Cairo University

MULTI-OBJECTIVE OPTIMIZATION OF STEEL FLOORS AGAINST COST AND EMBODIED ENERGY

By

Ahmed Magdy Mohamed El-Sayed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Structural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

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Key Words:
Multi-Objective; Optimization; Steel; Cost; Embodied Energy

Summary:

This thesis takes the advantage of evolutionary optimization algorithms to use it in finding the optimal layouts for steel floors against cost and embodied energy through making a program that can do this task. Effort is made to acquire embodied energy values for common structural materials in Egypt to be used along with the cost data according to the Egyptian market in finding the optimal layouts. The program is tested on three case studies and the results are analyzed to successfully give recommendations to structural engineers in order to obtain near optimum solutions for their design without using the program.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Ahmed Magdy Mohamed El-Sayed Date: 10/10/2018

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Nomenclature

w_{DL}	Applied dead load on secondary beam per unit length of beam
B_{OW}	Own weight of the secondary beam per unit length of beam
I_{MD}	Intensity of metal deck weight per unit area of floor
γ_{RC}	Density of concrete
t_s	Thickness of reinforced concrete slab
a	Secondary beams spacing distance
I_{Fl}	Intensity of flooring load per unit area of floor
w_{LL}	Applied live load on secondary beam per unit length of beam
I_{LL}	Intensity of live load per unit area of floor
w_T	Applied total load on secondary beam per unit length of beam
Q_y	Shear in y direction
M_x	Moment about x-axis of beam
l	Secondary beam length
w_{eq}	Equivalent uniformly distributed load over main beam.
B_{OW}	Own weight of the main beam per unit length of beam
$\sum R$	Sum of reactions of secondary beams exerted on the main beam
L	Main beam length
f_{act}	Actual bending stress
f_{all}	Allowable bending stress
q_y	Actual shear stress in y-axis direction
q_{all}	Allowable shear stress
E	Young's modulus for steel
I_x	Second moment of inertia of beam section about x-axis
Δ_{act}	Actual deflection
Δ_{all}	Allowable deflection
n1	The number of rooms in the horizontal direction
n2	The number of rooms in the vertical direction
A_i	The area of the room
n_H	Number of horizontal rooms
n_V	Number of vertical rooms
n_T	Total number of rooms
X	The optimization variable vector
md	The metal deck section
C_T	The total cost of structure
C_s	The cost of steel per ton
C_c	The cost of concrete per cubic meter
W_s	Total weight of steel material
W_c	Total weight of concrete material
E_T	The total embodied energy for the structure
E_s	The embodied energy factor for steel per ton
E_c	The embodied energy factor for concrete per cubic meter
W_{max}	Maximum width of structure defined by user
W_{min}	Minimum width of structure defined by user
w_i	Room width or dimension in x-axis
L_{max}	Maximum length of structure defined by user

L_{min}	Minimum length of structure defined by user
l_i	Room length or dimension in y-axis
A_{UD}	Total area of structure defined by user
W	Total width of layout
L	Total length of layout
A	Area of layout
r_u	Upper bound for aspect ratio at a specific load value
r_l	Lower bound for aspect ratio at a specific load value
T_L	Total applied load
S_{ru}	Upper bound for ratio between secondary beams spacing and longer side of room at a specific load value
S_{rl}	Lower bound for ratio between secondary beams spacing and longer side of room at a specific load value
R	Global aspect ratio of layout at a specific load value