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APPLICATION OF COST SIGNIFICANT ITEMS TOWARDS IMPROVING ESTIMATION FOR LIFE CYCLE COSTING OF BUILDING PROJECTS

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Construction projects have numerous variable factors affecting the value of life cycle-cost (LCC) and there is interaction between these factors, leading to complicated process. Therefore the current LCC models suffer from the absence of a standardized and a simple methodology of both the collection data and estimation LCC. Identification of the significant cost factors affecting the output of LCC is important step before embarking upon the collection of progress information. Furthermore, components of construction differ in their cost and time -importance, and thus management effort must be equivalently distributed. The concept of cost significant items (CSIs) is the best method to simplify estimation methodology as well as the collection data of construction projects. In general, The CSIs concept aims to determine the small number of items which represent a constant percentage of the LCC of construction projects. Therefore, this paper aims to present the explanation of each stage of LCC, the current classifications of asset components, the CSIs concept and previous practice of the significant cost items on the construction sector.

Keywords: Pareto's principle, Construction costs, Design and construction stage, Operation and maintenance stage, Asset management.

1 INTRODUCTION

An increase in the level of goods and services are an indicator of the growth of a country's development; physical infrastructure, services provision and building projects require being sustainable. For continuous future economic growth, (sustainable) physical infrastructural development is a significant prerequisite (Tabish and Jha 2011). Indeed, Ferran and Zayed (2012) asserts that building and construction projects contribute significantly to the gross domestic product and gross fixed capital formation but that increases in economic growth in the future, require increased construction and building projects in line with socio-economic trends.

Governmental agencies, corporations, and the private-sector spend trillions of dollars on construction and infrastructure systems. Organizations must protect their enormous facility investment and assign particular resources among numerous other competing needs to their life-cycle maintenance (Ottoman *et al.* 1999). In order to preserve public (and private) sector infrastructure's operational and safety performance, there is a need for a suitable management system (Farran and Zayed 2012). Often costly and disruptive replacements will be required due to the potentially careless mismanagement of refurbishments and retro-fitting. The continuous rehabilitation of both existing and future infrastructure is challenging due often to the restrictions of the (set-aside) financial elements of resources upkeep. Therefore, improving and developing the usage of funds through accurate cost (prediction) requires a suitably robust decision support system (Farran and Zayed 2012); this proposal suggests that life-cycle cost analysis provides such a system.

2 BUILDING LIFE CYCLE STAGES

A building's life cycle consists of several stages that must be conducted in order to transform the ideas, and rationale that prompted its development, products and services significantly. In this respect, a building's life cycle has been created to gain greater value. It consists of four stages which are the design and construction stage, operation and maintenance stage, and disposal stage. The following section presents more details for each stage.

2.1 Design and Construction Stage

In this stage the project manager defines what the project is and what the users hope to achieve by undertaking the project. This phase also includes a list of project deliverables, the outcome of a specific set of activities. The project manager works with the business sponsor or manager who wants to have the project implemented and other stakeholders who have a vested interest in the outcome of the project (Alqahtani and Whyte 2013). Furthermore, the project manager lists all activities or tasks, how the tasks are related, how long each task will take, and how each tasks is tied to a specific deadline. This phase also allows the project manager to define relationships between tasks, so that, for example, if one task is x number of days late, the project tasks related to it will also reflect a comparable delay (Farran and Zayed 2012). Likewise, the project manager can set milestones, and dates by which important aspects of the project need to be met (Ashworth 1994).

2.2 Operation and Maintenance Stage

This stage is the largest stage of asset's life cycle. It start at early occupancy and ends at the end of asset life. It concerns to maintain and review the asset at frequent intervals to evaluate its implication within management of cost-in-use as the cost of this do not remain uniform or static throughout a asset's life. For example, the taxation rate and allowances will alter during the asset's life, and can have an influence on the maintenance policies being utilized. Grants may become obtainable for asset repairs or to solve particular problem such as energy or environmental considerations. The change in the method that the asset is utilized and hours of occupancy, for instance, should be monitored and control to maintain an economic life cycle cost, as the asset is developed to reach the new demand placed on it (Al-Hajj and Homer 1998). Before the end of asset's life, careful consideration should be exercised before future expenditure is apportioned. The decision for replacing a component is made based on a comparison of the rising operation and maintenance with the cost of its replacement and the linked operation and maintenance costs. For instance, the improved productivity of the heating boiler and its systems recommend that these, in term of economic, need to be replaced every 10-12 years regardless of its performance condition (Ashworth 1994).

