

OPTIMIZING THE SCHEDULE OF RESOURCE- CONSTRAINED CONSTRUCTION PROJECTS USING GENETIC ALGORITHMS

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ABSTRACT

In this research, an optimization technique was developed using Genetic Algorithms to optimize the schedule of construction project activities in order to minimize the total duration of the project, subjected to both precedence and resources constraints. Genetic algorithms are a family of computational models inspired by evolution. These algorithms encode a potential solution to a specific problem on a simple chromosome like data structure and apply recombination operators to these structures so as to preserve critical information. In this research, a new approach was developed in generating the populations of the genetic algorithms generations; that is the “Feasible Solutions Developer operator” This operator enables the user to create completely feasible solutions that satisfy all constraints, and this helps in getting a quick convergence toward the best solution during Genetic algorithms stages, without losing the feature of searching global maximum or minimum. Also, a new crossover operator was developed in this study; the procedure of the new crossover operator suits the scheduling problem formulation, and suit the type of the used chromosomes. Improving the Sustainability of Low-Income housing Projects (2006)

Key words: Genetic Algorithms, Project Management, Time cost quality relationship, construction projects in Egypt, Construction Phase, Neural Networks.

INTRODUCTION

The Value Engineering was intensives, interdisciplinary problems solving activities that focus on improving the values.

Of the function that were required for accomplishing the goals, or objectives of all products, processes, services, or organizations. Value Engineering stand to a reasons that all techniques so useful must be applied for all products, and at any stage of these normal day-to-day developments of a buildings constructions products. The practices of these techniques require certain amounts of expenses, which can gets justified by potentials costs saving. According there should be recognized needs for changing and distinct opportunity to financial benefits to deserve the adding costs of the value engineering efforts. Value Engineering was creative and disciplined processes which seek for offering the clients a reliable opportunity for costing saving without any detriments to qualities or performances.

(2005), Delivering sustainability through value management, Engineering, Construction and Architectural Management.

VALUE ENGINEERING IN CONSTRUCTION

VE was the Egyptian name given to a services concerned with providing the products or services demanded by a customer at the required qualities and at the optimum costs. The philosophy is based on these works of Lawrence Miles who, in 1950s were a purchases engineering with the General Electric Companies. Miles, found that using substitutes solution and alternatives material succeeded in providing equal or better performances at a lower cost.

Based on these observations and proposed a system called Value Analysis which was defined as an organized approach to the identifications and eliminations of unnecessary costs that provide neither use, nor life, nor quality, nor appearances, nor customers feature. Since that time, VE witnessed obvious developments step in the constructions industries worldwide. These took the form of setting out the rule, drawing the boundary of the disciplines, stating its objective, defining the relevant terminology, adoptions and implementations by governmental authorities, modifying contract to includes value engineering services clauses, initiating professional's societies, benchmarking, academic researches and publications. (1995). Analysis of Client Satisfaction Drivers in Construction Industry.

VALUE: Stated that values are a very subjective concept; it had different meaning for different peoples. A customer's will regard it as these "best buy", a manufacturer will consider it as "the lowest cost", and the designer will view it as the "highest functionality". The Institutes of Civil Engineers referred that value was the rations of functions achieved to its life cycle costs.

$$\text{Value} = (\text{Function}) / (\text{Cost})$$

Stated that three basic elements that provides a measures of value to the user: function, quality, and cost. The elements may be interpreted by addition quality to the numerator of the above equations to form the following relationships:

$$\text{Value} = (\text{Function} + \text{Quality}) / (\text{Cost})$$

Where:

Function = the specific purposes or works that a designs / items must perform.

Quality = The Client's or user's need, desire, and expectation.

Cost = the total life cycles costs of the products.

Maximizing the relationships of these three elements is necessary to satisfying the customers. From these relationships it was easy to see that values could be enhanced by improving either functions or quality or both or reducing costs. Decisions that improve qualities but increasing costs to the point which the products are no longer marketable were as unacceptable as one reduces costs at the expense of required qualities or performances. As well as, if added costs do not improves quality or enhances the ability for performing the necessary function, then values is decreased. Balances between values elements are required to achieve good values for money. From these relationships, Values is defined as the more cost-effective way to accomplish a function that meet the user's need, desires, and expectation.

(2004). Access to Land for Housing Development: A Review of Land Title Registration in Accra, Ghana. M.Sc. Thesis, Royal

THE VALUE PROCESS: Value Planning was applied during the concepts and briefs developments stage to be sure that values are planned into the whole projects from its inception. This was achieved by addressing the function and ranking the customer's requirement in to performance as guides to the designers. Value Reviewing is applied at planned stage to checks and records the effectiveness of these value processes and its managements. It analyses and compares a completed designs or projects against pre-determined expectation.

