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Research Paper

Potential Assessment Model of Planning, Procurement and Construction Management In Reducing Cost Inefficiency Due To Building Construction Material Waste (Case Study of SOE Contractors In Makassar City)

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ABSTRACT

The emergence of material wastes during the building construction is inevitable, with direct and indirect impact costs. However, this can be minimized by applying the concept of proper management on the planning, procurement and construction stages. This study, therefore, aims to analyze the level of potential influence on the application of management concept to the building construction materials. The dynamic simulation test was used to reduce the ineffective impact of material cost, reviewed by the parties involved in the project. Data were obtained by distributing questionnaires to building contractors consisting of experienced and responsible workers. Furthermore, the data were analyzed and interpreted using the path relationship concept, with the dynamic technique used to determine the potential value of the model against time changes. The results obtained in the Time Series Analysis are the dynamic test of the model concept. The results of the dynamic test analysis on the model concept is simultaneously integrated to the planning, procurement and construction stages, to reduce the impact of cost inefficiency in building construction. The result also showed that there is a future 74.41% decrease in the average construction waste by a state-owned contractor with the ability to optimally reduce cost inefficiencies.

1. Introduction

Presently, there is a yearly increase in construction in major cities located in Indonesia. This requires a lot of resources in the form of money, labor, equipment, methods and material resources. However, there are lots of problems associated with building projects in the location, such as the management of waste material and its impact on environmental, cost and social aspects (Nagapan et al., 2016; Osmani et al., 2012; Wang et al., 2008). Indonesia is one of the countries experiencing developments in recent years, with reference to the city of Makassar which is located in the eastern part of the country where trades, businesses, and government activities are carried out with the provision of supporting facilities and infrastructures. Building construction currently leads to vertical and horizontal spans of development due to the growing need for human activities. In reality, most of the implemented management materials are still low and not optimal, especially in private contractors compared to State-Owned Enterprises (SOE) contractors (Ervianto, W.I, 2015).

Previous studies generally focused on identifying the various causes of construction material waste, however, there are still very few studies its potential in Indonesia to lower cost. The existence of previous research shows the impact of cost inefficiencies during construction due to the occurrence of material waste. Therefore the purpose of this study is to develop a model capable of

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predicting the relationship between the effect of the application and the potential management of the building construction materials from the SOE contractor and make a simulation test toward the dynamic cost impact on time changes.

2. Literature Review

2.1 Construction Materials Waste

According to the Environmental Protection Agency (1998), construction wastes are unused materials in repairs or changes and are obtained due to three main factors as follows:

- Structure Type (residential, commercial or industrial buildings)
- Structure size (low *rise, high rise*).
- Activities such as construction, renovation, repair or demolition.

Alwi et al. (2002) defined construction waste as a Non-Value-Added Activity found in the building industry. According to Formoso et al. (2002), the emergences of waste material have a negative impact on the environment and also increase construction costs.

2.2 Management Concept of Construction Material Waste

Waste material management is the sole responsibility of planners, executors, suppliers, supervisors and building owners. Therefore, these construction workers need to plan properly, procure and implement to avoid poor management of waste (Nor Solehah Md Akhir et al., 2013; Khor Jie Cheng et al., 2014; Kelly Mark et al., 2015).

The occurrence of construction material waste is due to the combination of several sources (Intan et al., 2005; Bossink et al., 1996). Gavilan and Bemold (1994), divided the sources of waste into six categories, namely (1) planning, (2) procurement, (3) handling, (4) implementation, (5) residuals/waste, (6) others. The planning process plays a significant role in reducing the volume of material waste during the construction process (Saheed Ajayi, 2017).

Construction waste management includes the collection, transportation, storage, treatment, recovery and disposal of waste. It is also defined as a comprehensive, integrated, and rational system approach used to achieve and maintain environmental quality and support sustainable development (Gavilan and Bernold, 1994; Zuhairi Abd Hamid et al., 2016).

