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List of symbols and abbreviations

Acronyms and other notations

GSO	Gradientless shape optimization
SSCO	Simultaneous Shape and Cable Optimization
SCS	Steel-concrete-steel
PSC	Pre-stressed concrete
FEM	Finite element method
2D	Two-dimensional
3D	Three-dimensional
B-spline	Basis spline
CAGD	Computer-aided geometric design
FE	Finite elements
DFO	Derivative-free optimization
MF	Move factor
MV	Move value
MMF	Minimum membership function
FEA	Finite element analysis
L	Length
B	Breadth
D	Overall depth
MCC	Minimum concrete cover
PL	Point load
UDL	Uniformly distributed load

UIL	Uniformly increasing load
MPL	Multiple point load

Symbols

σ	Maximum shear stress (N/mm ²)
σ_t	Target maximum shear stress (N/mm ²)
X, Y	Co-ordinates for the generated nodal point
X_i, Y_i	Co-ordinates of the master node 'i'
ζ and η	Natural co-ordinates
N_i	Shape function of nine-noded element
N_m	Number of master nodes
μ	Membership value
L_{min}	Smallest distance among all the distances between the design node and their respective direction node
N_d	Number of design nodes
δ	Deflection (mm)
ΔX and ΔY	Perturbation vector
β and α	Magnitude of perturbation
Φ	Bending stress
E	Young's modulus
ν	Poisson's ratio
ρ	Density
t_f	Thickness of faceplates
t_c	Thickness of concrete core
k	Order of B-spline
P_i	N+1 defining polygon vertices
$N_{i,k}(t)$	Weighting function
S_c^1, S_c^2, S_c^3	Shape function of three-noded bar element
\bar{T}	Tangential vector
\bar{N}	Normal vector
K	Curvature
R	Radius of curvature
P_n	Tension in the cable

\bar{t}	Unit tangent vector
\bar{n}	Unit normal vector
F_t	Tangential force
F_n	Normal force
\bar{F}	Resultant force
F_L	Equivalent nodal force vector
F_A	Anchored force vector
P_{end}	Tension in cables at end nodes
F_{final}	Total load
G_p^1 & G_p^2	Gauss points
ω	Wobble coefficient
γ_e	Density of the element
A_e	Area of the element
B_e	Breadth of the element
m	Total number of elements
σ_{top} and σ_{bottom}	Bending stress at top and bottom of pre-stressed beam
B1, B2, and B3	Three different types of beams
CC	Circular plate with a square cut-out
B3a, B3b, B3c, B3d, and B3e	Five different versions of Beam B3
P_{B1} , P_{B2} , and P_{B3}	Three types of PSC beams
M-1, M-2, M-3, M-4, and M-5	Material 1, Material 2, Material 3, Material 4, and Material 5