MODELING OF RESOURCE-DRIVEN SCHEDULING IN HIGH-RISE BUILDINGS USING GENETIC ALGORITHM

[1]Mithila Vand [2]Annie Sonia Xavier
[1]M.Tech Scholar,[2]Asst.Professor
Toc H Institute of Science and Technology, Cochin, India

ABSTRACT

Construction industry often faces projects having repetitive activities and they are known to be repetitive projects. Repetitive projects like high-rise buildings require construction management schedules for effectively carrying out an activity in one floor to a similar activity in the next floor. The paper describes resource-driven scheduling model for high-rise building construction to minimise project duration and to maximise effective utilisation of resources (material, machine, man). The proposed model guarantees to produce a realistic and achievable timetable for executing the work. The model can also reduce idleness of man and machine due to unbalanced and ineffective planning of repetitive activities and variability during execution. The resource-driven scheduling model proposed here uses optimisation tool as genetic algorithm which is a natural evolutionary process operate on a population of solutions rather than a single solution. Java, the programming language and MySQL, the standard language for accessing databases is used as frontend and backend for the development of the scheduling model.

KEYWORDS: *High-Rise Buildings, Resource-Driven Scheduling Model, Genetic Algorithm, Java, MySQL*

I. INTRODUCTION

The construction companies are often faced with projects that contain several repetitive activities. These multi-unit projects are identified by their repetitive activities in which individual identical activities are repeated consecutively from unit to another [8]. The activities which are repeating throughout the project are called repetitive activities and the projects are often called as repetitive projects. The repetition of activities are seen clearly in floors of high-rise buildings. The efficacy of managing a construction project mainly depends on proper planning and scheduling of resources [1]. Repetitive scheduling methods are more effective than traditional critical path methods in the planning and scheduling of repetitive construction projects [24]. Resource allocation optimization is a combinatorial problem with multiple objectives (project duration confinement, resource-constrained allocation, resource leveling) and its size and complexity grows exponentially as the number of activities, resource types, and execution modes increase [5]. High-rise buildings require construction management schedules that ensure the uninterrupted usage of an activity in one floor to a similar activity in the next floor. For the development of this schedule, it is important to assign resources (material, machine, man) to each construction activity by comparing availability and requirement of these resources.

In repetitive projects, construction crews (resources) repeat the same tasks from one unit to the next, such as from floor to floor, or station to station and resources move from location to location and perform similar work [17]. Also there may be a great chance of using same resource by several activities of repetitive construction projects. It is common to observe in high rise buildings that man and machine is idle and waiting because the preceding man and machine have not finished their works. This idleness is due to unbalanced and ineffective planning of repetitive activities and variability during execution. Idleness may also arise due to bad weather, accidents, or equipment breakdown. This makes contractors suffer from higher costs and possible delays [1]. It can be solved

by developing an effective scheduling method for repetitive projects. The major challenge is allocation of limited resources among all activities to meet the resource requirements of project, and to optimize all the project's multiple objectives [3]. Unlike the existing scheduling methods for construction processes, a resource-driven scheduling model which uses genetic algorithm can be used to optimally allocate resources to repetitive activities. The genetic algorithm procedure searches for an optimum set of tasks and priorities that produce shorter project duration and better-levelled resource profiles [12].

The structure of this report is at first we have brief introduction followed by problem definition and comes methodology followed by concept behind the proposed model and then resource-driven scheduling model system architecture followed by results and discussion and finally conclusions.

II. PROBLEM DEFINITION

The repetitive construction projects are projects in which each construction activity is repeating from one unit to next unit. There are mainly two types of repetitive construction projects; one is discrete repetitive projects and other is continuous repetitive projects [2]. In case of discrete repetitive projects, construction activities are repeating from one unit to other unit. Multi-storey buildings, housing development projects are the examples for discrete repetitive projects. On the other hand, in continuous repetitive projects, construction activities are repeating continuously. Highways, tunnels, railways, bridges, pipeline networks, sewer mains are the examples for continuous repetitive projects [5].

