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Construction Waste Material Management and Logistic System

Construction is one of the industries that produces significant amount of waste. Construction site produces waste as a result of construction work. In the context of direct waste, it is a mixture of surplus materials arising from any kind of construction works, be it construction, site clearance, excavation, renovation or refurbishment. Construction waste consumes a large amount of natural resources and hence a strategic management is significant to reduce or manage construction waste. There are studies showing that waste represents a relatively high percentage of production costs. Previous researcher defined waste as the loss of any kind of resources produced by activities which generate direct or indirect costs and do not add any value to the final product from the point of view of client. The society's concern has gone from the perspective of efficiency to the impact to the environment. It is undeniable that the waste generated has caused an impact to the environment. However, building waste can hardly be recycled as it may be highly contaminated in the process of production or assembly. Building materials and inventory on site will contribute to waste generation if not handled properly and systematically. This paper will discuss some important elements of construction waste and management such as waste material management, construction logistic system and generation of construction waste.

Keywords: *construction, waste, management, building material*

1. Introduction

Waste is defined in such a way that anything other than the minimum amount of resources which can add value to the product is regarded as waste [1]. According to the researcher, the seven classifications waste can be categorized are waste from overproducing, inappropriate processing, unnecessary inventory, transporting, producing defects, time waiting for materials and unnecessary motion

waste. As waste is often seen as a result of productivity, the construction projects having productivity changes will have direct impact on the economic health and the potential for the United States economy growth [2]. Also, in production system, waste is defined by the performance criteria. (Howell 1999) Performance of production highly affects the generation of waste. Once waste is generated, it will increase the cost for the company, resulting in adverse influence to the company's productivity and performance, not forgetting having a negative impact on the environment. In this context, the construction waste generated must be identified and minimized to lessen the influence to the company's productivity. By doing so, the overall manufacturing cost can be reduced, save time and money, and the opportunity would be provided for reallocation of the saved resources to other profit generating activities.

Generally waste can be disposed by two means; landfill and incineration. Mining pool, burrow pits and disused quarries are always the choices of landfill areas. A properly designed and well managed landfill is important for it is a hygienic and cheap method for waste disposal. However, landfill leads to shortage of land making it not the best way for waste management. For instance, the United Kingdom is facing severe shortage of landfill sites. Realizing the fact of landfill site shortage, the UK has been compelled by the enactment of the European Union landfill directive on to make use of other more sustainable waste disposal methods [3].

Incineration is commonly used as another alternative to landfill in places where land is scarce. In Japan, disposal of waste is done by incineration or the process of burning. Despite the pollution issue with the emission of toxic gases, incineration does not require as big area as landfill needs for its facilities. As a measure by the governing body, the UK government not only reduced the landfill site but also used the collection of landfill tax to increase awareness among businesses and industry to achieve minimization in waste [4].

As a proposed method for waste disposal, recycling and reuse of waste is highly recommended as a sustainable alternative to landfilling and incineration. By extracting resources or value from waste, the material will be recovered or reused by the process of recycling. The main stages of recycling are reprocessing of old materials into new products, reducing the use of raw material and reducing energy consumption. One main objective of recycling is to prevent the use of new fresh raw material which puts on high demand on valuable resources.

Waste management is a crucial part in construction industry. In contrary to waste control, waste management involves the investment and development in new technology, products, processes and training that can reduce waste. While waste control is deemed to only a short term period, waste management is preferred for its potential of becoming a revenue generator [5]. Eliminated of waste in terms of inventory scrap and electricity is suggested by the researcher by reducing the material, cost and waste. The researcher proclaimed that even small

improvements such as reduce a little bit cost will have dramatic impact on the bottom line or final profit.

