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A Critical Literature Review on Criteria for Effective Selection Of Equipment And its Management in Construction Industry

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Abstract -*Good project management in construction must vigorously pursue the efficient utilization of labor, material and equipment. The use of new equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades.It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction. The systematic evaluation of soft factors and the weighting of soft benefits in comparison with costs these issues are mainly affected by different construction equipment selection criteria. The purpose of this paper is to evaluate these criteria. The identification of the criteria that effect on equipment selection has been carried out using different literatures and by interviewing from experts in construction. This paper has been planned to deal with identification of criteria affecting equipment selection and its management, developing a framework for assessing the criteria affecting equipment selection. A framework has been developed, which will be used for the future research in this area.*

Index Terms–*Construction equipment, Criteria affecting in selection*

I. INTRODUCTION

A problem which frequently confronts a contractor as he plans to construct a project is the selection of the most suitable equipment. he should consider the money spent for equipment as an investment which he can expect to recover with profit during the useful life of the equipment. a contractor does not pay for the construction equipment; the equipment must pay for itself by earning for the contractor more money than it cost. Consequently, successful contractors and construction managers understand the substantial impacts on their projects when equipment management decisions are not made in a proper and timely manner. Since equipment selection is highly influenced by myriad factors, most contractors tend to rely upon their historical data and experience in similar projects to assist them in determining the optimum fleet.To overcome this shortcoming, the proposed model is being developed based on integrating manufacture's data for selected pieces of equipment with a comprehensive economical operation analysis for different scopes of earthwork operations. At this stage, however, the developed model includes an optimization of equipment fleet based on simple economical operation analysis.

II. LITERATURE REVIEW

Aviad Shapira[1]and Marat Goldenberg[2],researched oncurrent models offered by the literature fail to provide adequate solutions for two major issues: the systematic evaluation of soft factors, and the weighting of soft benefits in comparison with costs. This paper presents a selection model based on analytic hierarchy process (AHP),a multi-attribute decision analysis method, with a view to providing solutions for these two issues. The model has the capacity to handle a great number of different criteria in a way that truly reflects the complex reality, to incorporate the context and unique conditions of the project, and to allow for manifestation of user experience and subjective perception.[1]

KunalR Ghadge1[1], Ashish B Ugale[2],refered to the economic dam site is one which is handled with economy of equipments thus here the part of concern is to have proper planning and management of equipments on dam site. Another part of concern is to complete the project on time where time for dam site is most important as the project is planned with proper weather forecasting and for efficient dam its also important to have the structure a good quality. Thus these three factors as economy, time, quality contributes to many factors of resources but much affected by equipments.[2]

David Arditi[1], Serdar Kale[2]and Martino Tangkar[3], indicate that the rate of innovation in the construction equipment industry increased in the 30-year study period and also suggest that these innovations are incremental in nature, stimulated by technological advances in other industries, but primarily driven by market forces. Technological advances are not confined to the industry that produces innovations. The mapping ofthe inter-industry flow ofinnovations highlights that while construction companies play a prominent role in generating their own technological innovations, they are also heavily dependent on other industries, such as the construction equipment industry for the flow of technical system innovations. As such, the continuous and incremental innovations in the construction equipment industry are bound to act as a catalyst for the generation of technological advances in the construction industry.[3]

Dushyant A. Deshmukht[1], Parag S. Mahatme[2], Examined the improper selection and use of excavator can cause excessive costs, time and injuries to labors. Time required for excavation work depends on the performance of equipment. There are various factors that can affect excavator's performance and productivity. In this paper, we have studied literature and identified some of those factors. It is found that, understanding fundamentals of such factors is important role of construction manager for better excavating equipment performance.[4]

a.Balamurugan and dr.s.senthamilkumar, proposed that Selecting the right equipment for the project is inherently a multifaceted cost and benefit evaluation process that is further compounded by the complexity of today's building projects. A careful selection of the equipment size and number can result in substantial savings both in time and costs. The objective of this study is to identify the factors that influence the effective usage of equipment which can be achieved through attaining proper knowledge and sensibly implementing them to develop a more effective technique. Further, various tasks involved in the construction projects will also be assessed from the survey of sample respondents which constitutes engineers, contractors and supervisors within the State of Tamil Nadu and results are analyzed and interpreted using SPSS tool.[5]