The high-rise buildings are buildings with 35 m or greater in height, divided at regular intervals into occupiable levels [20]. High-rise buildings are discrete repetitive projects where repetitive activities are seen clearly in each floor [1]. It is important to reduce the complexity of scheduling of repetitive activities of high-rise building construction [3]. Existing scheduling models currently available in the market are focusing on all type of constructions. The main problem concerned with scheduling of high-rise building construction activities is to obtain optimal project duration with the constraint of available resources (man, machine, material) and effective allocation of these resources to these construction activities. By considering this, resource-driven model is developed so as to maintain resource continuity to reduce idleness of labour and equipment in high-rise building construction projects.

III. METHODOLOGY

Construction companies which build high-rise buildings are identified and repetitive works for construction were determined. Identification of repetitive activities has been carried out using different literatures and by interviewing experts in construction. Data were collected from almost 10 construction companies. Also resources required for each task of construction works are collected and tabulated. Resources required for each tasks include material, equipment and labour required to complete each activity in construction of high rise building.

After the collection of inputs (repetitive activities, dataset consisting of duration of each activity and resources availability in projects) for the proposed model for resource- driven scheduling in high rise building, inputs are used to develop genetic algorithm inorder to model resource-driven schedule for repetitive activities of high-rise buildings.

Java, the programming language and MySQL, the standard language for accessing databases is used as frontend and backend for the development of the scheduling model.

IV. CONCEPT BEHIND THE PROPOSED MODEL

The major aim of the project is to schedule the repetitive activities of high-rise building construction and to automatically generate the minimum number of days required to complete the work with the constraint of available resources. For achieving this aim, huge amount of data (repetitive activities, sub activities, materials, machines and no: of labours required for each activity) were collected on the basis of twelve storied high-rise buildings having 750 x 750 mm column size and having six flats in a floor (1000 square feet area, 2 BHK each). Genetic algorithm is the tool used to develop the proposed

model since it is an evolutionary computation technique used to achieve optimization of resources allocation and levelling concurrently and produced shorter project duration. The backend of the proposed model is MySQL which is a standard language for accessing databases. The frontend of the proposed model is Java which is a programming language and a software environment in which a program runs, known as a platform. The proposed model runs as desktop application.

V. RESOURCE-DRIVEN SCHEDULING MODEL SYSTEM ARCHITECTURE

Fig. 1 illustrates the overall framework used to develop the Resource-Driven Scheduling Model system architecture, consists of three modules. The input module contains project data collected from various construction companies which had high-rise building constructions. Input data were coded in MySQL language and tabulated in it. This huge input data is processed using genetic algorithm which works based on fitness function to be optimised. The fitness function of the proposed model is to minimise the project duration and to maximise the effective utilisation of resources. Java is the programming language which is used as frontend of the proposed model. The resource-driven schedule module generates the desired output according to the input given.