3 CLASSIFICATIONS OF ELEMENTS OF EACH STAGE OF BUILDING'S LIFE CYCLE

At constriction stage, the demand for a worldwide elemental classification has led several construction institutes, such as the Royal Institution of Chartered Surveyors (RICS) to develop a standard format of elements in construction stage. This format consists of several cost's elements such as substructure costs, superstructure costs, internal finish costs and other like costs. At the operation and maintenance stage, the cost data includes major and minor maintenance, redecoration, external and internal cleaning; utilities, such as gas and electricity; and administration and overheads costs, such as security and rates. The Standardized Method of Life Cycle Costing for Construction Procurement (SMLCC) has given details of these items (Al-Hajj and Horner 1998). In general, there are two elements of construction cost items that should be identified to estimate the total LCC of construction projects. These elements are quantity of the cost item and unit price of the cost item. As mentioned before, each stage of construction project's life cycle usually consists of several of costs items. It is time consuming and very costly to gain the quantity estimate and unit prices of all items in construction projects (Alqahtani and Whyte 2013). The CSI can solve this problem. The CSI suggests that 80% of the total project cost can be identified by 20% of the cost items. As a result, estimation the quantities and unit prices of the top 20% important cost is useful method to save time and money and provide the accurate estimation. This paper will only suggestion utilized the top 20% of important cost factors to simplify the estimating processes of LCC of construction projects. The next section will provide information about the CSI principle.

4 COST SIGNIFICANT ITEMS (CSIs)

The CSIs idea was derived from the Pareto's principle. In 1897, Vilfredo Pareto conducted study on wealth and poverty and attempted to create formula to determine the unequal distribution of income in Italy. He found that 20% of the people earned 80% of Italy wealth. This idea is known as Pareto's Law or 80:20 rule which refers to fact that 80 % can be reached by 20% (Tas and Yaman 2005). In construction sector, it has long been known that the value of the bill of quantities is contained in only 20% of the total number of items. Various scholars found and noted on biased distribution of bill item prices (Alqahtani and Whyte 2013).

In 1981, in order to achieve 80:20 rule, Shereef suggested that CSIs, which represent 20% of the total number of item, should be equal or greater than (V/N) where: V: total value of measured items, N: total number of the measured items.

He studied 25 bills of quantities and noted that the value of 20% of items greater than or equal to V/N exhibited the 80:20 rule (Shereef 1981). Saker (1986) utilized 85 bills of quantities from both building and civil engineering projects in order to test Shareef's hypothesis. The result of this research concluded that 18.5% of items represent 81.5% of the total cost of these projects. Asif (1988) was found similar result to Saker when he was carrying out study to develop an estimating system based on the 80/20 principle. 100 bills of quantities of bridges, road and sewer projects were utilized and he found that the contribution of the 22.6% highest value items represented 81.7% of the bill value.

In 2005, Tas and Yaman developed a building cost prediction model based on the concept of CSIs for the Turkish construction sector public projects in its detailed design phase. They examined twenty one bills from residential building project to identify the important cost items. They concluded that the number of CSIs of these was between 16 and 21 of the total number of items 53 to 57, and the mean value was

19.24. These CSIs were about 36% of the total number of items and the average bill value of these items was 81.86%. These CSIs were grouped in a work package in order to reduce the numbers of cost items based on the 80:20 rule. Those items were summarized in 12 cost significant work packages (CSWP) which included reinforced concrete, masonry, formwork, scaffolding, roofing, doors and windows, reinforcement, painting, flooring, wall finishes, wall and ceiling plasters and glazing. The final step created the ratio of the total cost of these CSWP to the total project cost. This ratio is known as the cost model factor. After creating the cost model factor, the total cost of project can be calculated by only pricing CSWP and applying the suitable cost model factor that represents the value of the non-cost significant items and work package. They used the data of 20 projects to test the model. They found that the accuracy of the model between -16.6% and +8.58% with a mean accuracy -5.1%. The CSWP represent 77.8% of the total bill value of 20 projects.

