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Criteria for the selection of sustainable onsite construction equipment

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Abstract

Today's construction projects are highly mechanized and becoming more so every day. With the growing industrialization of construction work, the role of onsite equipment and machineries is vital in achieving productivity and efficiency. During the construction phase, selection of right equipment has always been a key factor in the success of any construction project. 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.

Keywords: Construction equipment selection; Sustainable criteria; Construction management; Mechanized construction; Sustainable construction

1. Introduction

All construction projects require different types of equipment and machineries having their own level of application. For example residential projects have a low level of equipment usage. It requires simple and traditional machines like fork-lifters, backhoes, hauling and hoisting equipment, material handling along with pneumatic tools. Commercial projects have moderate usage of equipment and machineries. 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 (Gransberg et al., 2006). The common application of heavy construction equipment includes but is not limited to; earthwork, structural steel works, concreting, building, lifting and positioning of components (Mahbub, 2012). Heavy construction activities are further grouped into horizontal and vertical construction. The former type of construction required more ground work whereas the later one is characterized by more lifting works rather than exca-

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vation and earth works (Gransberg et al., 2006). The roles of heavy equipment are very vital for increasing the construction productivity especially for infrastructure works. However, their acquisition is very much capital intensive for construction firms. It is also considered as a major financial burden during the construction phase beside other expenditures (Prasertrungruang and Hadikusumo, 2007). The past research shows that the acquisition of heavy equipment constitutes 36 percent of the total project cost and possesses high risk and uncertainties for the owners (Yeo and Ning, 2006).

This increased level of awareness and the application of mechanized equipment and machineries are considered as a positive thrust for the advancement of construction industry. It has abundance of benefits for all the stakeholders. Nevertheless, its adoption has significant drawbacks for the environment and the people working in its vicinity. The emerging concept of sustainable or green construction emphasizes the minimization and elimination of harmful impacts to the environment (Nunnally, 2000). Construction organizations are accountable for the impacts of an implemented project on the society, environment and economy long after the project has been completed. Therefore, construction and sustainable development issues are closely related because this sector is a principal contributor to global resource depletion (Rees, 1999). According to International Council for Building (1999), the buildings in European Union countries are accountable for more than 40% of the total energy consumption and construction sector is estimated to generate approximately 40% of all man-made waste. Sustainable development has now become a significant subject discussed and debated at various levels e.g. national, international, governmental, non-governmental and as well within the academic circles as an agenda of socio-economic and environmental development. A fair amount of diversity exists among the definitions of sustainability and sustainable development. However, most of them agree that the concept is based on three pillars i.e. social, environmental and economic considerations (Labuschagne and Brent, 2005). The most common and well-known definition for sustainable development is defined by the World Commission on Environment and Development (1987) which is stated as "satisfaction of present needs without compromising the ability of future generations to meet their own needs". Sustainability is, therefore, considered as an ultimate objective where balance in socio-economic activities and environmental concerns is appropriately addressed. The concept of sustainability in construction has been reviewed by many researchers and its focus keeps on shifting with passage of time (Boonstra et al., 1998; Cole and Larsson, 1998; Hakkinen et al., 2002; Brophy and Lewis, 2005; Kibert and Hoboken, 2005). As such, the sustainable construction is a broad term and it includes processes from preliminary to detailed design, engineering, planning and procurement consideration toward the approved deliverables of the client, and then the different stages over the product's lifetime which consist of operation, maintenance, refurbishment, reconstruction, demolition and recycling (Persson et al., 2008). International Council for Building (1999) in the Agenda 21 emphasized on the notion of sustainable construction through environmental, socio-economic and cultural aspects. This agenda has identified many vital issues and challenges such as, management and organization; product and building issues and resource consumption in construction. The past studies have shown that environmental focus in construction was more towards the material selection, structure design, materials recycling rather than greenhouse gas emissions (Kim et al., 2012). Furthermore, previous efforts to reach sustainability have primarily focused on the environmental performance of facilities in the "use" phase, and such efforts are lately being expanded to mitigate environmental impacts from the "construction" phase (Peña-Mora et al., 2009). Among the environmental impacts from construction processes (such as waste generation, energy consumption, resource depletion, etc.), emissions from onsite construction equipments account for the largest share (more than 50%) of the total impacts (Guggemos and Horvath, 2006). All non-road construction equipment, machineries and vehicles which are power-driven by diesel engine have a high impact on environment. The emissions from these equipments are considered as a source of air pollution. The United States Environmental Protection Agency (EPA) stated that the US construction industry is comprised of approximately two million equipment, machineries and vehicles which are powered by diesel engines. These engines are operated by fossil fuels, hence discharge significant amount of carbon dioxide, hydrocarbons and particulate matter. EPA report further exemplifies that a road bulldozer with an engine capacity of 175 hp releases particulate matter which is equal to the emissions produced by 500 new auto mobiles (Lewis et al., 2009). In the United States, 5839.3 million metric tons (MTs) of CO_2 is produced by the usage of fossil fuels to operate heavy construction equipment in 2008 (USEIA, 2009). According to the Korean Institute of Construction Technology (2010), air pollutant emissions from onsite construction equipment account for 6.8% (253, 058 MTs/year) of the overall emissions produced in Korea in 2009. The average rate of production of emissions is much greater for construction equipment as compared to passenger vehicles because of differences in the type of fuel i.e. diesel versus gasoline, engine technology and horse power (NESCAUM, 1997). As an example, earthwork produces highest percentage of GHG emissions among all construction activities (Kim et al., 2012). Equipment categorization, age and horsepower and as well as type of fuel used, can greatly affect rates of emissions (Avetisyan et al., 2012).

Therefore, during the selection of construction equipment, there is a need for the most rational criteria that have a positive impact on operational efficiency, productivity, cost minimization and as well as environmental and human well being. These criteria make it possible for the contractors to consider the sustainability agenda in the equipment selection procedures. Hence, this study aims