2.3 The Achievement of Green Construction by SOE Contractor

Generally, the projects implemented by State-Owned Enterprise (SOE) contractors are able to fulfil the green construction policies (Ervianto, W.I, 2015). Therefore, to improve the ability of private contractors, it is necessary to possess an education from SOE through external and internal collaboration. Private contractors were able to reach 53.06% of the green construction indicators in Indonesia (Ervianto, W.I, 2015). The research show a variation between SOE and private contractors, where the average of SOE contractor is able to reach 90.97% of the best achievements in Indonesia (Ervianto W.I, 2015), and Green Building Council Indonesia (GBCI, 2011).

2.4 Inefficiency Costs Due to Construction Material Waste

One of the impacts of construction material waste is inefficient costs (Garas et al., 2001). Therefore, the implementation of construction material waste management is a standard that needs to be applied by each stakeholder to reduce the impact. This management tends to have a significant positive effect assuming it is simultaneously conducted continuously, especially on the type of building projects. Positive potential in implementation has an effect on cost during the construction process (Shen, L.Y et al., 2002). Many references explained the factors capable of guiding the process of preventing and controlling waste materials during the construction process in the form of standards and policies. Governments, contractors and researchers have tried to develop a management model capable of reducing the environmental impacts and costs of material waste during construction (Chen Z et al., 2000). A. Al-Hajj et al. (2011) stated that cost efficiency directly increases profits for the construction executor through the implementation of optimal management of waste materials. Several studies have shown the potential for constructing cost-efficient building from applying the concept of material waste management (Osmani et al., 2006; Begum et al., 2006; Tam et al., 2007; Shen, L.Y et al., 2002).

3 Research Methodology

3.1 Types of Research

This is a survey research with inferential-development methods used to create a model capable of predicting the effect of waste material management in reducing the impact of the cost inefficiency of the construction projects. Respondents are SOE contractors, consultants, planners, supervisors, sub-contractors, material suppliers, and professional academics in the topic of construction waste.

3.2 Research Time and Location

This research was carried out for five months and was conducted on several completed and incomplete building projects by the SOE in Makassar city, Indonesia.

3.3 Collection Data and Sources

Data used were obtained from primary and secondary sources, as described in the following sections:

3.3.1. Primary data

The data were obtained in the location through questionnaires, observations, documentation and interviews with parties that understood the topics studied. These include consultants, contractors, material suppliers and some academics that are experts in the construction waste. The observational data were obtained from periodic independent observations in all project locations determined during the research survey. The questionnaire was made on the basis of a Likert scale where in the first stage consisted of "very influential", "influential", "not very influential", "not influential" and "very insignificant" analysis for structural equation modelling analysis then the second stage consisted of scale " very potential "," potential "," not very potential "," no potential "and" very potential "for dynamic analysis.

3.3.2. Secondary data

The data were also obtained from contractors in the form of a project cost budget, and also from journals, book references, internet sites and other supporting documents which are accurate and relevant to the study material.

3.4 Population and Sample

The population in this study consists of a total of 125 respondents purposively obtained from saturated participants namely SOE contractors (67.2%), subcontractors (16%), consultant planners and supervisors (6.4%), material suppliers (6.4%) and academics/associations experts in the topic of construction waste (4%). Respondents had an average experience of over 15 years, and 72.8% of the undergraduates understood the problem being studied, and building material suppliers. The sample was purposively selected and adjusted to the research needs.

3.5 Study Measurement Variables

The research model consists of 19 categories and 113 sub-categories of measuring variables, as shown in **Fig. 1**. The main variable consists of management at the planning stage, such as planning, modern design concepts, standards, material selection, feasibility, consultant competence, and management. The procurement stage consists of budgeting, material purchases, management at the construction stage, implementation of reused and fabricated materials, worker competencies, supervision, policy, storage, methods, as well as field and shipping handling. Meanwhile, the cost impact variable consists of the total average on inefficiency due to material waste in building construction projects in accordance with the report from the contractor.

3.6 Data Processing Analysis Method

The data analysis technique used is Structural Equation Modeling (SEM) software Type Smart-PLS-22. In this stage, a further modeling test was conducted to determine the effect of significant positive potential in reducing the impact of the cost inefficiency of material waste based on the sub-category variables determined as a measurement tool by the respondents. Furthermore, a dynamic simulation was used to determine the optimal potential on the implementation of management concepts towards time changes using VENSIM-PLE software due to its ability to provide predictions of measuring variables over time (Sterman, 2000; Rahman et al., 2013).