Al-Hajj and Horner (1998) argued that the Building Maintenance Cost Information Service (BMCIS) offered a comprehensive framework for collecting whole cost data of LCC, but this framework is not used often. They developed a model to predict the total running cost (operation and maintenance costs) based on CSIs concept. They identified 11 elements (only 16% of the total number of items) as CSIs of this model and created a cost model factor. Their model was able to estimate the total running cost of building with an accuracy of between 2.5 and 5%, and annual costs with an accuracy of 7%. They concluded that CSIs concept was able to simplify the estimation process because their model only used 16% of items which would be extracted from BMCIS. If the CSIs can be identified and generated from BMCIS, then this would lead to simplify the current estimation process of LCC, for those who believe the present process to be not used often.

Similar approach models for estimating the total costs are available. Bouabaz and Malcolm (1990) developed a model for estimating the new-build and repair cost of bridges. This model was created based on the concept of CSWP. They identified only 10 items as the CSIs of this model and this model is able to estimate the cost of new bridge within 10% accuracy and 0.73 the cost model factor. They improve the accuracy of this model to 5% by modification of the model to consist of an additional 11 elements within cost model factor 0.82. A computer package called BRIDGET has been built based on this model to be able to calculate the price of a new build bridge in less than 15 minutes. The same concept was used to develop a model to estimate the repair costs of bridge. 14 elements were considered as the CSIs of the cost model used for repair bridges and this model is able to estimate the cost of repair bridges within 10% accuracy and 0.82 the cost model factor (Branco 2004). As evidence exists in support of CSIs, Horner and Rashad also argued (1996) that quantity-significant items are worthy of note in estimation total cost. They found that there is a surprisingly liner relationship between value and quantity when a model was developed based on the field of the effect of quantity-significant in estimation project cost and duration.

5 METHODOLOGY

The definition of CSI's suggests in this paper is those measured items whose individual values were greater than the mean value of all measured items. This can be achieved by breaking down the methodology into two distinct parts.

In this phase I, the CSIs for building project at different building stage will be identified. All the cost items whose values exceed the average value of the cost items are selected as the CSIs. The value and number of these CSIs are summed up and divided by the total value and number of items of project in order to calculate the proportion that the CSIs contribute to the total value and number of items of the project. At each stage of building life cycle, a group of very similar items will be consistently identified as cost-significant. However, a few items tend to lack of consistency in terms of being CSI or not. These cases may occur because of some components are utilized more often in some types of buildings, than in others. Therefore, all these CSIs at each stage of building life will further analysis in phase 2 in order to determine whether a CSI has a significant effect of the total costs for all type of building and including in the final model.

After identifying CSIs, the next step would be to select the CSIs for use in the final estimation of costs. Application of the mean value identified CSIs at each stage of building life across all projects. This is considered to be too many for optimum efficiency. In order to further reduce the number of CSIs for a cost estimating process, a method is used which considerably reduces the number of items. This method applies the mean value method on the importance rate rank, so that the number of CSIs can be reduced efficiently. The factor to measure the contribution of cost items is the importance rate (IR), which is the percentage contribution of a cost item's value to the total value of the all projects.

$$IR = \frac{\sum_{j=1}^{n} Ci}{\sum_{j=1}^{n} Ct} \tag{1}$$

where: Ci : The value of a cost item in each project; and Ct : the total costs of each project.

The final CSIs including in the final estimation of costs are identified on the basis of this rank, which indicates the contribution of each item to the overall value of all projects at each stage of building life cycle. According to the mean value method the efficient way to handle the total of the CSIs is to focus on the items bigger than the average. Therefore the items exceeding the average of IR result at each stage are deemed the CSIs for the final estimation of costs.

6 CONCLUSION

One significant conclusion from the above discussion is that enhancements in prediction process of total cost in construction projects would stem from a shift in highlighting towards the high-cost items. If the CSIs could be simply recognized, it would motivate estimators to straight their judgments to such items, and to reduce the time required for pricing. Moreover, Cost information required to estimation of total cost could be collected, analyzed and recording in manner which will boost a more significant and realistic method to predict total cost.

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