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Technology, Social Impact

Design Optimization of RC Moment Frames by ABC Optimization and Finite Element Method using System of Design Rules

ABSTRACT

- Artificial Bee Colony (ABC)method optimization procedure for design of RC moment frames
  - Cross-section properties of frame members are optimized considering constraints specified by design codes
  - Structural design provisions enunciated in Indian Standards IS456 (2000), IS1893 (2016) and IS13920 (2016) are used as system of design rules, to interact with Finite Element Method of analysis of frames developed for the study
    - Cross-sectional properties of structural members are chosen from a set of pre-defined sectional properties from the database developed to form design variables compliant with Indian Standards. The optimized design & detailing of frame elements are obtained after the frame structure is analyzed under the action of multiple load combinations
      - ABC method can then be applied, to improve the Nonlinear Static Response (*e.g.,* inelastic drift capacity) of the frame

METHOD

The Section optimization of RC structural elements using ABC algorithm Optimization of Frame structures using the ABC algorithm can be formulated as follows :

Find: X = {x1, x 2…, x d}, x min n ≤ x n ≤ x max n n = 1, 2, . . . , D

To minimize: f(X) = |M(X)| + |P(X)|,

Subjected to:

$$\mathrm{B(breadth)} \geq 0.3 * D(\mathrm{depth})$$

$$p_{sc} \geq 0.5 * p_{st}$$

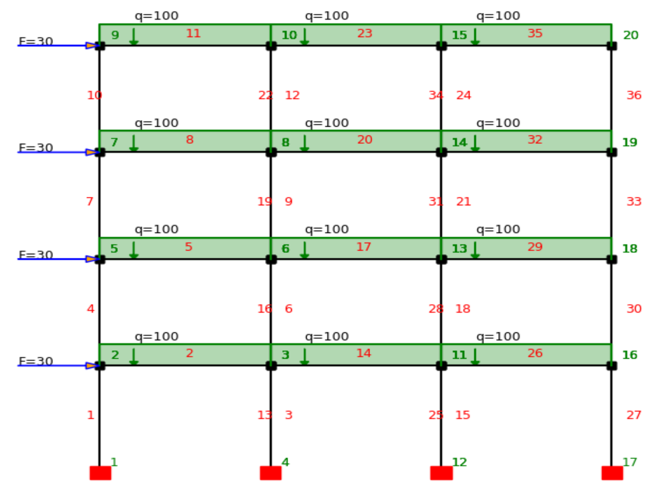
$$g_i(X) = M_{Design} / M_{Demand} \geq 1.2,\ i = 1, 2, \ldots, NM,$$

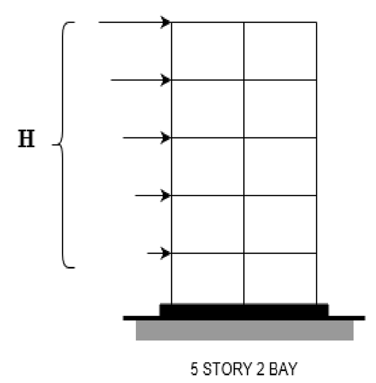
$$g_{i,j}(X) = M_{designcolumn@P=0} / M_{designbeam} \geq 1.4, i,j = 1, 2, \ldots, ND,$$

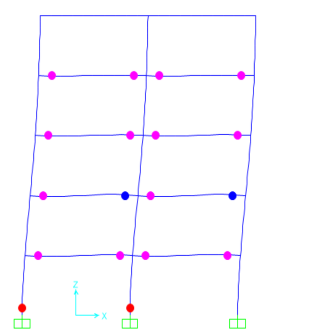
- X: Candidate design, $x_{min\ n}$ and $x_{max\ n}$ are the lower and upper bounds of the n-th design variable x_n (here, they are breadth, depth & reinforcement percentages of member cross-sections)
- D: Total number of design variables of a food source
- f(X): Objective function
- M(X): Design moment of the structural element
- P(X): Axial load capacity function

NUMERICAL STUDY & RESULTS

Performance of proposed ABC algorithm is evaluated through typical optimization examples of planar structural frame elements. The frames considered have typical storey height of 3 m and bay size 6 m. The loading of 10 kN/m^2 is applied on each beam and the lateral load estimated according to IS 1893 and given as input

