Prediction of the Life Cycle Cost for Erosion and Sediment Control Measures

Ibrahiem Abdul Razak Al-Ani, Lariyah Mohd Sidek, Mohamed Nor Mohamed Desa
Department of Civil Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor
(Corresponding author: Assoc. Prof. Ir. Dr. Lariyah Mohd Sidek, E-mail: lariyah@uniten.edu.my)

Abstract: Commonly used Best Management Practices (BMPs) such as geotextile and mats, silt fence and sediment basins can be very effective in alleviating sediment stress to the streams. However, improperly placed, sized, or maintained BMPs can negatively impact stream biota and habitat, creating a more severe sedimentation/erosion problem. The effectiveness of the BMPs system depends on the regular operation and maintenance of the BMPs. However, the increased cost is known as barrier to the wider implementation of the BMPs by the developers and contractors. Therefore, the challenge is to develop a clear life cycle cost of BMPs which can be used in any development site. Life cycle cost (LCC) of a BMP is a combination of the installation, maintenance and removal costs of the various BMPs. In this research, software called Life Cycle Cost Decision Support System (LCC-DSS) has been developed to predict the LCC of the various BMPs desired to be installed within the construction site. Two scenarios have been adopted herein, the first one is the estimation of the LCC depend on the current prices available in the market. Whilst the second scenario is the prediction of the LCC based on the future prices in which the user is required to do some data input. The LCC-DSS has been verified and validated using real data from construction site in Malaysia and has shown convenient results which were confirmed by professional experts.

Keywords- Erosion and sedimentation; life cycle cost; decision support system; construction sites.

I. INTRODUCTION

Erosion from construction sites usually result from raindrop impacts and sheet flows. The impact of erosion will include the onsite impact, which has the action of losing of the top soil where construction equipment in construction sites reduces or demolishes the property of the top soil by the action of compaction or disturbing the soil. The top soil has the highest biological activity, organic matter, and plant nutrients that are essential for establishing and maintaining vegetation. The loss of nutrients results in less fertile environment for the plants. The loss of organic matter will increase the soil density and compaction will take place which lowers the infiltration rate of water. This will result in poor growth of the plants and might make the site drought. The loss of organic matter will reduces the soils natural ability to control diseases since the top soil is the food source and habitat for beneficial microorganisms and insects [1; 2; and 3]. In Sarawak, Malaysia, soil erosion was not meaningful problem during the 1950s and 1969s [4]. A number of colonial officers had the judgment that the land has to be managed well and further development will result in the destruction of Malaysian river systems during the late 1930s. One officer advocated that " no land within 150 feet of designated rivers should be cleared and that occupants of river bank areas should be compelled to plant riparian strips to reduce bank erosion", while a Belgrave Commission (an officially appointed commission), recommended that catchments boards should be appointed for each major river basin in Peninsula. Unfortunately, the War and Emergency interfered and hence no action was taken until after the 1970s [5]. Commonly used Best Management Practices (BMPs) such as geotextile and mats, silt fence and sediment basins can be very effective in alleviating sediment stress to the streams. The effectiveness of the BMPs system depends on the regular operation and maintenance of the BMPs. However, the increased cost is known as barrier to the wider implementation of the BMPs by the developers and contractors. Therefore, the challenge is to develop a clear life cycle cost of BMPs which can be used in any development site [6; 7; and 8]. Life cycle cost (LCC) of a BMP is a combination of the installation, maintenance and removal costs of the various BMPs. The aim of this study is to develop a software called Life Cycle Cost Decision Support System (LCC-DSS) for predicting the life cycle cost of the different BMPs for any construction site in Malaysia.

II. METHODS

As mentioned earlier, the objective of this research is to develop LCC-DSS for predicting the life cycle cost of the desired BMPs. To achieve this, two scenarios were adopted herein. Figure 1 illustrates the methods adopted for developing the LCC-DSS. The following sections provide description for each scenario.