2. Waste Material Management

Material management is an important issue as seen in construction waste management. Best practice of material management is accompanied by various benefits which are acknowledged by several studies. The site layout has particular effects on both materials and their waste through effective waste management practice [6]. Ignoring the benefits of material management could result in a daily reduction in productivity of up to 40% by material wastage [7]. Thus, the benefits of effective material management must be well comprehended for the sake of waste minimization. Another convincing fact about waste is that poor site management accounts for the largest factor of waste generation [8]. Hence the site condition is very crucial in developing effective material management. Factors contributing to the efficiency of material management process are effective logistical management and supply chain management. The logistics system must be performing as schedule so that materials are wisely managed on-site without encountering presence of excessive materials.

As materials management is closely related to logistics in construction projects, there will be delay in construction projects when materials are not delivered to site as scheduled [9]. The management must be effective in terms of delivery, off-loading, storage, handling, on-site transportation and on-site utilization of materials [10]. The principles are applicable to all development and effective in universality.

One of the most significant attributions of effective material management is the saving attained. Rooting from the need of saving is due to proposition of material cost amounts up to btween 50-60% of total contract cost [11]. Hence, the need for saving is crucial as money is a form of resource and should be wisely spent. Monetary achievement is obvious and important as a parameter in determining the successfulness of material management process. Since monetary savings help to reduce cost, the effective management of this resource is highly regarded throughout the whole process. Achievement of earlier projects showed a potential of 6% saving on total cost through effective materials management.(Bell and Stukhart 1987) In contrary to the savings earned, the construction industry invests only 0.15% in materials management and control. Researches show that savings are achievable through effective material management and are becoming increasingly beneficial in the current economic climate. Hence, the practice to adopt effective material management should be familiarized to the public.

The first issue material management is facing is that the available space is insufficient to accommodate the existing materials. In a confined or limited site construction, availability of space becomes the main concern regarding material management. A complete and comprehensive coordination is required and

expected to ease the management considering construction materials make up an average of 40-50% of total project costs [12]. Coordination between sub-contractors and principal contractor is required so that a comprehended understanding is established to achieve effective material management. The increasing number of contractors involved in a project to counter the issue is accompanied by increasing level of complexity. Since material management requires logistics for moving the materials from manufacturers to the site, sufficient data must be provided before logistics services commence. The site manager should have profound knowledge on logistics system and developing a strong communication with suppliers and logistics team. In order to ease the process of logistics in moving the required materials, records on space required must be documented, managed and allocated accordingly [13]. The next frequently-met issue is the coordination of the material to the ongoing program. The usage of different types of materials varies according to the building phase as different parts of structures are erected accordingly.

Hence, the coordination on material storage must be strong enough so that required materials are abundant at certain phases. For example, cement, sand and aggregates are most required in the structural phase as they are the main components in erecting of reinforced concrete structures. Conventional construction projects frequently deal with the storage of materials as materials are ordered in a large quantity due to certain reasons. Material storage on site is a challenging issue as spaces available in any construction projects are limited. The project team has to get the balance between retaining the quality of materials and maintaining materials storage on site. Adequate space and shelter provided for material storage must be planned accordingly so that no damage is acted on the materials. Failure to maintain material storage at an acceptable level results in poor productivity and waste.

The failure of material storage system can also be devoted by the location of storage. Unsuitable storage locations are a big issue in poor labor productivity. Spatial arrangement in construction sites is precious as the space available is limited. Material storage shall be allocated at a place with least disturbance to the progress of the erecting process while providing ease of reach to workers needing them. Once the material storage is assigned at a suitable place, transferring of storage location is not needed and hence leads to an increased productivity. Spatial congestion arising from mismanagement will affect the effectiveness of material storage system apart from resulting in diminished productivity levels [14].

