Developing activities of green design, green purchasing, and green transportation as the part of green supply chain management in construction sector

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Abstract. Green Supply Chain Management (GSCM) is a concept that integrates environmental factors into the traditional SCM started from the process of design, material procurement, production, distribution and end-of life. The benefits of implementing GSCM does not only improve the company's environmental performance, but also improve economic performance such as reducing operational costs and organizational performance such as improving the company's image. In manufacture and automotive industry, GSCM is able to improve company performance, therefore construction industry can consider of adopting this approach. Some GSCM practices in construction sector include green design, green purchasing, green transportation, green construction, green warehousing, green recycling and facilitating green practices. The aim of this study is to identify relevant green design, green purchasing and green transportation practices as part of GSCM if applied in the construction sector. The research variables were obtained through a literature study on GSCM both in construction sector and other sectors, then the variables were validated by respondents, practitioners in construction sector. Based on three respondents, there are ten green design practices, six green purchasing practices and five green transportation practices that are relevant to the construction sector, especially building projects.

1. Introduction
Green Supply Chain Management (GSCM) is a concept that integrates environmental factors into traditional SCM started from the process of design, material procurement, production, distribution and management of products after their useful life [1] while in the construction sector the series of activities are planning, design and production on site [2]. An environmentally friendly construction project is the result of environmentally friendly practices carried out at each stage of the supply chain by each stakeholder started from the design stage to the demolish stage, so stakeholders must be able to work together and align their respective interests [3]. Green practices in the construction sector include green design, green purchasing, green transportation, green warehousing, green construction, green recycling and green practices [4], [5], [6].

GSCM implementation provides several benefits related to the environment, namely reducing waste production, saving energy consumption, reducing the use of hazardous materials, increasing the use of reuse and recycle materials and reducing the level of carbon emissions. Other benefits that are
not related to environment are increased customer satisfaction, improved corporate image, expanding market share, and increased customer social responsibility. Beside benefits to environment, cost reduction is the most important and the main benefit at once for the organization. If the implementation of green innovation is made broadly and effectively, there will be a decrease in costs of operational activities, both in the manufacturing and construction sectors [6].

The implementation of GSCM in construction sector that can be proved from limited research with GSCM in construction sector topic is still rare. According to Balasubramanian and Shukla [4], research about GSCM in construction sector is still fragmented and they only use single view from supply chain stakeholder for example contractor or developer perspective and just explore one of stage from supply chain stage, for example green transportation or green purchasing. The study about GSCM in construction sector is important because this study provides a whole understanding about steps that must be done to make this sector more. From explanation above about limited research and implementation of GSCM in construction sector especially in Indonesia, the aim of this study is to get relevant green practices of green design, green purchasing and green transportation as part of GSCM so that the practices can be well implemented in the construction sector.

2. Literature review

2.1. Green supply chain management (GSCM)

Supply Chain is described as the activity to meet consumer needs containing flow and goods transformation started from raw material until accepted by end consumer, and there are flow and money transformation too [7]. Activities in supply chain are looking for raw materials, manufacturing and assembling, storage, list the order and tracking, distribution until accepted by consumer [8], while in construction sector the activities are planning, design and on site production [2]. Supply chain in construction sector is more complicated, diverse and fragmented if compared to another sector because it involves many stakeholders [9]. Green Supply Chain Management (GSCM) is a concept that involves environmental consideration into traditional SCM both in upstream and downstream [10], while Jung [11] described GSCM as a primary effort to integrate environmental requirement with SCM. GSCM is an important organization philosophy which plays a significant role in supporting efficiency and synergy between partner, facilitating environmental performance, minimize waste, cost saving for corporate profits and market share through risk reduction and environmental impact [12].

2.2. GSCM Practices

GSCM practices are practices carried out by companies to minimize adverse environmental impacts associated with the activities they undertake [4]. The environment is affected at every stage of the production process [13] and it is very important for companies to ensure the production process and supply chain implement green practices to minimize environmental impacts [14]. In several previous studies, each GSCM researcher in the construction sector grouped GSCM practices into several sections (see Table 1). In this study, the practices of GSCM that will be discussed are green design, green purchasing and green transportation.