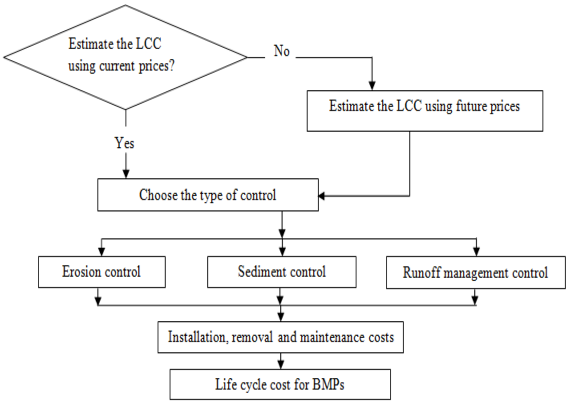

Figure 1. Life cycle cost for BMPs

A. LCC from private companies and local authorities

This scenario aims to outline a standardized protocol for estimating the BMPs' life cycle costs of the erosion and sediment control BMPs based on data collected from local authorities like DID and from private sectors such as the consultation firm, developer companies besides the suppliers. This scenario provides an easy method for the users to estimate the costs based on the current prices in the market.
Information required for predicting the LCC in this module are the dimension and types of the BMPs desired. Once the input data has been identified, the system will be able to calculate the LCC for the BMPs. A pie chart shall be drawn to show the percentages of the LCC components for all the BMPs desired.
The costing used in this module is average costing from private companies and local authorities departments. The data collected regarding the costing is limited to 11 BMPs only, besides, the costing for various BMPs are variable due to the market changes. That's why, the second scenario was designed.

B. LCC based on user input for the desired BMPs

This scenario aims to predict the LCC for various BMPs in case the costing of the BMPs collected from the local companies and local authority are being changed or the user would like to use a more accurate estimation for the LCC based on his/her input. Besides, as mentioned earlier, the data collected was limited to 11 BMPs only, thus, the user in this scenario can assess the LCC for all the BMPs used within the ECO-ESCES. In this scenario, the user is required to key in values for the installation, maintenance and removal components for the desired BMPs.

III. RESULTS AND DISCUSSION

Following the development of the LCC-DSS, software validation has been fulfilled for proving the software's functionality and durability in predicting the LCC for all the desired BMPs [9]. Two case studies have been selected and applied for this purpose. The LCC-DSS results regarding the life cycle cost and the results obtained from the bill of the quantity of the two case studies were compared for each of the erosion control, sediment control and drainage control measures. The life cycle cost involves the installation cost, maintenance cost and the removal cost of the desired BMPs. The main interface window for estimating the LCC is shown in Figure 2. Once the user selections and data input process being completed, the ECO-ESCES recommendations for protecting the drainage inlets can be obtained.

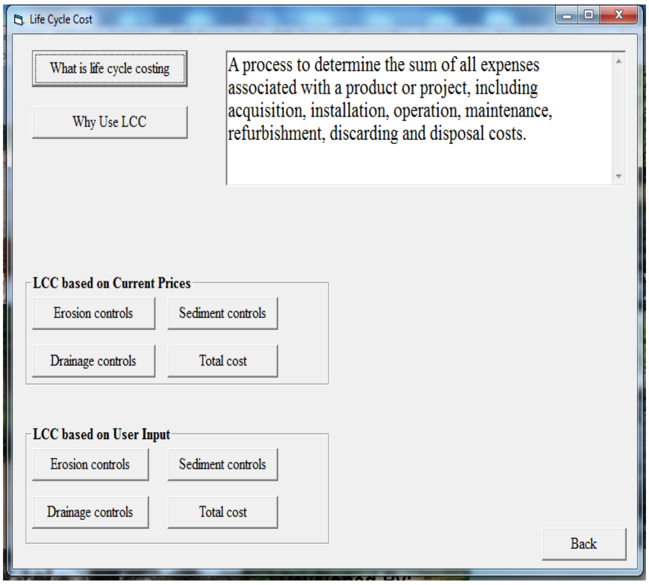

Figure 2. The main interface window of estimating the life cycle cost

Based on user input, ECO-ESCES has provided the costing for each of the sediment control, drainage control of the desired BMPs as shown in Figure 3 and Figure 4 respectively. The erosion control costing was not estimated since there is no erosion control measures were installed within the current project. Table 1 compares the results obtained from the ESCES and the field results for the LCC (based on sediment and drainage controls).

