Cairo University

PLANNING OF CONSTRUCTION LABORS EMERGENCY EVACUATION USING BIM AND COMPUTER SIMULATION

By

ISMAIL ZAKARIA IBRAHIM AL DAOOR

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
STRUCTURAL ENGINEERING

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Title of Thesis:

Planning Of Construction Labors Emergency Evacuation Using BIM And Computer Simulation

Key Words:
Building Information Modeling (BIM); Labors Evacuation Planning; Computer Simulation; Construction Sites

Summary:
Evacuation of labors during emergency situations is a crucial aspect when considering construction project planning. To support emergency evacuation planning, it is critical to estimate labor evacuation times during project execution. This research presents a framework that aids in planning of construction labors emergency evacuation using building information modeling (BIM) and computer simulation. 4-Dimention models are created using BIM in order to generate construction project scheduling to visualize evacuation of labors in emergency situations at any time during project execution. Computer simulation is adopted by applying agent-based simulation to model the behavior of labors in evacuation situations. MassMotion simulation platform is utilized to implement agent-based simulation. Ranking and Selection statistical procedures are used to determine the best simulated model configuration among the considered four alternatives. Multi Criteria Decision Making (MCDM) is applied to help in selecting the suitable construction alternative. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is used to identify the best construction method scenario taking into consideration three main criteria which are: construction total cost, execution time, and evacuation time of labors. The proposed framework is examined within the context of a case study that considers evacuation of labors during the construction of building in Egyptian social housing national project. This framework can be used as a decision support tool that aids contractors and safety managers to select the appropriate construction alternatives.

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DEDICATION

To my father and mother for their endless support

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To my uncles and my family for their endless support

To my wife for her unlimited encouragement and my children Anas, Rehab, and Jood

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Ismail Z. AL Daoor

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LIST OF ABBREVIATIONS

AEC	Architecture, Engineering, and Construction industry
IFC	Industry Foundation Classes
SD	System Dynamic
ABM	Agent Based Modeling
ABS	Agent Based Simulation
DES	Discrete-Event Simulation
BIM	Building Information Modeling
VR	Virtual Reality
DEVS	Discrete Event systems Specification
ISEE	Immersive Safety Engineering Environment
CA	Cellular Automata
IAI	International Alliance for interoperability
API	Application Programming Interface
NIBS	The National Institute of Building Sciences
GPSS	General Purpose Simulation System
MCP	Multiple Comparison Procedures
STEPS	Simulations of Transient Evacuation and Pedestrian movements
MASCOT	Multi Agent System for Construction Claims Negotiation
FDS	Fire Dynamics Simulator
CFD	Computational Fluid Dynamics
AHP	Analytic Hierarchy Process
MCDM	Multi Criteria Decision Making Process
TOPSIS	Technique For Order Preference By Similarity to Ideal Solution
PIS	Positive Ideal Solution
NIS	Negative Ideal Solution

ABSTRACT

Evacuation of labors during emergency situations is a crucial aspect when considering construction project planning. To support emergency evacuation planning, it is critical to estimate labor evacuation times during project execution. This research presents a framework that aids in planning of construction labors emergency evacuation using building information models (BIM) and computer simulation. 4-Dimention models are created using BIM in order to generate construction project scheduling to visualize evacuation of labors in emergency situations at any time during project execution.

The construction total cost and project execution duration are estimated for each construction scenario based on the information in building information model (BIM). Computer simulation is adopted by applying agent-based simulation to model the behavior of labors in evacuation situations. MassMotion simulation platform is utilized to implement agent-based simulation and to imitate labors' behavior during emergency evacuation times under various conditions. Four alternatives that represent different scenarios are modeled in the proposed research. These scenarios take into consideration the sequence of activities, the number of labors for each activity, and duration of activities.

Ranking and Selection statistical procedures are used to determine the best simulated model configuration among the considered four alternatives. The Rinott's procedures are implemented to rank and select the evacuation time for these scenarios. Multi Criteria Decision Making (MCDM) is applied to help in selecting the suitable construction alternative. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is used to identify the best construction method scenario taking into consideration three main criteria which are: construction total cost, execution time, and evacuation time of labors (safety considerations).

The proposed framework is examined within the context of a case study that considers evacuation of labors during the construction of building in Egyptian social housing national project. The proposed framework can be used as a decision support tool that aids contractor and safety managers to select the appropriate construction alternative(s) according their preference with respect construction total cost, execution time, and evacuation time of labors.