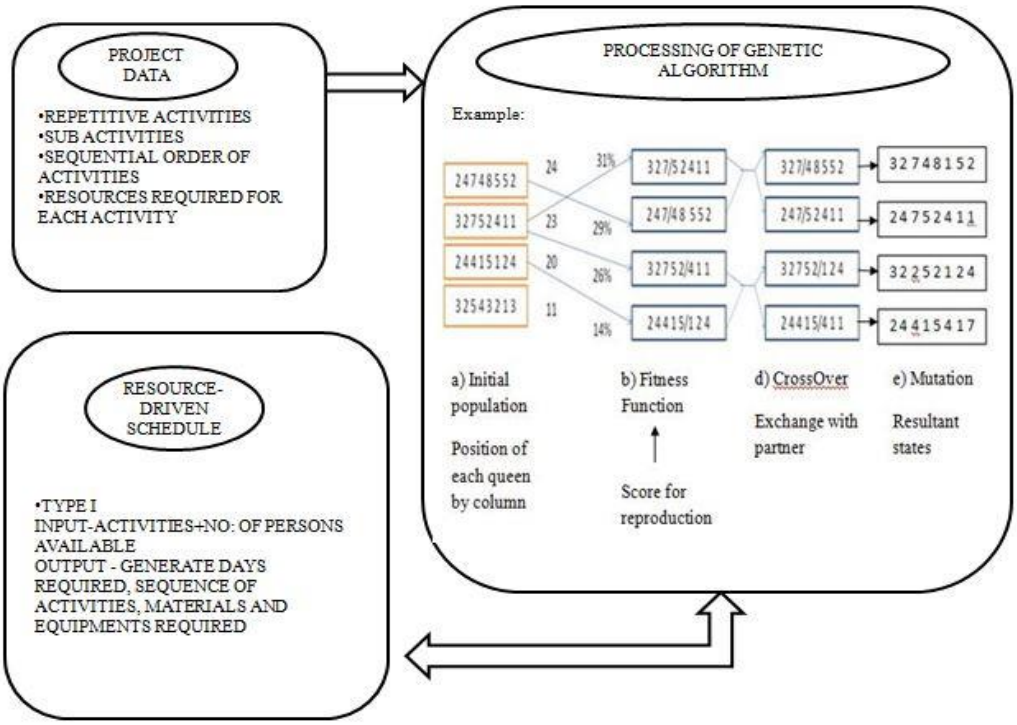

Figure.1 Flowchart of Resource-Driven Scheduling Model

VI. RESULTS AND DISCUSSION

The proposed resource-driven scheduling model is developed to determine the resource scheduling and activity sequencing with the objective of minimum project duration and maximum resource utilisation. The model is developed by using Java programming language as front end and MySQL as backend. The scheduling model (Type I) is effective for high-rise building constructions.

In Resource-driven schedule (Type I), repetitive activities to be performed and number of persons available for performing these activities are given as input. Then the model automatically generate the number of days required for completing these activities, sequential order of these activities (including sub activities) and materials, equipments required for performing these activities. The following figures explains how it works.

