

# Column Capital and Drop Panel Optimization of Flat Slab Using Genetic Algorithm

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**ABSTRACT:** Flat slab optimization using genetic algorithm is worked out using various trial error based thickness criterion. An initiation of main depth has been taken from two way shear based on IS:456-2002 using necessary guidelines. The mathematical curve of shape profile for the flat slab is initiated mathematically which gives corollary idea of an angle section with prismatic shape throughout. By modifying proper mathematical order of curvature based criterion each thickness are optimized with number of cycles. Safety and serviceability of regular design criterion also fully checked for each optimized depth. The prime criterion to optimize the minimum cost and weight design of optimized depth

**KEYWORDS:** Profile, Genetic Algorithm, Optimization, Economy, GUI based Programming

## I. INTRODUCTION

Optimization of structure has been area of interest of researches in recent decade, as major duty of structural engineer deals with design of most optimum structure without imparting with its structural properties of strength and stability. Optimization of RC structure differs from optimization of other structure due to its characteristics. Cost of RC structure is summation of cost of concrete, cost of Reinforcement and cost of form work. In the design optimization of RC structures, we have to determine dimensions of element and reinforcement, e.g. quantity and dimension of steel bars, need to be determined. Also serviceability and strength criteria increases design constraints in optimization of RC structures.

**Optimization & Genetic Algorithm:** Optimization can be characterized as the strategy of finding the circumstances that add to amazing or base estimation of a capacity or the benefit favored in any pragmatic circumstance have the capacity to understandable as a motivation behind guaranteed optimum design of structures has been the point of numerous studies in the field of structural engineering. Structural designer will probably build up an "most optimal practical solution" for the auxiliary configuration under thought. As there are an unbounded number of structural dimensions, support that resist same moment, it gets to be hard to accomplish the minimum cost plan by customary iterative techniques.

Genetic algorithms belong to the family of evolutionary algorithms (EA). Evolutionary strategies (ES), evolutionary programming (EP) and genetic programming (GP) are some of the other major algorithms of this family. Evolutionary algorithms have been inspired by the principles of evolution in nature.

**Hatindera Singh et al. (2014)** carried out analysis and optimization of one-way slab carried as per IS 456:2000 taking into account only vertical static loads using Genetic Algorithm. It is assumed that all columns are rectangular and cost optimization is carried meeting strength and serviceability requirement as per IS 456:2000 and concluded that optimized is achieved at span to depth ratio of 29 to 30 and using M20 and Fe 415 steel.

**Kiran S. Patil (2013)** carried out analysis of flat slab using D.D.M Using IS:456:2000 accommodation only vertical static loads. It is assumed that all column is of rectangular cross sections are considered for analysis and concluded that optimized design for flat slab depends upon the number of bay, grade of reinforcing steel and characteristics strength of concrete. Cost of flat slab is reduced by 33.91% in case of flat slab with drop. Using M20 and Fe415 yields in most optimized design.

**Yousef Zandi et al (2013)** carried out analysis of flat slab using E.F.M Using B.S.8110 accommodation only vertical static loads. Genetic Algorithm is used as optimization tool. Cost optimization of RC flat slab buildings using a multi-

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level optimization procedure is presented. Optimum column layout, cross-sectional dimensions and reinforcement of concrete elements is found out. The design optimization of two RC flat slab buildings with different plan and number of storey was illustrated.

**Vikunjetal. (2011)** presented comparison of cost between flat slabs without drop panel and with drop panel in four storey considering lateral load. A four storey building (having 6m x 6m panel is subjected to gravity load + lateral load in ETABS (Extended 3D Analysis of Building Systems) software and then each storey is exported to SAFE (Slab Analysis by the Finite Element Method) software for analysis of two-way shear due to lateral loads. On the basis of permissible two-way shear criteria as stated in IS 456-2000, optimized depth of flat slab with drop panel and without drop panel are found and monetary analysis is done by using S.O.R. (Schedule of Rates 2008-09).

## II. GENETIC ALGORITHM PROCEDURE

**Initialization of genetic algorithm:** At to start with, numerous individual arrangements are by and large created haphazardly to frame an Initial population. The populace size ought to be reliant on the problem nature, however for the most part contains various hundreds or a huge number of promising solutions. Ordinarily, the arbitrary population is created, letting the entire differing qualities of possible solution.