2.2.1. Green design. Green design or better known as eco-design consists of activities designed to minimize the adverse impact on the environment of products and services during their lifetime [14]. The design consists of planning in which the material will be purchased, how to make products from the material and how products that have expired will be discarded [6]. The selection of appropriate materials and components can minimize negative impacts on the environment, such as the use of prefabricated components which can increase the ease of construction as well as reduce waste. In addition, the selection of the right material also influences the demolis stage, namely the amount of material and components that can be recycled increases [15], so that energy and resource consumption, air emissions, water pollution and waste generation can be minimized [16].
2.2.2. **Green purchasing.** Green purchasing aims to ensure that purchased materials and components have environmentally friendly characteristics such as the ability to be reused, the ability to be recycled and the absence of hazardous materials [14]. Green purchasing requires companies to consider aspects of sustainability in the material purchasing process in addition to aspects in traditional purchasing such as cost, quality and reliability [17].

| GSCM Practices       | Balasubramanian and Shukla [4] | Shurab et. al. [5] | Ali et al [6] |
|----------------------|--------------------------------|--------------------|---------------|
| Green Design         | √                               | √                  | √             |
| Green Purchasing     | √                               | √                  |               |
| Green Transportation | √                               |                    | √             |
| Green Construction   | √                               |                    | √             |
| Green Recycling      | √                               |                    |               |
| Green Warehousing    |                                 |                    |               |
| Facilitating Green Practices |                   |                    |               |

2.2.3. **Green transportation.** Green transportation is an activity related to transportation and carried out by the construction sector with the aim of minimizing negative impacts on the environment [18]. According to Ng et. al. [15] 6-8% of carbon produced during the construction process comes from transportation material, therefore it is necessary to apply green practices related to transportation such as transporting material to full trucks and using fuel-efficient vehicles. In addition, the use of technology such as video calls during meetings, the use of public transportation for employees, and choosing the location of employee residence close to the project location can also reduce the adverse effects of transportation activities [18], [19]. Green transportation can save expenses and contribute a lot to the development and economic sustainability.

3. **Research methodology**

The research process started from background explanation, problem formulation and research objectives, then continued to a literature study on GSCM both in construction sector and other sectors to obtain research variables. The research questionnaire was based on research variables to validate activities in green design, green purchasing and green transportation practices that were relevant for construction sector, especially building projects in Indonesia. Respondents in this study were practitioners in construction sector involved in building projects with green construction concept namely Grand Sungkono Lagoon and Grand Shamaya. Questionnaires that had been filled in by respondents were analyzed. Activities in green design, green purchasing and green transportation practices were relevant to the construction sector especially building projects if:

a. Three respondents stated it was relevant.
b. Two out of three respondents stated it was relevant.

4. **Result and discussion**

There were three respondents in this study who were practitioners in building projects with green construction concept. The respondent profiles can be seen in table 2.

| Respondent             | Company  | Working Experience |
|------------------------|----------|--------------------|
| Site Engineer Manager  | Contractor| 5-10 years         |
| Site Operational Manager | Contractor| 5-10 years         |
| Project Director       | Developer| > 15 years         |
Research data were obtained by meeting the respondent one by one to fill out the questionnaire. The questionnaire was filled out immediately so that respondents could ask questions if there were variables in the questionnaire that they did not understand. If the respondent could not fill out the questionnaire at that time, then an appointment would be made. Analysis of the results of the questionnaire was carried out after all the questionnaires had been filled out with the method described in the research methodology chapter.

4.1. Green design

Out of 14 green design practices obtained from literature study, there are only 10 relevant practices to be applied in building projects which can be seen in table 3. The four irrelevant practices are designing a building with less material and energy consumption, consideration of the ease of the demolish stage, consideration of building life cycle and incorporating consumer feedback in the eco-design phase.

Table 3. Green design questionnaire result.

| Green Design Practices | Respondents | Conclusion |
|------------------------|-------------|------------|
| Provision for natural ventilation [4] | ✓ ✓ ✓ | Relevant |
| Provision for natural lighting [4] | ✓ ✓ ✓ | Relevant |
| Integration of photovoltaic panels [4], [5] | ✓ ✓ ✓ | Relevant |
| Consideration for energy efficient lighting system [4], [5] | ✓ ✓ ✓ | Relevant |
| Consideration for energy efficient heating and air conditioning (HVAC) systems [4], [5] | ✓ ✓ ✓ | Relevant |
| Consideration of materials with high recycled content [4], [6], [16] | ✓ ✓ ✓ | Relevant |
| Consideration of materials with low embodied energy [4], [16] | ✓ ✓ ✓ | Relevant |
| Design a building with less material and energy consumption [6], [16] | ✓ - - | Not relevant |
| Provision for the use of prefabricated components [4] | ✓ ✓ ✓ | Relevant |
| Consideration to reduce the use of hazardous materials [4], [6] | ✓ ✓ ✓ | Relevant |
| Consideration of the ease of the demolish stage [16] | - - ✓ | Not relevant |
| Consideration of building life cycle [16] | - - ✓ | Not relevant |
| Provision for waste water recycling [4], [5] | ✓ ✓ ✓ | Relevant |
| Incorporate consumer feedback in the eco-design phase [6] | - - ✓ | Not relevant |