Serji N. Amirkhanian[1] and Nancy J. Baker[2]describedin this research project, a rule-based expert system (i.e., VP-Expert) was used to develop a system for selecting earth-moving equipment. The system, with 930 rules, interprets information concerning a particular project's soil conditions, operator performance, and required earth-moving operations. The knowledge for the development of the expert system was obtained from several experts working for two contractors, an equipment rental company, equipment manufacturers' sales representatives (e.g., Caterpillar, Case) and several geotechnical engineers. The system was tested, using the requirements for an actual project, by three contractors. The contractors' selections compared favorably with the developed expert system with regard to the size and type of equipment needed to perform the various tasks.[6]

Prajeesh. V. P, Mr. N. Sakthivelstatesthis thesis is to study the management of equipments practices in Construction Industry and to present the most popular practices of the contractors and to compare the equipment management policies with a Case study of a construction industry. The needed data were collected via a structured questionnaire. The contractors were divided into three grades based on their annual work volumes. The collected data were analysed using the SPSS software. The elements of the management policies were cross-tabulated against the grades of contractors for finding possible significant differences in contractors' practices. Hypotheses on some expected results were tested.[7]

Omer Tatari[1] and Mirosław Skibniewski[2]stated that Effective management of equipment is crucial for the success of construction firms. Inadequate manual processes of equipment management and the subjective decisions of equipment managers usually result in major losses in construction firms, hence, the economy. The main purpose of this paper is to introduce an agent-based equipment management system aiming to increase integration and automation, and to minimise decision errors. Recent research on agent technology allows the proposition of an automated and integrated application for equipment management. The proposed application makes use of the current databases of the firm and adds wireless technology to construction equipment for automated data integration.[8]

Miquel Casals[1], Nuria Forcada[2], Xavier Roca[3], states that present pressures from governments and other institutional agencies as well as general conscience are forcing the construction industry to further adopt safety and environmental aspects in their normal way of functioning, and so every activity or process that a company carries out has to be rethought in order to achieve this integration of other parameters. The aim of this paper is to present the results of a research project for creating a methodology to select construction equipment, combining the use of several well known methods for each of the aspects involved in the selection and using the multi-criteria analysis to reach at the final choice or recommendation.[9]

Mr. Nilesh D. Chinchore[1] and Prof. Pranay R. Khare[2]states that equipment improves quality, productivity and safety. Construction equipment planning aims at identifying construction equipment for executing project tasks, assessing equipment performance capability, forecasting date wise requirement of number and type of equipment and finally participating in the selection of equipment to be acquired. To derive full benefits from the equipment, there should be proper selection and good planning of its operations. This paper deals with the planning and selection procedure for equipment adopted by a company to achieve its objective of timely project completion.[10]

M. Waris[1], Mohd. Shahir Liew[2], Mohd. Faris Khamidi[3], Arazi Idrus[4] proposed this decision is typically made by matching equipment available in a fleet with the tasks at hand. Such analysis accounts for equipment productivity, equipment capacity, and cost. However, the emerging notion of sustainability in construction has emphasized energy conservation, efficiency, green environment, economy and human well being. In this context, selecting the most appropriate equipment from the available options is highly challenging. Therefore, this paper aims to determine a selection criteria based on the fundamental concept of sustainability and provides an assessment framework. A questionnaire survey was conducted among a classified group of Malaysian contractors to elicit information pertaining to the sustainable selection of onsite machineries. The findings of this study will guide the decision makers to appraise the selection process of construction equipment on the triple bottom line of sustainability.[11]

Gransberg et al.[1] stated that industrial and heavy construction projects required intense and high utilization of machinery for carrying out mass excavation, stabilizing, compacting, asphalt paving and finishing, pipelines, railroads and many other special activities.[12]

Thanapun Prasertrungruang[1] **and B. H. W. Hadikusumo**[2] reviewed a questionnaire survey to collect data on equipment management practices and downtime consequences among highway contractors in Thailand. The SEM model proposed is of value for both researchers and practitioners to facilitate a better understanding of the relationships among acquisition condition, operational practice, maintenance quality, disposal practice, and downtime consequence of heavy equipment. The model also helps contractors to manage equipment more efficiently by concentrating on several practices that can convey the greatest benefit in minimizing downtime consequences at each particular stage of a machine’s life cycle, rather than considering all practices simultaneously where the benefits gained are perhaps not proportional to the effort..[13]

Peurifoy et al.[1] stated that the complexity of today’s building projects makes it harder to evaluate equipment alternatives and make the right selection from many alternatives.[14]