4. Result and Discussion

4.1. Variables of Development Model Management Concepts

Based on the results of validation and feasibility tests, the sub-variables were reduced from 133 to 113 ideal and effective variables in the concept of this research model. Furthermore, a total of 29 sub-variables were found in Design Planning, Sustainable Concepts, Standards & Regulations, Selection of Low Waste Materials, Pre-Design and Planner Competence categories.

Subsequently, there were a total of 13 sub-variables at the procurement stage, which consist of Budget Preparation, Material Volume Estimation and Ordering, Supplier Selection and Contract Planning categories. The implementation/construction phase consists of 71 sub-variables and 9 variable categories, namely Material Reuse, Human Resources Competence, Storage Handling, Management Commitments, Rules / Policies, Work Methods, Field Handling, Monitoring / Supervision and Material Delivery.

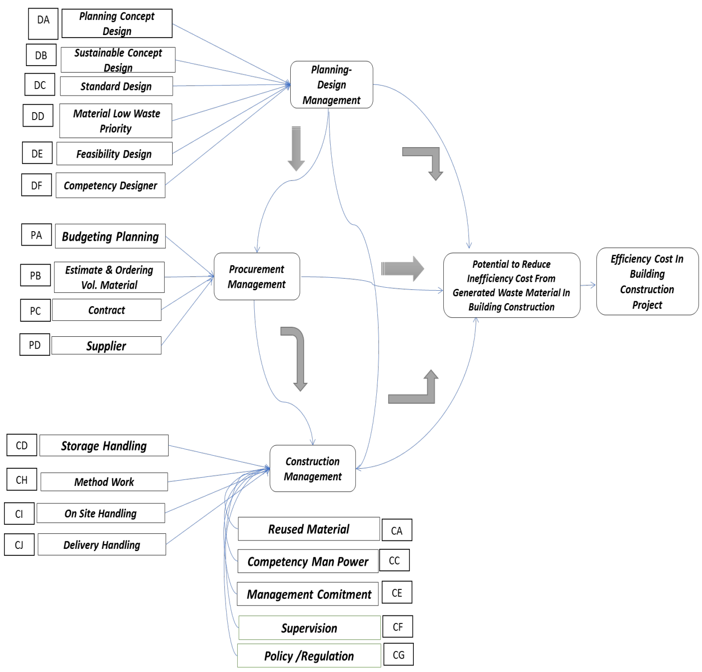

Fig. 1. The model concept of management control on cost inefficiency due to material waste in building construction

Fig. 2. shows the output of the final structural of model concept after several sub-variables have been removed from the model system. Therefore the ideal of model conceptis obtained by predicting the relationship effect on the implementation of management towards reducing the impact of cost inefficiency due to material waste during the building construction. Based on the results of the outer model analysis, the parameter values are shown as follows:

- Outer Loading Factor: This shows a value above 0.5 (Chin, 1998) of most sub-variables in the system model. Therefore, the model fulfills the requirements towards the influence of latent variables and indicators. Although there are some sub-variables that were drop-out because not meet the requirements.

- Composite Reliability (CR): The SEM PLS analysis show that the CR and Alpha Cronbach values have an average value above 0.6 / 0.7 (Ismail Abdul Rahmana et al., 2014). Therefore, the variables in this model concept test are consistent and stable.

- Convergent Validity (CV): The analysis of Average Variance Extracted (AVE) shows the average value of the model is above 0.57 seen in **Table 1**. Therefore, the latent variable has been able to properly explain the relationships of the indicator in a block, which is a minimum of 50% (Ismail Abdul Rahmana et al., 2014).

- Discriminant Validity (DV): This determines the validity test results by using Cross Loading. The indicator variables in each block of the dominant average show the DV with a higher correlation effect compared to other blocks in the model system, therefore the model compatibility is good.