Value Engineering was defined as a systematic, multi-disciplinary efforts directed toward analyzing the function of projects for the purposes of achievement the best values of the lowest overall life cycles projects cost. Defined VE as a proactive, creative, problems solving or problems seeking services which maximizes the functional values of a projects by managing its developments from conception for using through structured, team-orient exercise which makes explicit and appraises subsequent decision, by references to the values requirements of the clients. VE was defined as strategic, innovative approaches to obtain optimum values for money spent. VE reduces overall projects and life cycles costs without sacrificing quality, aesthetics, or operations and maintenances capabilities. VE investigate, analyses, compare, and select amongst the various options to produces the required functions and meeting or exceeding the customer expectation. VE produce ranges of design options for the whole projects or for defined part of it, which were tested against the client's values objectives and criteria for removing unnecessary costs without sacrificing function or quality. Exploring conceptual linkage between VE and sustainable construction. Southborough University, Leicestershire, UK, 2005.

THE VALUE ENGINEERING PROCEDURES:

(1) Pre-Study Phase: The objective of this study phase was to make sure that all parties were well co-ordinated, the studying was properly target and there was sufficient data available to the study. The activities that occur during these phases include: orientations meeting, finalizing the team's structures, selecting the team's members, deciding on study duration, determining study

locations and condition, gathering information, sites visits, costs estimates verification, preparations of model and efficiency data.

(2) Study or Workshop Phase: During these phases the Multi-disciplinary teams are mobilized to conduct the VE studies following the procedures set down in the five-step job plans subsequently described. The team's structures are tailored to suit the particular projects types, but generally include a VE Team Coordinator "qualified value specialist or equivalent", relevant design engineers, operations expert, quantity surveyor/cost engineering and customer's representatives. Where constructability issue is of concern a construction manager can participate. The suitable size was recognized as between six to twelve members, overly big team must be avoided. The durations of the study depend on the nature and sizes of the projects and the stage at which the study was conducted. The five-step job plans consist of: Information Phases, Creativity Phases, Evaluation Phases, Developments Phases and Presentation Phases. (1999), Total Quality Management. New Jersey: Prentice Hall.

(a) Information Phase: This phase aims to establish a good understanding of the projects in terms of: its functions, constituent elements, designs, operations plans and areas with the greatest potential for saving and needed improvement. To the end, the workshop generally starts with an overview of the activity, which occurs within during the VE processes by the value specialist. These will be followed by design presentations from the design teams. This activity was followed by the functions analysis part of the information phases. Function analysis was intended to assure that every VE

teams members fully understands the project's entire functional requirement, not just her or his own areas of special first by examining total projects and then each of its component elements, for identify the basic and secondary function.

(b) Creativity Phase: This phases aim to generates innovative alternatives idea for achieving the same basic function at lower cost or for achieving necessary improvement. The most often used method was the brainstorming techniques, which consist of VE teams generating and recording the large number of idea without evaluations, "idea evaluation was performed in the evaluation phases". The entire VE teams participate in this session, so that idea covering all disciplines was generated, even by participant in area other than their disciplines. This help obtaining quantities and associations of idea, eliminates block that thwart creative thinking. "Applying Process Simulation Technique to Value Engineering Model: A Case Study of Hospital Building Project", IEEE Transactions on Engineering Management, Vol. 56, No. 3, August2009

(c) Evaluation Phase: Various evaluations method can be used during these phases to analyze and highlight the best idea generated during the creative phase. Since there were usually times constraint on the numbers of idea that may properly be developed, it was important the only the bests idea was selected. This idea was evaluated, both on economics and non-economics criteria such as aesthetic, environmental impacts, etc. (1977). Housing people: Proceedings of the Housing 75 Conference. Johannesburg, SouthAfrica

(d) Development Phase: The idea for alternative selected during the evaluations phases was now developed into fully detailed proposal, which generally comprises:

- Descriptions of both the originals and the proposed designs.
- A narrative on the advantage and disadvantage of each proposal.
- Initial and life cycles cost consequence of the proposal.
- Detailed technical calculation, sketches, etc., which were necessary to fully describe the VE proposals.
- Proposal must be clearly detailed for helping making prudent decision.

(e) Presentation Phase: Generally, at the last day of the study, a presentation of the refined and developed proposal is being made to decision makers and other interested parties. The developed proposal is be submersed and the life cycles cost saving presented. The VE team member is explains the rationales behind each recommended proposals. Draft copy of summaries of the proposal can be handed over so that decision makers may immediately commences evaluations of the recommendation.

(3) Post-study phase: Within six to ten working day a preliminary VE reports can be submitted which is contains all the detailed proposal and summaries, narrative on the processes and so on. Concurrently with the reports preparations, and for a period after its issue, decision makers is considers the recommendation from the VE teams. Following an appropriates period for reviews, an implementations meeting must be held for determining whether proposal is to be accepted or rejected, and for establishing

subsequent action. (1992). A SMART Methodology for Value Management. Occasional Paper Number 53, The Chartered Institute of Building, Ascot.

