 - 1$

V. OPTIMIZATION METHOD

5.1Methods of optimization

A. Mathematical Stochastic Statistical Methods
B. Programming Programming
C. Techniques Techniques

A)Mathematical Programming Techniques

- Calculus Method
- Calculus Of Variations
- Nonlinear Programming
- Geometric Programming
- Quadratic Programming
- Linear Programming
- Dynamic Programming
- Integer Programming
- Stochastic Programming
- Separable Programming
- Multi Objective Programming
- Cpm & Pert
- Game Theory

B) Stochastic Programming Techniques

- Stastical Decision Theory
- Markov Processes
- Queing Theory
- Renewal Theory
- Simulation Methods
- Reliability Theory

C) Statistical Method

- Regression Analysis
- Cluster Analysis
- Design of Experiments
- Discriminate Analysis

The optimum cost design of elevated circular water tank formulated in is nonlinear programming problem (NLPP) in which the
objective function as well as constraint equation is nonlinear function of design variables. The various methods available for the solution of NLPP are compared in brief and the advantages and limitation of the chosen method is discussed. The various subroutines used in the program are also discussed.

Methods for the Solution of the NLPP

1. Method of Feasible Directions
2. Sequential Unconstrained Minimization Technique (SUMT)
3. Sequential Linear Programming (SLP)
4. Dynamic Programming

A. **The sequential unconstrained minimization technique (SUMT)**

In SUMT the constraint minimization problem is converted into unconstraint one by introducing penalty function. In the present work is of the form, f(x, r) is the penalty function f(x) is the objective function r is the non-negative penalty parameter, and m is the total number of constraints. The penalty function (x, r) is minimized as an unconstrained function of x and r, for a fixed value of r. The value of r is reduced sequent rained and the sequence of minima obtained converges to the constrained minimum of problems as r 0.

5.2. Computer program

The present optimization problem is solved by the interior penalty function method. The method is used for solving successive unconstrained minimization problems coupled with cubic interpolation methods of on dimensional search. The program developed by S. S. Rao for SUMT is used for the solution of the problem. The program is written in Matlab language.

V1.CONCLUSION

The object from this study is to investigate from the appropriate of optimization method to deal the minimum cost of structural design of a elevated circular water storage concrete tanks. With the help of computer programming and giving a safe design with minimum cost of the elevated circular water storage tank, the design of the tank can be more economical, reliable and simple.

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