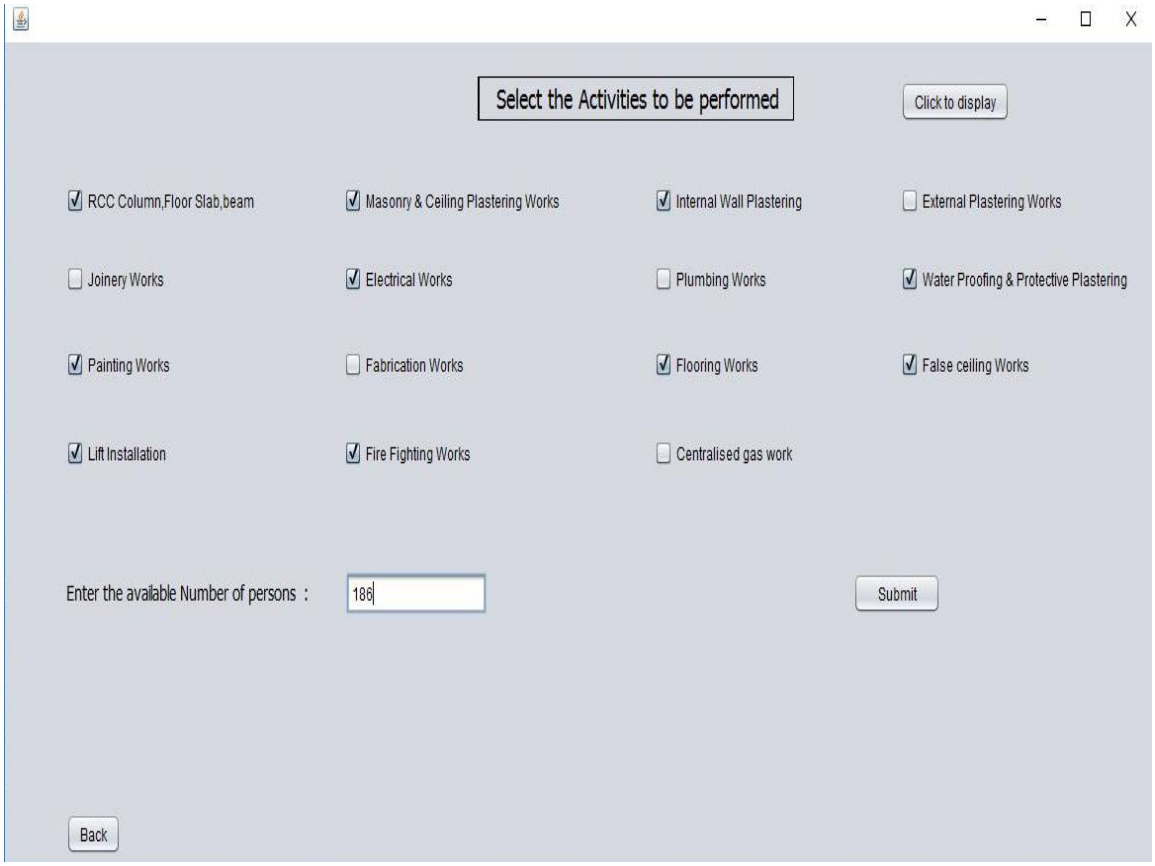

Figure 2. Window of the model showing repetitive activities of high-rise building

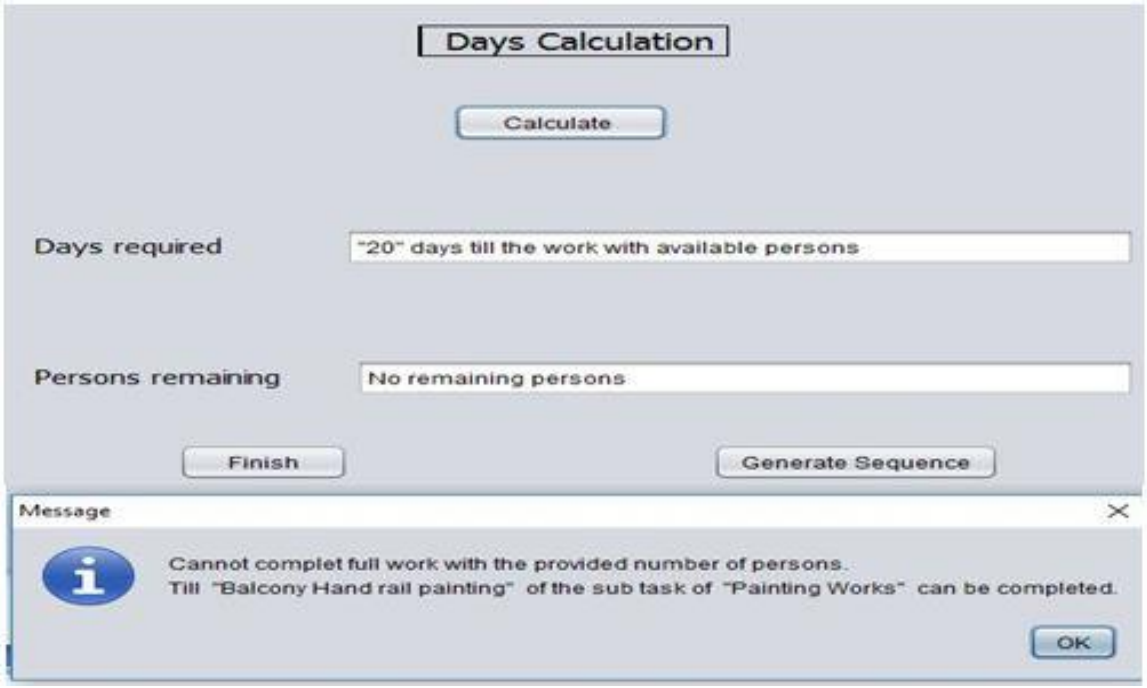

Figure 3.Window of the model giving the output as number of days required for completing the selected activities