As suggested by previous researcher, adequate stockpile of materials on site boosts the management of production. However, this step is sometimes omitted due to the space constraint. As a result, the productivity and materials management tends to show negative growth. Recording the materials on-site is a good practice for material management to have insight on the current situation of materials on site. As the project progressively moves on, the materials are experiencing substantial change gradually and hence keeping an eye on the

present materials is the best way to perform material management. Effective site and space utilization are the keys to achieving potent material storage system. As each site provides different space for material storage, the project team must be able to adequately manage the available space to accommodate the maximum storage of materials required by a project. Profound experience and vision are needed to make the best arrangement to accommodate on-site materials. Formal knowledge received must be developed through years of experience in order to develop a strong and profound experience for one to oversee the future in the industry. However, projects are often constructed in 'sub-optimal conditions' while congestion requires high exclusive management to accommodate such working conditions on site

3. Construction Logistic System

Transportation of materials and waste is another equally important key area in construction industry. It is undeniable that construction is an industry that initiates the creation of infrastructure that changes the face and function of towns and cities. Not only construction activities extract and utilize high volume of energy consuming materials, the activities also generate large quantity of waste as output. Without successful and efficient logistic, the project will be behind of schedule and estimated cost. Since construction projects are not carried out in a fixed location, be it rural or urban area, transportation of materials and waste to and from the site becomes very important for the progress of any project. Millons of vehicular movements are required in order to make the construction project a success. Besides supplying materials and equipment to the site, the transportation from the site also include the management of waste production on site.

The usage of transportation services in construction industry is significantly high. For example, materials utilized by the UK reach 100 million tonnes while waste produced reaches 100 million tonnes too. In South Africa, 400 million tonnes of materials are utilized in the construction industry and about 100 million tonnes of wastes are produced. From the data it has proven that efficient coordination between parties in the transportation and construction are vital as in supplying materials to the site and removing wastes from the site. However, the reality is always the other way round. Previous researcher has concluded that the flow of construction materials and removal of waste are uncoordinated based on a few facts [15]. One of the facts that leads to such situation is that the suppliers have their own dedicated vehicles and delivery schedules which makes synchronizing with waste collection contractor impossible. Likewise, the waste management operators arrange ad hoc delivery to various locations locally and nationally in dealing with waste. As such, the uncoordinated situation results in worsening traffic problems in the road transport system. When synchronization does not occur, critical scenario happens when construction materials delivery traffic fails to back-haul waste from site to points of disposal reclamation or recycling. Waste is

not removed at the moment materials are sent to the site. The severity can be seen from the increasing vehicular traffic as additional vehicles to remove physical waste from sites.

Despite the large amount of energy and resources consumed, construction industry produces large quantities of waste. In urban areas, construction activities bring about a significant proportion of all goods vehicle transits. In the context of environmental sustainability, construction transits initiated by construction activities seemingly increase air pollution, noise, accidents, gridlock, fuel costs which inhibit the quality of urban life [16]. Hence, conflict arises in the relationship between construction activities and resulting urban environment. It is undeniable that construction transits are a must in the construction activities, the impacts to the environmental aspect must be evaluated thoroughly. The researcher urged for sustainable environment with activities conducted by maintaining level of materials flow into the sites without neglecting the need to reduce total number of vehicle transits.

As materials are closely associated with logistics services, there is a need to investigate the corresponding influence of logistics to the materials management. The importance of logistics to construction projects is obvious from the vast development to accommodate the growth of population. However, as spaces are as scarce as resources, major problems of material management occur in a confined site. The problems arisen must be dealt with by deep investigation on the relationship among the major parameters.

Transportation of materials appears to be one of the most common factors in material management on site. Common problem in logistic includes the location of site entrance complicates the delivery of materials. When the materials are to be transported, they are likely to face damages resulting from location of site entrance. The materials are vulnerable to damages, require double handling and are misplaced as a result of this problem. Other than that, increased management intervention arising from multiple deliveries might occur.