Tatari et al.[1] stated that the primary agenda of equipment selection process is to achieve higher productivity, more operational flexibility and viable economic considerations. The past research shows that the appropriate selection of equipment has always been considered as a strategic decision during the construction phase of any project.[15]

Tatum et al.[1] found that proper use of appropriate equipment contributes to economy, quality, safety, speed and timely completion of the project.[16]

Mayer and Stark et al.[1] suggested that unit costs of operations that are affected by factors such as the experience of the operators, condition of equipment, type of soil, and team composition. Therefore, they vary throughout the project, and the use of static values is not consistent with jobsite realities. [17]

Tavakoli et al.[1]described that equipment productivity is a key factor that enables contractors to make a decision regarding the project scheduling, fleet selection, and project costs. Most contractors rely on their historical data and previous projects to obtain the productivity of selected equipment.[18]

Amirkhanian et al.[1] developed an expert system model for equipment selection in earthmoving operations. As part of developing the expert system, a rule-based expert system was used for selecting earthmoving equipment. The system was developed to interpret data pertaining to soil conditions, operator performance, and volume required for the earthmoving operations.[19]

Haidar et al.[1] split the equipment selection process into knowledge based and optimization genetic algorithms.The former part involves procedures that screen the desired equipment from the list based on subject knowledge whereas the later one refines the selection on the basis of criteria. These criteria include production rate,ownership cost, operating cost, equipment characteristics along with manufacturer, model, number and operating life.[20]

Shapira et al.[1] studied that, a list of tangible (hard) and intangible (soft) factors were identified. The tangible factors include technical specifications, site conditions and cost consideration. The intangible factors are qualitative and include safety considerations, company policies regarding equipment acquisition, market conditions and environmental constraints. It is an important aspect that this research work raises the issue of soft consideration in the selection of construction equipment in building projects.[21]

Aviad Shapira[1]**, and Marat Goldenberg**[2]aims at increasing the awareness: [1] to the nature, variety, and richness of soft factors; [2] to their significant role and potential impact on the outcome of decision making; and [3] to the inherent difficulty of evaluating them and integrating them within a comprehensive selection process. Existing state-of-the-art equipment selection models were analysed and found to be inadequate in terms of both considering soft factors and providing mechanisms for their systematic evaluation. Six cases of large-size, complex construction projects were investigated to obtain an extensive list of typical soft factors. This investigation revealed that the consideration of soft factors in current practices is essentially unstructured and is not integrated within the selection process in a systematic manner.[22]

Major Virender Singh phogat[1], ajit pratap singh[2]examined an application of five multi-criteria decision making (MCDM) techniques to a typical selection of equipments used for hilly road construction is presented. Three criteria representing earthwork operations, operational efficiency and convenience of manager have been considered with six sub criteria each for selection of seven different construction equipment alternatives. Five MCDM techniques: Analytical Hierarchy Process (AHP), Simple Additive Weights Method (SAW), Distance Based Method (DBM), Preference Ranking Organization Method (PROMETHEE) and Elimination Et Choice Translating Reality (ELECTRE) methods are examined as potential decision-aid tools to select the appropriate management scheme. Comparison of the results shows that these quite different MCDM techniques lead to a similar subset of recommended solutions.[23]

III. CONCLUSION

[1] The proposed equipment selection model purports to offer a comprehensive solution for the systematic evaluation of qualitative decision factors alongside a mechanism for the overall integrative evaluation of hard and soft factors. The model has the capacity to handle a great number of different criteria in a way that trulyreflects the complex reality, yet without losing its practicality.[1]

[2] The described type for the selection of construction equipment has suggest its results in actual construction processes cases and has been of help to the persons responsible for this kind of decisions. Although some time and effort has to be invested in the development of all the criteria for each of the equipment involved in a construction project the decisions can be supported on a scientific method, thus being able to take fewer risks when purchasing equipment.[2]

[3] The findings of the study presented here suggest that the rate of innovation in the construction equipment industry increased during the last 30 years.0 This increased rate of innovation can be linked to pressures generated by buyers' behavior and to technological developments in the equipment industry as well as in other industries. The findings also indicate that the rate of innovation has been uniform and incremental over these 30 years. Even though innovations in the construction equipment industry are incremental in nature, their cumulative benefits can be enormous because incremental innovations result in continuous improvements in product features. These incremental innovations are primarily driven by market forces.