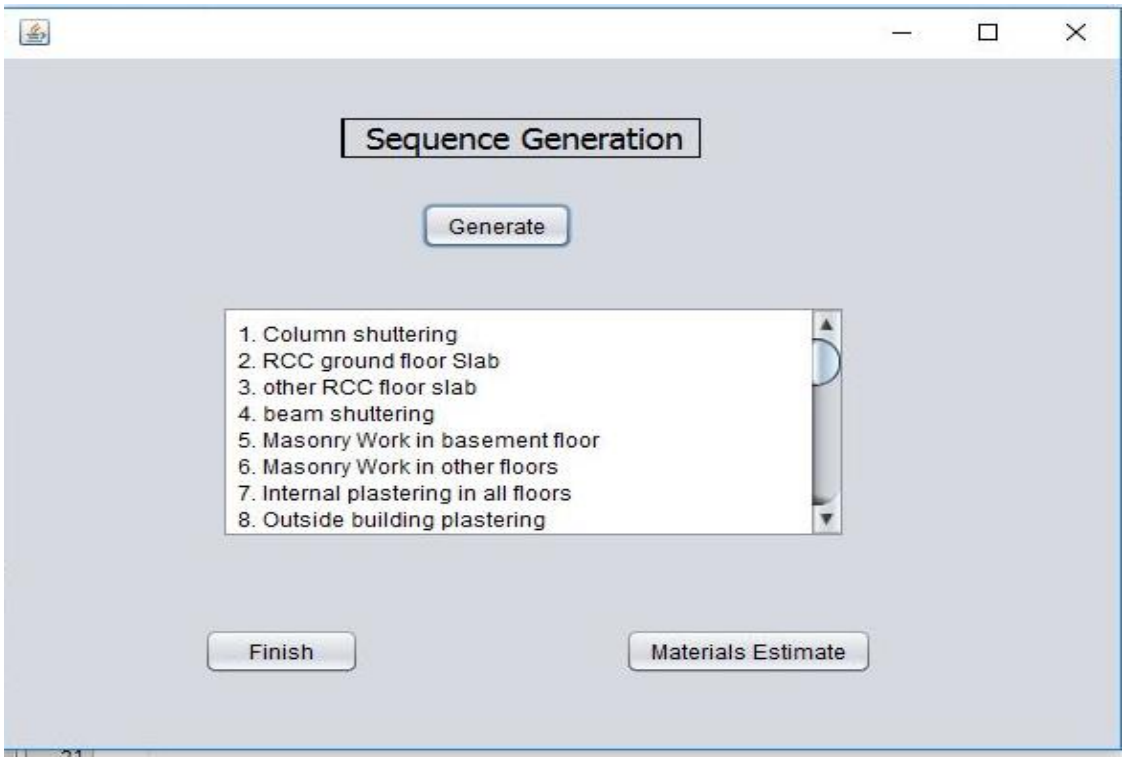

Figure 4. Window of the model showing sequential order of activities

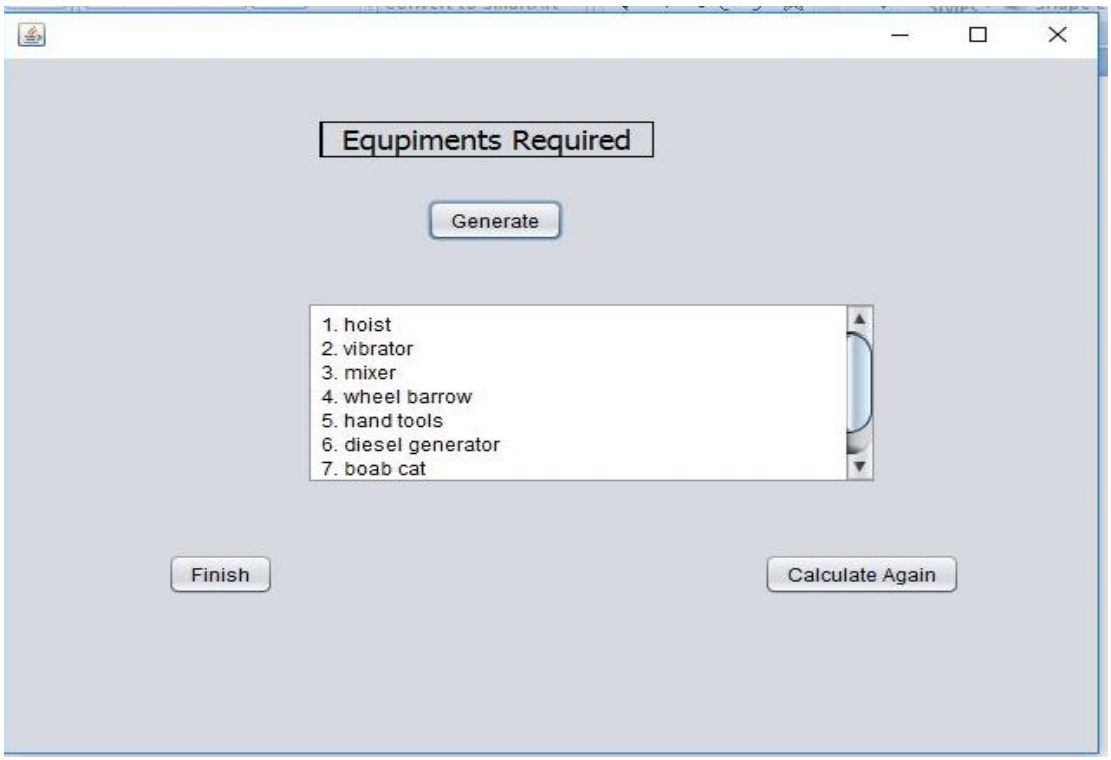

Figure 5.Window of the model showing output as equipments required for completing the selected activities

VII. CONCLUSION

Thus the proposed resource-driven schedule can effectively schedule repetitive projects like high-rise buildings for effectively carrying out an activity in one floor to a similar activity in the next floor. The model optimally allocate resources (material, machine, man) to repetitive activities of high-rise building. The model can reduce the complexity of scheduling of repetitive activities and can provide work continuity for labour crews. The resource-driven scheduling model is effective to reduce idleness of man and machine due to unbalanced and ineffective planning of repetitive activities and variability during execution. The resultant outputs obtained from the model illustrates that resource-driven scheduling can achieve minimum project duration and maximum effective utilisation of resources. In future, practical constraints like impact of weather, labour accidents, equipment failures etc can be considered along with allocation of resources to repetitive activities.