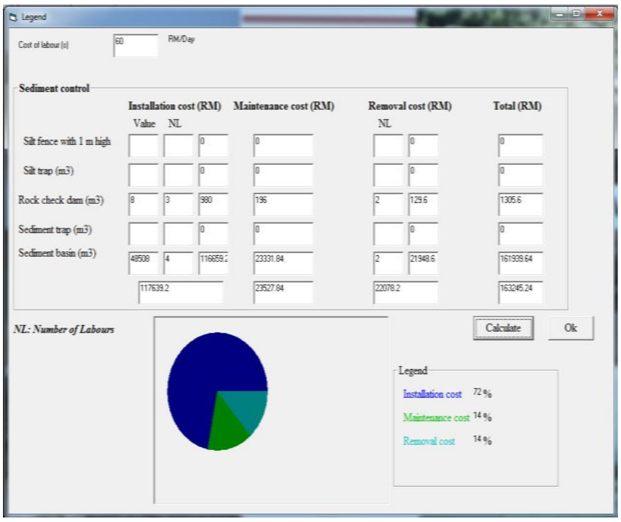

Figure 3. LCC-DSS estimation for the sediment control's LCC

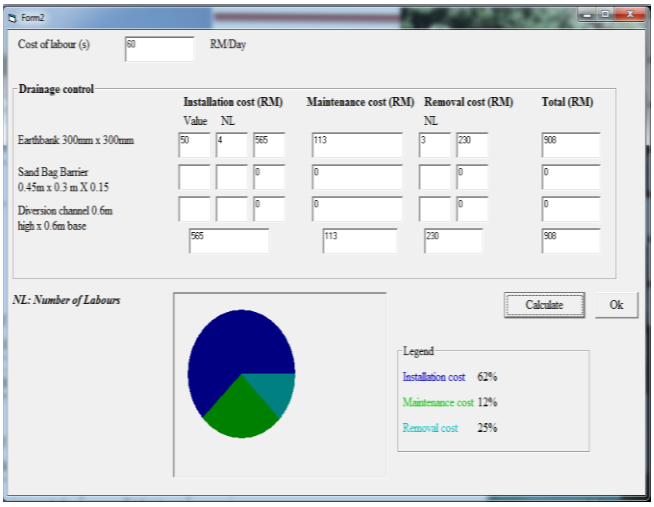

Figure 4: LCC-DSS estimation for the drainage control's LCC

Table 1. Comparison between the field results and the ECO-ESCES results for the LCC

Observed values (Field results)			Predicted values (ECO-ESCES results)		
Sediment control (RM)	Drainage control (RM)	LCC (RM)	Sediment control (RM)	Drainage control (RM)	LCC (RM)
162500	850	163350	163245.2	908	164153.2

Table 1 indicates that the results obtained from the LCC-DSS and the field results were close to each other.

IV. CONCLUSIONS

Construction sites have long been recognised as the main source of sediments into the ambient water bodies. This is because of the land clearing and earthmoving activities that disturb the soil and make it ready for the erosion process by rainfall. Thus, installing the erosion and sediment control measures is essential in any construction site in Malaysia. Predicting the life cycle cost of these measures (i.e. erosion control, sediment control and drainage control) is an important issue for developing the project's bill on quantity. This manuscript presents the development of the LCC-DSS software for predicting the LCC of the desired BMPs that targeted to be installed to any construction site in Malaysia. Two case studies were used for validating the LCC-DSS software. Results have shown that LCC based on the field study and the one predicted by the LCC-DSS are almost the same. The results were confirmed by the experts as well. The end users of this software are engineers, contractors, and decision makers.

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