[4] In this paper, they have studied different literatures related to excavators in terms of its planning, selection and performance. Some of the common factors that can affect the performance of excavating equipment has been identified and discussed in this work and on the basis of this, we can conclude following points, 1) Incorrect equipment selection may directly affect to its productivity for that particular work. 2) Excavation is generally faster for soft soil as compared to hard strata. 3) Greater angle of swing results in greater cycle time which may lead the work to delay. 4) Time saved per cycle is nothing if the operator's skill is poor. 5) Regular repairs and maintenance of equipment may increase its life providing better performance. Thus, it is important role of construction manager to understand and properly utilize such factors for better performance of excavating equipments.

[5] The study reveals that the types of machines used in the construction industry have a significant influence in the construction industry. As the cost of the equipment plays a major role, the construction industry based on the size of the projects .ie. small, medium or large scale projects utilize the types of equipment based on their need. From the study it could be ascertained that excavator are highly used large scale projects due to its cost effectiveness and trenching machines are deployed in medium and small scale projects. However optimism among construction equipment distributers remains high. Rental fleet growth is anticipated to play an increasingly important role in the business model of distributers who can't afford to own equipment.

[6] In this paper, the knowledge acquisition and development of a knowledgebased expert system for selection of earth-moving equipment were discussed. This paper discusses one of the most important parts of developing any expert system, which is the successful acquisition of knowledge and problems and solutions associated with them. Like any other expert system, this system has some limitations including the scope of the project (i.e., maximum of 4,000,000 BCY [3,060,000 m3]), not performing balancing the selected fleet, and the limited number of the equipment manufacturers used (i.e., 2). The system indicated that the application of an expert system for the selection of earth-moving equipment is feasible. The extent of knowledge required for the expert system is available from human experts and other references. Based on discussion with the experts after the system was developed, it was concluded that the expert system application is helpful in selecting the type and size of earth-moving equipment required for the earthmoving operations.

[7] Only one third of the construction industries were found to have documented policies, it was found that there is a uniform practice of management among industries. This indicates that there is a policy for management although it is not properly documented.

[8] This paper provided an overview of an equipment management system that can be used for better integration and automation. Moreover, taking into accountinformation overload and expectations from human operators, an agent-based architecture aiming to minimise human interference has been introduced.

[9] The described method for the selection of construction equipment has proven its results in practical cases and has been of great help to the persons responsible for this kind of decisions. Although some time and effort has to be invested in the development of all the criteria for each of the equipment involved in a construction project the decisions can be supported on a scientific method, thus being able to take less risks when purchasing equipment.

[10] Planning of equipment depends upon nature and quality of work and time available for completion.Planning of equipment needs to be doneby a well experienced person, who has got good exposure of execution of work and who knows the factors that affect the output of equipment.

[11] This study has presented an over view of earlier research and investigations in terms of significant measures for theThe sustainable criteria presented as a result of this endeavor are different from the conventional way of procurement which emphasizes on cost, time and quality.A total of six factors were derived from the Varimax rotation method of factor analysis. The principal factors are life cycle cost, performance, system capability, operational convenience, environmental impact and social benefits. These factors are correspondingly loaded with thirty eight items which form criteria based on the socio-economic, engineering and environmental functions of sustainability.

[12] First factor to consider would be matching the right equipment to the proper type of activity. Another factor would be the availability of the right equipment with proper service, maintenance, and repair reserves. Two factors that can be considered when selecting proper equipment: (i) type and condition of the site work; which includes the distance to be travelled; and (ii) desired productivity; which is a critical factor that affects equipment selection.[12]

[13] This research is intended to give an insight into how equipment management practices influence downtime consequences using SEM methodology. According to a range of GOF measures, the final SEM model successfully passes all recommended criteria suggested in the literature. This indicates that the model is sufficiently fit to the data and is acceptable for use in characterizing factors influencing downtime consequences as confirmed by the model validation test.[13]

[14] The model presented herein offers a comprehensive solution for the systematic evaluation of both qualitative and quantitative decision factors alongside a mechanism for the overall integrative evaluation of criteria. The analysis clearly demonstrates that dozer D80 (A1) scores the first rank and blasting (A7) being the last. Sequence of most preferred to least preferred is dozer D80 (A1), wheel loader (A5), dozer BD50 (A2), JCB (A3), tippers (A6), rock breaker (A4), blasting (A7). During road construction the alternative selection procedure results were verified and testimony was the timely completion of earth operations of the road construction.[23]

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