The second most critical problem in construction logistics is material flow management. Goal-oriented material flow management is similar to logistics but it focuses of efficiently managing materials. An effective site layout will help to minimize the occurrence of the problem as damages by having preferable location and number of site entrances, which in return contributes to the flow of materials. Resulting from poor location of site entrance, it will increase the difficulties for the workers to perform transportation tasks [17]. Such inadequate working conditions favor material handling and thus there is higher chance of injury to personnel. The personnel face difficulties in transporting the materials due to inadequate location of site entrance and are likely to perform in lower productivity. Besides, it is likely for damages and accidents to occur due to substantial working conditions. Adequate spatial considerations are crucial in material management. This includes the consideration of excessive movement of material on-site.

Making such consideration will enable doubling handling in adverse conditions to be avoided. Generally, the poor working conditions will adversely affect the performance and labor productivity in normal materials flow. This is due to more effort is required to perform the same level of output and this causes the labor to be unfamiliar with their works. Hence, when the site is not capable of providing sufficient space for the transportation of materials, problems will arise and leading to severe consequences [18]. Hence, a properly planned site layout is important to increase the functionality of the available space as site layout is directly connected to the material managements. Site layout is an essential element especially in urban development as there are limited spaces for development. However, if the sit layout is designed properly, not only the project team can help in financial savings, the movement of materials onto and to the site will be smoothened. Hence, the combination to effective transportation of materials both unto and around site is with the presence of adequately accommodated logistics management plans, site layout plans and management plans not forgetting material management plans. The importance of site layout plans is shown when in absent, it might cause increased manual handling, double handling, waste lost productivity, increased health and safety risks and inevitably project failure. Hence, site layout plans must be treated as a critical issue in material transportation to be able to maintain or enhance overall project productivity.

4. Generation of Construction Waste

Construction waste is a critical issue in the industry not only due to efficiency of the projects, focal point has also been falling onto the adverse effect of the waste of building materials on the environment. When the issue of waste is raised, many people will relate it with the debris removed from the site and disposed of in landfills. This narrow perspective seems untrue since the beginning of industrial engineering. Other than material loss, there are other forms and factors of creating waste in construction industry. For instance, when comparing to inefficiency of human work, material waste comprises a big proportion in economic loss. From the statement above, generation of waste is also contributed by human factor. This is true as human work is suggested as the focus of waste prevention by adding to that is due to value of materials depends on the work has been spent on them.

Realizing the fact that material is an critical element in the construction industry, defines waste as the loss of any kind of resources including time, materials, and capital, produced by activities that generate direct or indirect costs but do not add any value to the final product [19]. As mentioned before, human work defines largely on the content of waste. Waste is also defined as any inefficiency that results in the use of resources in larger quantity than those considered necessary. The generation of waste can also be recognized from the classification of waste. As such, direct and indirect material wastes are distinctively distinguished by based on their physical condition and availability. Direct material

waste refers to a complete loss of materials while indirect waste only causes a monetary loss but not physically lost. Lean Production is recommended as a solution to waste in construction industry incorporating Just In Time Management and Total Quality Management. Toyota is known for the adoption of Lean Production in their production system, and hence seven categories of waste are concluded from their production including unnecessary movement of people, waiting for process equipment to finish an upstream activity, defects in products, overproduction, inventory of goods awaiting further processing, unnecessary processing, and unnecessary transport of goods. First two categories are associated with work by people or the operations, while the remaining categories relate to the process or flow of materials [20]. Looking at a smaller scale, waste can be produced throughout the whole process and involves different intention. For instance, in the design stage, surveys beforehand were not carried out up to certain emphasis. Thus, design of products does not meet users' needs. From the client's perspective, unnecessary capital investment could cause waste production. Some unexpected scenes which could cause waste are accidents or working under suboptimal conditions and theft and vandalism. Although accidents could not be expected but prevention stage must be intense to protect the rights of all parties in a construction project.

Material and waste both have high correlation between each other under the principle of cost. The main materials in conventional construction projects are concrete, steel bar, timber, bricks and blocks. They account for a significant percentage of the total cost of buildings and consequently they are the main components of waste. Apart from the allowance dedicated in the cost estimates, the high level of material waste is indeed predictable and avoidable.