From the results of the Inner model analysis, the parameter values are shown as follows:

- Determinant Coefficient R^2: This is used to obtain the value of R^2 on each latent variable with a planning value of 0.844 or 84.4%. Meanwhile, at the Procurement stage, the value is 0.722, with a correlation effect of 72.2%. At the Construction stage, R^2 equals 0.806, and produces a correlation effect of 80.6%. The impact of cost inefficiency due to the presence of material waste, produces a value of 0.496. with a significant effect above 0.26 (Cohen, 1988) at the Planning, Procurement and Construction stages. These are used to reduce the inefficiencies by 49.6% in the first year, which can be seen in **Table 1**.

Table 1. Average AVE and R^2 values

Variable	AVE	R^2
Planning-Design	0.965	0.844
Procurement	0.78	0.722
Construction	0.706	0.806
Potential Reduce Inefficiency Cost	0.865	0.496
Average	0.829	0.717

- The f^2 Influence Test: The average test on exogenous and endogenous latent variables is obtained by $f^2 > 0.15$. Therefore there is a sufficient influence between latent variables with a significant influence value of f^2 above 2.433 in the planning stage. Furthermore, the Procurement stage consists of the Estimated Material Volume category with values of f^2 = 2, 9 and at the Construction stage is the Management Commitment with a value of f^2 = 4,528.

- Goodness of Fit (GOF): From the analysis results, a GOF value of 0.77> 0.38 is obtained, therefore, in overall conclusion, the model's concept is quite good.

- Hypothesis Test (Significant Level): This is used to determine the analysis, the average value of T-Sign > 1.96 (5% t-table) is obtained.

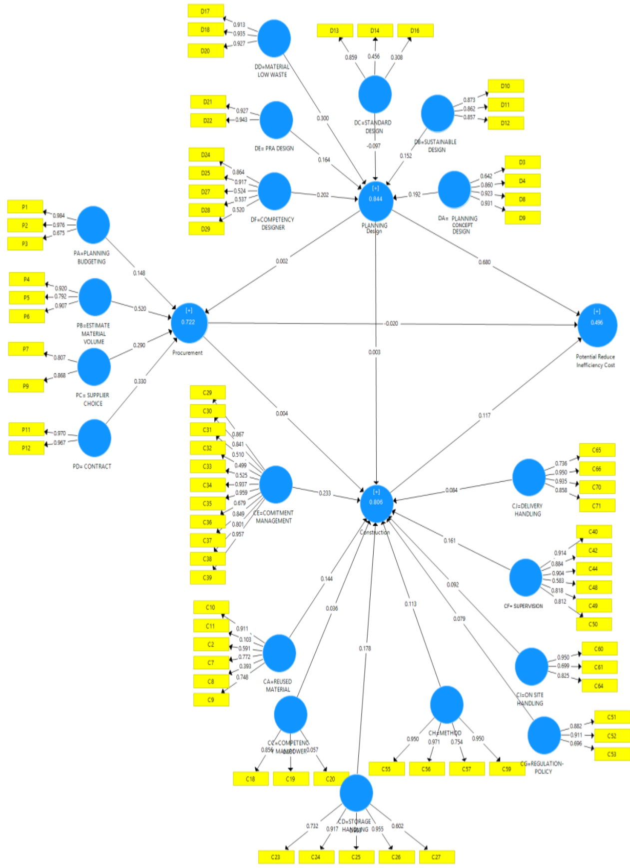

Fig. 2. The analysis results of the model concept test using *Structural Equation Modelling* SEM-PLS 22 final

4.2. Dynamic Analysis of Model Concepts

From the results of the SEM analysis extract, the number of sub variables is reduced to 76 which will be used in dynamic analysis. The analysis of the Pareto concept shows that ± 20% of material provides a significant value of approximately ± 80% of the total average cost. This is because the waste is 29% concrete in structural casting work, 15% reinforcement iron, 13% ceramic tiles, 12% light brick on the walls, 10% gypsum in the ceiling and partition, 7% cement for plastering and casting, 6% fine aggregate/sand for plastering and piling, 4% coarse/gravel aggregate for casting, 2% spun pile in sub structure/foundation work and 2% zincalume material in roof covers. Furthermore, the fresh concrete material shows significant waste costs with the largest proportion at 29%, at a dominant material waste of ± IDR. 215,726,000.00 total inefficiency cost.