**Selection:** All through each back to back era, a small amount of the present population is assigned to breed a fresh generation. Individual solution stays chose through a fitness based technique, where best solution are normally more probable to be nominated. The fitness function remains depend over the hereditary representation and measures the nature of the portrayed solution. The fitness function is always subject to the solution. For representation, on account of rucksack issue, one yearning to augment the aggregate size of items that can be put in a backpack of some static ability. A delineation of an outcome may be a variety of bits, in which every piece means an alternate item, and the estimation of the bit (0 or 1) connotes regardless of whether the article is in the rucksack.

### Genetic Algorithm Operators

**Number of Iterations:** The quantity of redundancy distinguishes the quantity of circles that the model must keep running with a specific end goal to locate the best arrangement. Utilizing next to no number of emphasis may permit little use of the fundamental administrators of the GA on the population, so the model won't have the capacity to find extensive variety of created populations (arrangements) and the model may get adhered to a problematic or infeasible arrangement. In the interim, utilizing high estimation of the emphasis may back off particularly the model which is not proffered much of the time.

**Population size:** The population greatness characterizes the quantity of starting (practical and infeasible) solutions which are made toward the start of the GA model work. These underlying arrangements are made considering the variables' limits which are expressed in the Genetic Algorithm model. Restricting the population size to almost no underlying arrangements will keep the advancement of much better arrangements since the connection between the underlying arrangements are constrained to a slender extent. In the meantime, as we expand the population estimate, the hereditary calculation looks more indicates and empower hunt down a superior arrangement. In any case, on the off chance that we build the population size, then hereditary calculation expends more opportunity to Figureure every era.

**Crossover Type:** Crossover allows the algorithm to get the finest genes from individual and recombine the chose individual to shape best unrivaled youngsters. Three sorts of crossover are found in the books of the GA, two of them are considered in this concentrate, to be specific: single point crossover and two-point crossover.

**Mutation:** Mutation upgrades to the assortment of a population and along these lines builds the likelihood that the algorithm will create individuals with enhanced fitness. Diverse estimations of the mutation rate are considered in the models so as to inspect the best mutation rate that will prompt the ideal arrangement.

**Penalty function :**As on account of penalty technique, a constrained optimization issue got changed over to an unconstrained issue by expansion of penalty for every constraint violation to the cost function, two distinctive penalty functions are utilized as a part of the two models, the first is the basic penalty capacity and the second is the strategy that is proposed by Deb, (1998).

**Fitness function:**The fitness function is a basis for the appraisal of the integrity of every individual in a populace. Since the fitness function is a Figure of legitimacy, and a portion of the determination techniques require a positive

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fitness esteem, it should consequently take positive qualities. In common cost enhancement issues, minimization of some cost function is completed instead of boost of utility or benefit.

## III. RESULTS AND TABLES

### 1 Assumption and Limitation

- Slab Panel Is Rectangular in Cross Section.
- Column Are Rectangular.
- Only Vertical Static Loads Are Acting.
- M25 and fe415 is adopted throughout.
- Design as per IS: 456:2000 DDM
- Floor finish of  $1\text{kN/m}^2$  and live load of  $4\text{kN/m}^2$  is considered.

### 2 Terminology

- $l_y$  = Longer span.
- $l_x$  = Shorter span.
- $cl$  = Column dimension in longer span.
- $cs$  = column dimension in shorter span.
- $d_s$  = effective depth of slab.

### Cases for Optimization Problem

For every case two type of optimization is followed

1. Unconstrained Minimization
2. Constrained Maximization

Case-1 Finding Most Optimum Column Spacing in Longer and Shorter Direction.

#### Unconstrained Minimization

Variables =  $l_y$

$l_x$ .

Constants =  $cl = 400\text{ mm}$

$cs = 300\text{ mm}$

Objective Function =  $V_u = ((x(1) * x(2)) - (((cl + ds) / 1000) * ((cs + ds) / 1000))) * (fl)$

Constraints =  $vc = [((((((x(1) * x(2)) - (((cl + ds) / 1000) * ((cs + ds) / 1000))) * (fl)) * 1000)) / ((2 * (a1 + a2) * (ds)))) - (0.5 * ((x(1) / 3) / (x(2) / 3)) * (0.25 * \text{sqrt}(fck))$

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**RESULT** -  $L_y(\text{optimum}) = 4 \text{ m}$   
 $L_x(\text{optimum}) = 3.5 \text{ m}$   
 Shear Force = 235.982 kN  
 So Drop Panel and Column Head Not Required.