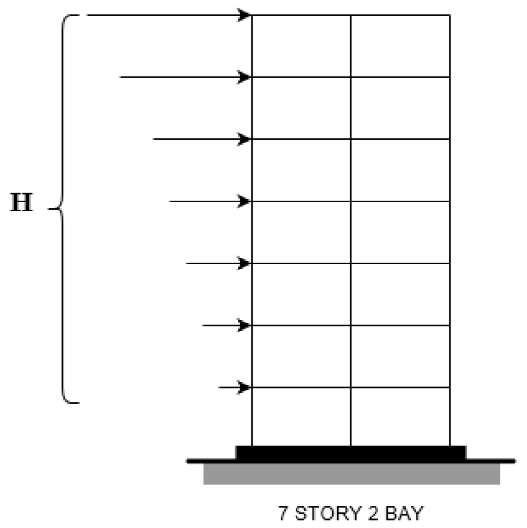


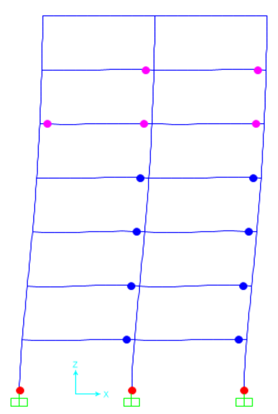




S. No	Beam Dimensions (mm)	Demand of Beam (kN m)	Tension Reinforcement (% of rein. (pt))	Compression reinforcement (% of rein. (pt)
1	300 x 400	283	1.96	0.96
2	300 x 400	276	1.90	0.90
3	300 x 400	255	1.77	0.87
4	300 x 400	250	1.77	0.86

Beam optimization evaluation



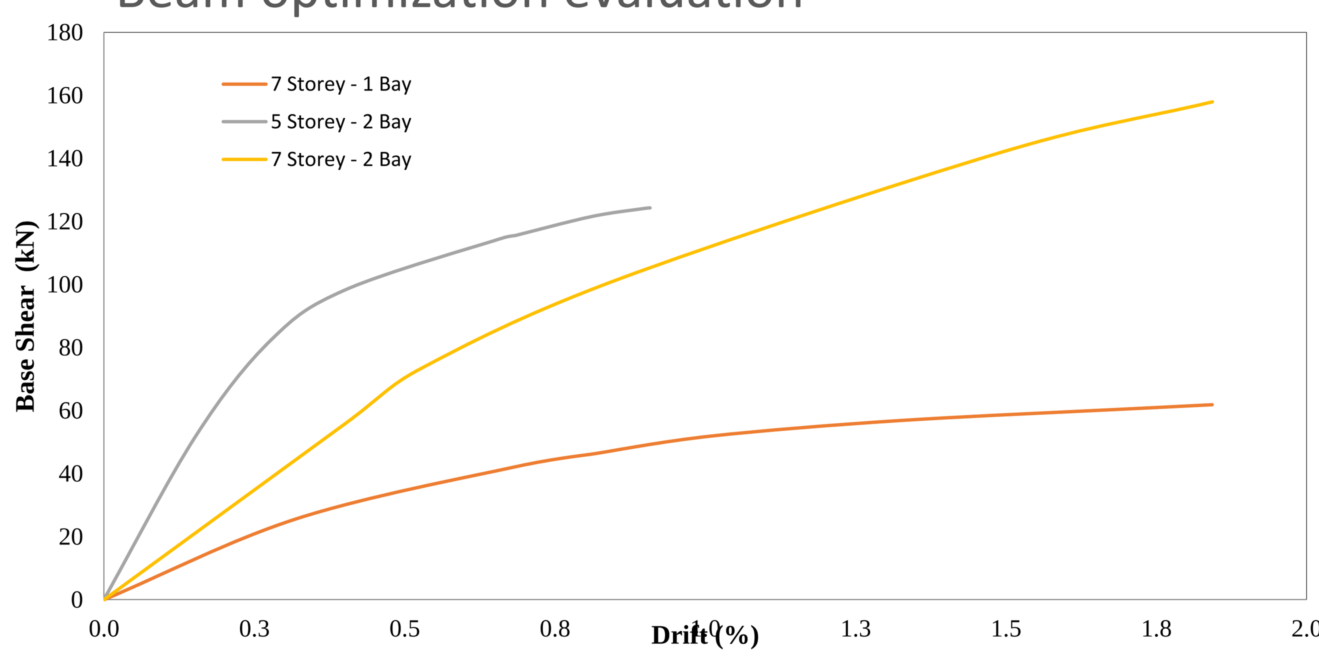


Storey	Beams			Columns		
	B × D (mm×mm)	Pst (%)	Psc (%)	B × D (mm×mm)	ps (interior) (%)	Ps (exterior) (%)
5	230 × 300	0.35	0.32	300 × 300	0.89	1.39
4	230 × 300	0.39	0.30	300 × 300	1.36	1.44
3	230 × 300	0.53	0.32	300 × 300	1.39	1.54
2	230 × 300	0.59	0.35	300 × 300	2.01	2.05
1	230 × 300	0.97	0.58	300 × 300	2.09	2.09

Five storey Two Bay

Storey	Beams			Columns		
	B × D (mm×mm)	P_{st} (%)	P_{sc} (%)	B × D (mm×mm)	P_s (interior) (%)	P_s (exterior) (%)
7	230 × 300	0.35	0.32	300 × 300	1.85	1.76
6	230 × 300	0.35	0.32	300 × 300	2.03	1.92
5	230 × 300	0.63	0.65	300 × 300	2.04	1.94
4	230 × 300	0.71	0.65	300 × 300	2.19	2.14
3	230 × 300	0.83	0.74	300 × 300	2.19	2.14
2	230 × 300	1.49	0.74	300 × 300	2.19	2.69
1	230 × 300	1.37	0.68	300 × 300	2.28	2.69

Seven Storey Two Bay



Pushover analysis results of the obtained Designs

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