Although waste can be produced at any stage of the project, studies have shown that design changes have great impact on the generation of waste. These design-related changes encompass changing materials previously ordered, poor detailing, over-specification, late variations and alterations to complete work. Other types of waste that happen due to other external factors include poor storage and handling of materials, design /detailing errors, leftover materials, waste from packaging and non-reclaimable consumables and insufficient protection of the completed works.

In order to assess construction waste management performance, waste management influence factor is developed. It is a management factor that will have impact on reducing construction wastes or aiding in the use of recycled materials for appraising projects. After a thorough literature conducted on the same area of research, the researcher gathered all possible influencing factors based on academic publications, company-level waste management policies and on-site manuals pertinent to construction companies [21]. There are 5 factors that can be categorized such as manpower, construction methods, materials and equipment, management practice and industry policy. These five main areas were categorized based on on-site conditions and are worth in-depth discussion for

enhancing construction waste management performance. The researched listed out a total of 59 influencing factors and they were fitted into the five listed areas. It is noticeable that among all the factors, ten factors outranged the remaining ones and emerged as the top-ten influencing factors in waste management practice. Among the top ten factors, four of them were coming from the group of management practice which led to the statement that management participation is crucial in successful waste management practice as many researchers maintained. The area of 'industry policy' is regarded less important for having none of the factors emerged into the top-ten listing. Regardless of classified areas, also identified five factors which are significant namely commitment of contractor's representative on site, collecting packed materials back by suppliers, minimizing rework in the construction phase, design and construction using standardized materials, and appointment of laborers solely for waste disposal.

Many literature studies show that environmental sustainability is leading the construction industry for continuous improvement. Most construction industry elements are discussed with the perspective of environmentally sustainable. Similarly in the aspect of waste, environment sustainability serves as a driving force for upkeeping of sustainable waste management practices. The thought for sustainable waste management must be instilled in the project participants' mind from the inception stage of a project. Minimal destruction to the environment and extraction of natural resources should be opted for choosing the approaches and materials [22]. Industrialized building system (IBS) is one of the recommended approaches used in the construction industry nowadays. However, the focus of sustainability falls mainly on the planning and design stage but little or no attention to the construction phase. This may be mainly due to the perception that designers have more control over the recyclability of a building. Waste at the production stage must be rectified so that the problems will not be carried over the stages over the time. When production of waste is avoided in the first place, the system will be more operative than having to treat the produced waste. Apart from that, managerial behavior is also important as an influencing factor. Mindset and awareness on the matter must be well educated to instill the concept of reducing production of waste. Project participants are the key person in producing waste. This is due to 'minimizing rework in construction phase' was listed in Cha, Kim et al. (2009)'s study as top-ten influencing factors. A great portion of causes causing this is human error or careless attitude. Hence, it seems that the commitment from project participants is important in effective waste management systems than new technologies or regulatory guidelines.

5. Conclusions

Construction is regarded one of the most important activities in Malaysia for the contribution in development and economic growth. However, problems arising from waste have caused an impact to the environment and sustainability of the

development. The effect of construction is obvious in terms of construction waste. The conventional projects in Malaysia seem to adopt less of effective strategies in waste management. Practices to reduce, reuse or recycle waste did not achieve widespread implementation for a number of reasons. This may due to the cost incurred in handling and transporting the physical waste to the dumpsite. Clients with low initial fund may tend to allocate less on waste management budget which leads to reduced priority in site management. Some even believed that the cost of reusing or recycling wastes was prohibitive. The rate of production waste is higher than the rate of imbursement of waste. In Malaysia, the percentage of municipal waste recycled in total solid waste weighed as low as 4%. (Municipal Waste Management Report) Other Asian countries such as Vietnam, Singapore and the Philippines each possessed 20%, 54% and 28% respectively. The relatively low in municipal waste recycling indicates the significance of waste management. Likewise, waste in construction must be treated in order to reduce the waste as a whole.

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