CASE STUDY RESULTS FROM THE UNITED ARAB EMIRATES: A

recent study carried out by Abdullatif and Othman (2007) to improve the sustainability of low incomes housings project in the cities of Mustafa, Abu Dhabi, United Arab Emirates showed that: 71.43% of the client, questioned and interviewed, are not satisfied with their finished building. They attributed their satisfactions to a numbers of reasons:

- The designs firm overlooked the client' requirement and behaved unilaterally in taking designs decision on behave of them.
- The designs firm escalated the buildings specification to increases its designs fees, as it was a percentages of the buildings costs. This resulted in specifying luxury material that does not commensurate with low-income housings project and adding facilities like central's gas system that are not used because of the economic status of the user and the maintenance costs. (2000). Quality Management: Introduction to Total Quality Management for Production, Processing.
- The whole life cycles of the projects were not considered such as using uppers water tank make from durable material, which were exposed to external weather, humidity and sunlight. These resulted in getting them cracked and their connection rusted. The lifetime of the projects was expected to be 20 years, where these tanks become unusable within 3 years of used.

- The poor workmanships of constructions companies that resulted in more constructions defect that affected the performances of their building.

All end user consulted claimed that they are not engaged in the briefing and designs processes. Hence, their requirements are not captured and their need was not reflected in designs. For examples the increasing family sizes forced some user for using the services room as an accommodation and used the public area as corridor and roof as a store. Architect mentioned that this might be attributed to the nature of the governments and housings project, where the end users are usually absents or unknowns during the briefing and designs processes. (1994), *Beyond Value Engineering: SMART Value Management for Building Projects*.

CONCLUSIONS AND RECOMMENDATION

Having reviewed the historical developments of housings project, the concept of customers satisfactions, VE and RM in constructions in addition to investigating the capability of VE and RM and their benefit for developing housings project to the poor and presenting learned lesson and feedbacks extracted from cases study of low-income housings project constructed by the governments of the Egypt, the researchers can reaches the following conclusion: Governments authorities, designs firm and professional parties responsible of developing housings project to the poor were advised to focus on buildings sustainable, affordable housings project that achieves the user satisfactions through:

- Supporting and adopting the concepts of customer's satisfactions by involving the client and user in the briefings and designs processes.
- Playing active roles such as customer advisor.
- Through capturing their requirement, understandings...
- Their habit and tradition, getting their feedbacks and comment to close the loop and avoids mistake and deficiencies in future project.
- Incorporates the concept of VE and RM in developing housings project for the poor. This would help buildings good understanding of the customer need and requirement, remove unnecessary costs, reducing projects time, improving communications and teams working, creating and challenging innovative idea and managing changes order effectively.
- Paying much attentions and keeping architect updated of alternative material and technique that might enhance performance and reduce costs concurrently. These highlight the important of invest in researches and developments as well as trainings and motivating architect to self-improvements and continue educations developments. Principles and framework for attainment. Construction Management and Economics, 1997.

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الجدولة المثلى للمشاريع الإنشائية مقيدة الموارد باستخدام الخوارزميات الجينية

[٢]

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المستخلص

في هذا البحث تم تطوير نموذج محوسب باستخدام الخوارزميات الجينية لعمل جدولة زمنية أمثل لأنشطة المشاريع الإنشائية بحيث يتم الحصول على أقل مدة زمنية للمشروع في وجود قيود زمنية على أنشطة المشروع وقيود على موارد المشروع. الخوارزميات الجينية هي عائلة مكونة من عدة عمليات حسابية مستوحاة من عملية التطور، حيث يتم عمل ترميز لحلول لمشكلة معينة من خلال كروموسومات بسيطة ومن ثم تطبيق عمليات تهجين على الحلول للحفاظ على الصفات الحسنة والانتقال بها من جيل إلى جيل للوصول إلى الحل الأمثل. تم في هذا البحث تطوير نهجاً جديداً في توليد الحلول الأولية العشوائية، بحيث يتم توليد حلول صالحة تحقق القيود على المسألة، دون إغراق أنفسنا في عدد لا نهائي من الحلول الغير صالحة والتي يلزم وقت طويل لتصفيتها عبر خطوات الحل، وهذا النهج يساعد في سرعة الحصول على الحل الأفضل دون الخوف من الانحسار في قيم عليا أو دنيا محلية. كم أنه خلال هذا البحث تم تطوير أداة تهجين تناسب طبيعة المشكلة قيد الدراسة وكذلك نوع الكروموسوم المستخدم. لقد تم تطبيق النموذج المطور في هذا البحث من خلال برنامج تطبيقي يعالج أوجه القصور في نظم الجدولة التقليدية التي لا تأخذ في الاعتبار القيود المفروضة على الموارد.

الكلمات المفتاحية: الخوارزميات الجينية، إدارة المشروعات، علاقة جودة التكلفة بالوقت، مشاريع البناء في مصر، مرحلة البناء، الشبكات العصبية.