Position	$V_u$ (kN)
Face of column	238.2000
20 mm from Face of column	237.7560
40 mm from Face of column	237.2640
60 mm from Face of column	236.7240
80 mm from Face of column	236.1360
d/2	235.982

Table :1 Shear Force of Case Finding Most Optimum Column Spacing In Longer And Shorter Direction.

## CONSTRAINED MAXIMIZATION

Variables =  $l_y$

$l_x$

Constants =  $c_l = 400 \text{ mm}$

$c_s = 300 \text{ mm}$

Objective Function =  $V_u = ((x(1) * x(2)) - (((c_l + d_s) / 1000) * ((c_s + d_s) / 1000))) * (f_l)$

Constraints= $v_c = [((((((x(1) * x(2)) - (((c_l + d_s) / 1000) * ((c_s + d_s) / 1000))) * (f_l)) * 1000)) / ((2 * (a_1 + a_2) * (d_s)))) - (0.5 * ((x(1) / 3) / (x(2) / 3)) * (0.25 * \text{sqrt}(f_{ck}))$

**RESULT** -  $l_y(\text{optimum}) = 7 \text{ m}$

$l_x(\text{optimum}) = 5 \text{ m}$

$d_s = 220 \text{ mm}$

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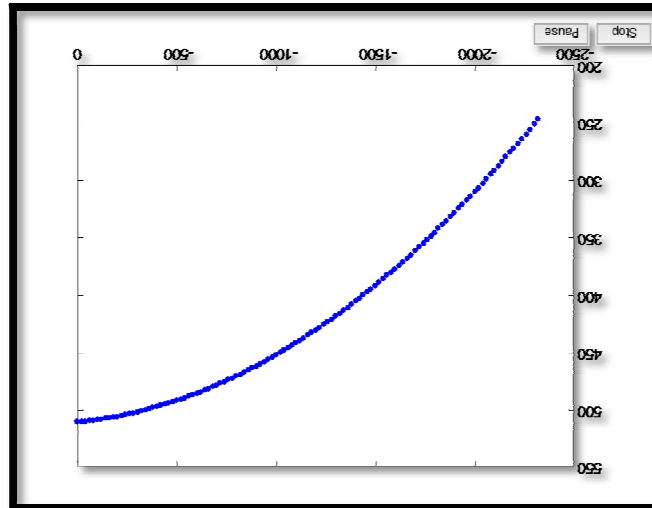


Figure 1 .Profile for Case Finding Most Optimum Column Spacing in Longer and Shorter Direction by Constrained Maximization

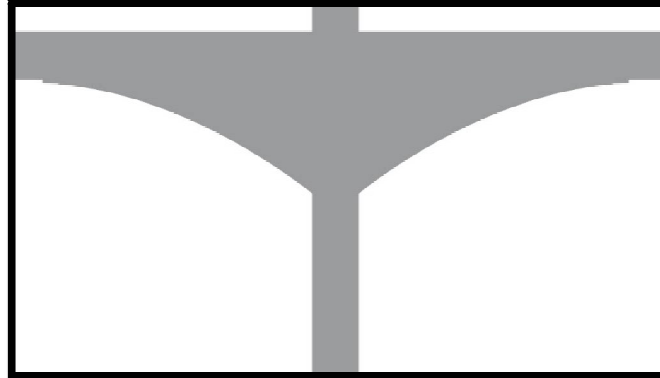


Figure.2 Diagrammatic Representation of Curve Case Finding Most Optimum Column Spacing in Longer and Shorter Direction.

## IV. CONCLUSION

Following are points:

1. In maximization process by increasing shear stress in slab to permissible limit longer span can and shorter column dimensions can be provided resulting in more column to column spacing.
2. There in minimum 20-30% approximately saving in material by optimization process.
3. Minimization process yields to such conditions that minimal shear reinforcement can be provided for same loading conditions.

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