Case study simulation conducted in Makassar City. Where the type of building projects with a number of 10-storey floors, with an area of ±1500 m2 and the planned duration of the project for 2 ½ years (30 months) as the duration of the simulation model. The Time Series Analysis at the Planning stage shows that the potential value of the model implementation is obtained at 98.5% in the Competency Planner (Consultant) Category. Subsequently, in the Procurement and Construction/Implementation stages, the Material Volume shows a significant potential value of 89.17%, and 98.69%, respectively. **Fig. 3.** shows the relationship of stock flow diagram of the management model concept holistically and **Fig. 4.** shows the dynamic test analysis of the model concept at the planning, procurement and construction stages. Furthermore, the potential value of the management model implementation is obtained, with a potential value of 88.6% in the Planning-Design stage to reduce the impact of cost inefficiency then followed by the construction and procurement stages. This is also similar to the research conducted by Ajayi Saheed (2017) in the UK, where the planning stage shows a significant potential estimation value in an effort to reduce the volume of material waste in a construction project.

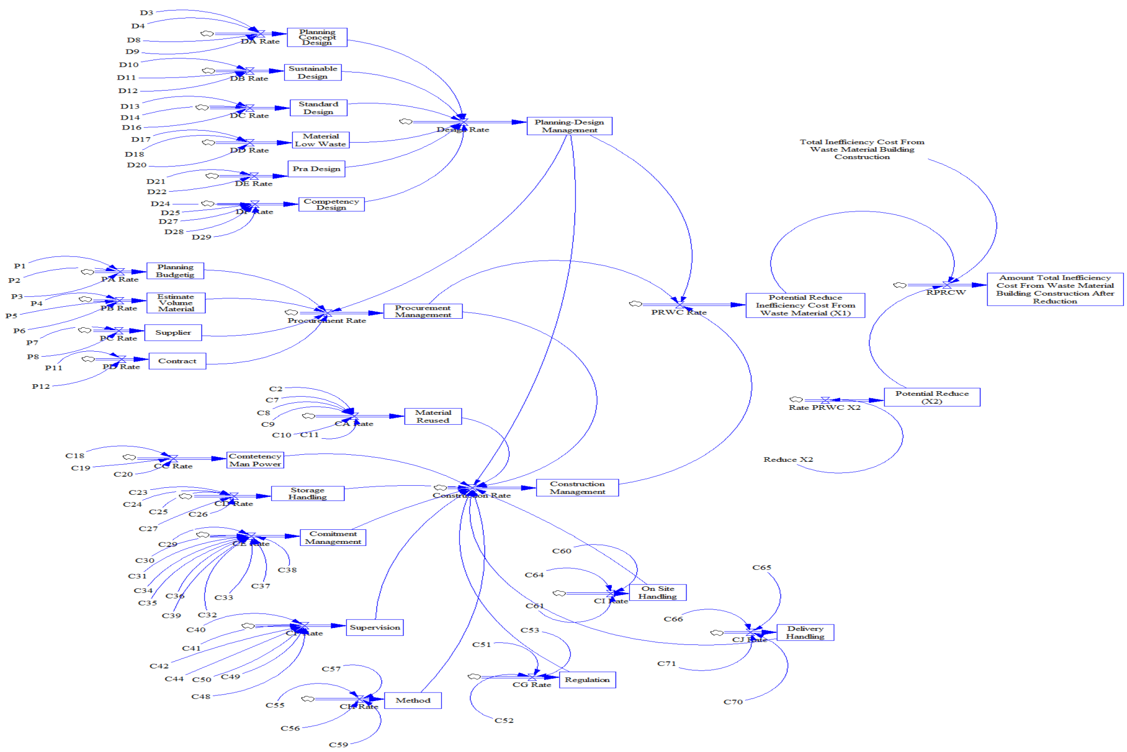

Fig. 3. Stock flow diagram of the concept model

Based on the dynamic test simulation of the model concept towards reducing the total cost , the tendency of the model test scenario shows a significant reduction in the amount of cost over the optimal scenario duration of 30 months (2 1/2 years). Subsequently, **Fig. 5.** and **Table 2** shows that the simulation test results has the ability to provide an ideal potential effect capable of reducing the total waste inefficiency cost. Meanwhile, the scenario test result has a tendency to reduce the total cost on the 6th month (1/2 year) by 1.25% at IDR. 213,029,000.00. Subsequent time duration, shows a potential cost reduction of 7.57%, 19.92%, 40.74% and 74.41% in the first, 1½, 2 and 2½ years, at a total cost of IDR 55,214,900.00 on the duration of the project case study simulation.