REFERENCES

[1]CindrelaDevi.A, Ananthanarayanan.K, (2015)"Development of Resource-Driven Scheduling Model for Mass Housing Construction Projects" IACSIT International Journal of Engineering and Technology, 7(5), pp 316-330
[2] KhaliedHyari and Khaled El-Rayes, (2006) "Optimal Planning and Scheduling for Repetitive Construction Projects"ASCE Journal of Construction Eng. Management , 22(4), pp 11-19
[3] Mohammed . S, AshrafElazouni and TarekZayed(2016); "MOSCOPEA: Multi-objective construction scheduling optimization using elitist non-dominated sorting genetic algorithm" ELSEVIER Automation in Construction, 71(9), pp 153-170
[4] Shih-Ming Chen , F.H. Griffis , Po-Han Chen and Luh-Maan Chang(2011); "Simulation and analytical techniques for construction resource planning and scheduling" ELSEVIER Automation in Construction, 21(7), pp 91-113
[5] Sofia Kaiafa ,Athanasios P. Chassiakos(2015); "A genetic algorithm for optimal resource-driven project scheduling" ELSEVIER Procedia Engineering , 123(2), pp 260-267
[6] SymeonChristodoulou(2010); "Scheduling Resource-Constrained Projects with Ant Colony Optimization Artificial Agents"ASCE Journal of Construction Eng. Management , 24(8), pp 45-50
[7] AbhayTawalare, Rajesh Lalwani (2012); "Resource Leveling in Construction Projects using Re- Modified Minimum Moment Approach" International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering 6(2),PP.112-124.
[8] Andrew Junfang Yu, JavadSeif (2015); "Minimizing tardiness and maintenance costs in flow shop scheduling by a lower bound-based GA" *ELSEVIER Computers & Industrial Engineering* 29(2),pp.352-360.
[10] Bernardo F. Almeida, Isabel Correia, Francisco Saldanha-da-Gama(2015); "Priority-Based Heuristics for the Multi-Skill Resource Constrained Project Scheduling Problem" *ASCE Journal of Construction Engineering and Management* 18(6),PP.602-626.
[11] DrorHermel, HamedHasheminia, NicoleAdler, Michael J. Fry(2015); "A solution framework for the multi-mode resource-constrained cross-dock scheduling problem" *ASCE Journal of Construction Eng. Management* ,12(5), pp 45-55.
[12] Devikamalam J, Jane Helena. H (2013); "Resource scheduling of construction projects using genetic algorithm" *International Journal of Advanced Engineering Technology 12(7),*PP.113-119.
[13] Hyun-Soo Lee, San Roh, Moon-Seo Park, and Han-GukRyu (2010); "Optimal Option Selection for Finishing Works of High-Rise Building" *KSCE Journal of Civil Engineering* 14(5),pp.639-651.
[14] Marco A. Bragadin, kallekahkonen(2011); "Heuristic solution for resource scheduling for repetitive construction projects" *ASCE Journal of Computing in Civil Engineering* 120(1), pp.96-116.
[15] Manuel Dios, Jose M. Framinan(2016); "A Review and Classification of Computer-Based Manufacturing Scheduling Tools" *ELSEVIER Computers & Industrial Engineering*, 28(8),pp 109-116.
[16] Pandelis G. Ipsilandis(2007); "Multiobjective Linear Programming Model for Scheduling Linear Repetitive Projects" *ASCE Journal of Construction Engineering and Management* 78(4), pp.745-791.
[17] Photios G. Ioannou,I-Tung Yang (2016); "Repetitive Scheduling Method: Requirements, Modeling, and Implementation" ASCE *Journal of Construction Engineering and Management* 45(4), pp.145-159.
[18] Rong-yau Huang and Kuo-Shun Sun(2006); "Non-Unit-Based Planning and Scheduling of Repetitive Construction Projects" *ASCE Journal of Construction Engineering and Management* 67(3),pp.567-602.
[19] Shih-Ming Chen , F.H. Griffis , Po-Han Chen and Luh-Maan Chang(2011); "Simulation and analytical techniques for construction resource planning and scheduling" *ELSEVIER Automation in Construction*, 21(7), pp 91-113.

[20] Mohammed Al Joma and Jean-Claude Mangin(2004); "A scheduling model for repetitive activities" *Association of Researchers in Construction Management*,2(6), PP 197-208.
[21] Onder Halis Bettemir and Rifat Sonmez(2014); "Hybrid Genetic Algorithm with Simulated Annealing for Resource-Constrained Project Scheduling" ASCE Journal of Management in Engineering 127(2), pp.408–424.
[22] Somayeh Kianpisheh, Nasrolah Moghadam Charkari, Mehdi Kargahi (2015); "Reliability-driven scheduling of time/cost-constrained grid workflows" Future Generation Computer Systems,29(4), pp. 158-169.
[23] Tarek Hegazy (2011); "Optimization Of Resource Allocation And Leveling Using Genetic Algorithms" ASCE Journal of Management in Engineering 25(5), pp. 167-175.
[24] Rong-yau Huang and Kuo-Shun Sun(2006); "Non-Unit-Based Planning and Scheduling of Repetitive Construction Projects" ASCE Journal of Management in Engineering 132(6), pp. 585-597.
[25] Umut Besikci, Umit Bilge, Gunduz Ulusoy (2014); "Multi-Mode Resource Constrained Multi-Project Scheduling and Resource Portfolio Problem" European Journal of Operational Research,128(3), pp. 166-177.

AUTHORS BIOGRAPHY

Mithila V was born in Thrissur, India, in 1994. She received the Bachelor in Civil Engineering under Calicut University, Kerala in 2015 and pursuing Masters in Construction Engineering and Management under Kerala Technological University(KTU), Kerala.

Annie Sonia Xavier received the Masters in Construction Engineering and Management from SRM University, Chennai. She is working as a Asst. Professor, Department of CE, Toc H Institute of Science and Technology, Ernakulam.