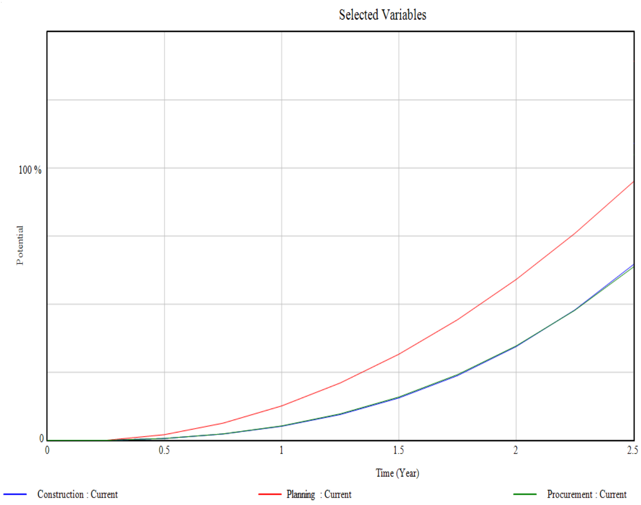

Fig. 4. Graph of dynamic simulation test results towards the potential of the model implementation simultaneously

The dynamic simulation model show that the Potential Reduce (X1) and (X2) from R^2 extract value have a significant effect in reducing the total cost inefficiency due to waste of building construction materials towards time changes. Therefore, the results of the simulation show that the average building project undertaken by a state-owned/SOE contractor is able to influence the value of the estimated projections in an effort to reduce cost inefficiencies due to building construction materials waste. This is also in line with the research conducted by Ervianto, W.I (2015), which stated that the average level of concept understanding on Green Construction indicators by the SOE contractor is good with an average achievement level of 90.97%.

Table 2. Recapitulation of the dynamic simulation test results towards the potential reduction in the total cost inefficiency due to building construction material waste

Year	*Status*	*Total Inefficiency Cost From Waste Material/Unit Average Building ConstructionAfter Reduction*	*Potential Saved/Unit Average Building Construction (%)*	*Tot. Reduction Inefficiency Cost From Waste Material Building Construction /m²*
0	*Current*	IDR.215,726,000.00	0.00%	IDR. 143,817.33
0.5	*Reduce*	IDR. 213,029,000.00	1.25%	IDR. 142,019.33
1	*Reduce*	IDR. 199,388,000.00	7.57%	IDR. 132,925.33
1.5	*Reduce*	IDR. 172,763,000.00	19.92%	IDR. 115,175.33
2	*Reduce*	IDR. 127,836,000.00	40.74%	IDR. 85,224.00
2.5	*Reduce*	IDR. 55,214,900.00	74.41%	IDR. 36,809.93

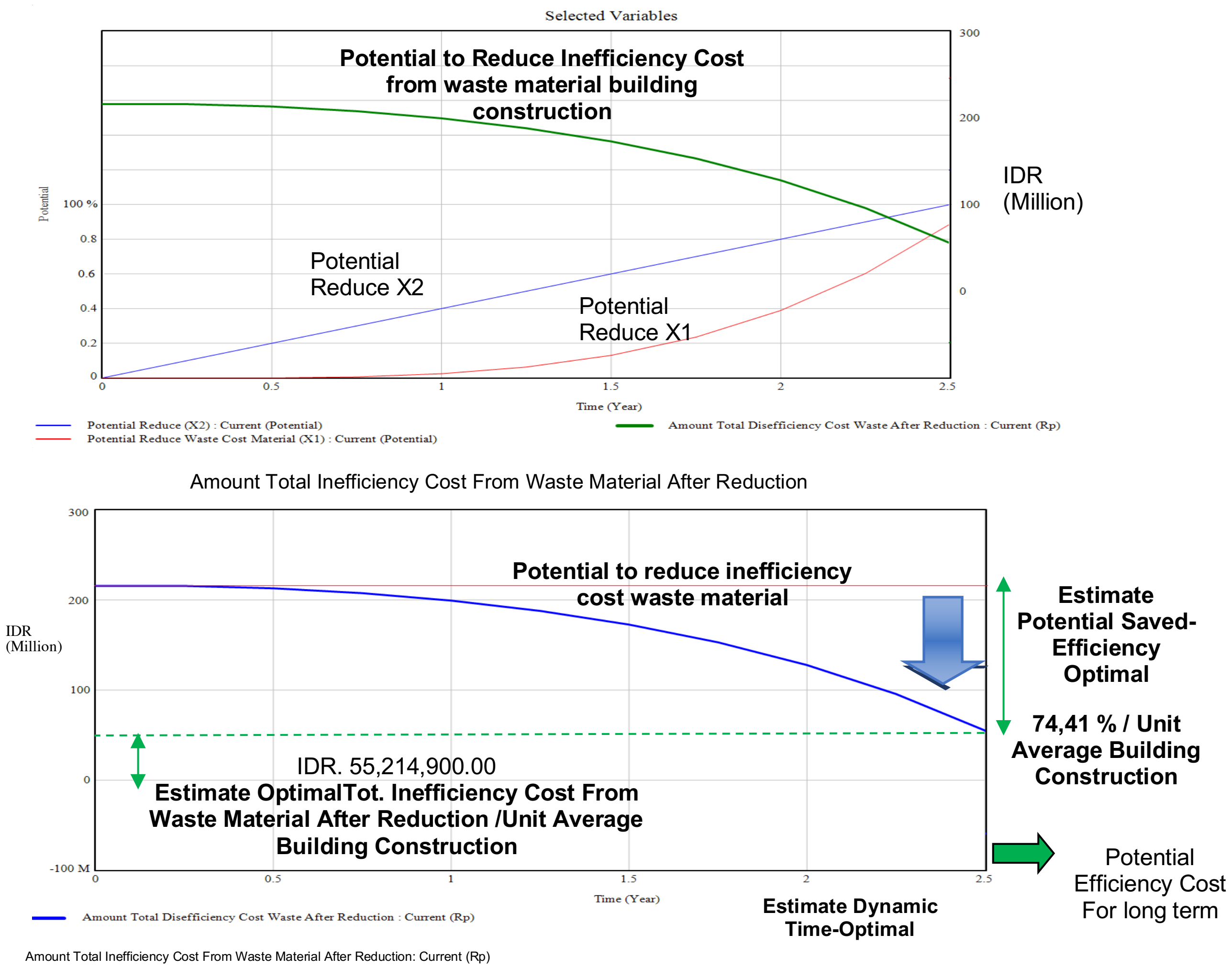

Fig. 5. The dynamic simulation test results of a potential reduction in total cost inefficiency due to material waste towards time changes

5. Conclusions

In conclusion, the model variable test using Structural Equation Modeling (SEM), which has a significant influence on management at the Planning, Procurement, and Construction stages are Competency, Material Volume Estimation, and Commitment, respectively. The R^2 determinant coefficient for the latent variables of the management model simultaneously reduces the inefficient cost of the building material by 0.496. Therefore, the implemented management model concept at the Planning, Procurement and Construction stages are influenced by a 49.6% reduction inefficiency cost in the first year. This is because , construction providers, executors, planning consultants and material suppliers reduces the proportion of cost inefficiencies by building materials waste in Indonesia. In accordance with the dynamic simulation test using the Time Series Analysis, the application of management models at the Design Planning stage has a significant potential value in reducing cost inefficiency due to residual materials. This is also in line with research conducted by Ajayi Saheed (2017) and Mohd Reza Esa (2017). Furthermore, the dynamic simulation test results based on time changes showed that the management model has the ability to optimally reduce the total inefficiency cost of the remaining construction material waste by 74.41%. Therefore, the results of the research simulation showed that the average building project undertaken by a state-owned contractor reduces cost inefficiencies of the residual construction materials waste in Indonesia, thereby, leading to optimal model management.

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