In Gharzeldeen and Beheiry's [20] research on the application of green design in building projects in UEA, there are 15 green design practices in which 5 practices are similar to green design practices in this study namely provision for natural ventilation, integration of photovoltaic panels, consideration for energy efficient heating and air conditioning (HVAC) systems, consideration of materials with high recycled content and provision for waste water recycling. The highest level of implementation is the consideration for energy efficient heating and air conditioning (HVAC) systems by 63.6% and the lowest is the integration of photovoltaic panels by 47.5%. In the study of Zhu et. al. [21] in nine manufacturing industries, the practice of designing products with harmless materials is part of eco design and has the highest level of implementation.
research specifically for the construction sector, the highest implementation is provision for the use of prefabricated components. Inhibiting factors in the application of green design include lack of knowledge about green parameters, lack of trust in recycled materials, high costs, lack of interest from both government and private parties and lack of green material inventory [20].

4.2. Green purchasing

From ten green purchasing practices obtained from the literature study, there are three practices that are not relevant to be applied in the construction sector especially building projects, namely providing design specifications to suppliers that include environmental requirements for purchased items, environmental audit for suppliers’ internal management, and second-tier supplier environmentally friendly practice evaluation. It can be seen in table 4.

| Table 4. Green purchasing questionnaire result. |
|------------------------------------------------|
| Green Purchasing Practices                      | Respondents | Conclusion   |
| Purchasing recycled material [5]                | √            | Relevant     |
| Purchasing non-toxic material [5]               | √            | Relevant     |
| Purchasing eco label material [21]              | √            | Relevant     |
| Requires the adoption of an Environmental Management System (EMS) by suppliers to take part in tenders [5], [6] | √            | Relevant     |
| Requires suppliers to have ISO 14001 certification to be able to participate in tenders [5], [21] | √            | Relevant     |
| Requires the supplier to have prior experience in providing green material to be able to participate in the tender [5] | √            | Relevant     |
| Providing design specification to suppliers that include environmental requirements for purchased item [21] | √            | Not relevant |
| Cooperation with suppliers for environmental objectives [21] | √            | Relevant     |
| Environmental audit for suppliers’ internal management [6], [21] | √            | Not relevant |
| Second-tier supplier environmentally friendly practice evaluation [21] | √            | Not relevant |

There are differences between the results of this study and the results of the study by Zhu et. al. [21], which providing design specifications to suppliers that include environmental requirements for purchased items obtain the highest level of implementation in nine manufacturing industries, whereas in this study the practice is considered irrelevant by respondents. Then for second-tier suppliers the environmentally friendly practice evaluation has the lowest level of implementation where nine manufacturing industries just consider the implementation, whereas in this study the practice is not relevant. The second highest level of implementation is requiring suppliers to have ISO 14001 certification to be able to participate in tenders. According to Murphy and Bendell [22] improving the environmental performance of an organization through the application of green purchasing is more complex compared to other green practices. Several steps were suggested by Murphy and Bendell [22] to overcome these difficulties including the application of EMS by suppliers and working with suppliers to increase awareness of the environment which both practices are presented in this study and...
are considered relevant by respondents. Lack of data on the environment in general is a major obstacle in implementing green purchasing and procurement.

4.3. Green transportation
Out of five green transportation practices taken from literature study, all of them are relevant if applied in the construction sector. It can be seen in table 5 below. In Balasubramanian and Shukla [4] research, the highest implementation was provision of accommodation to employees near project sites. The provision of mess for employees, especially daily workers near the project site, has many benefits for the company, namely workers are not tired in travelling from home to the project so that they can be more productive, workers rarely come late and the company more easily controls the cleanliness and health of workers’ mess. The lowest implementation in the study was the use of video conferencing. This is a bit odd, because in an era with extremely rapid technological developments like today, the use of video conferencing is common and very easy to do, and its implementation does not require a large cost. According to Ali et. al. [6] green transportation can save expenses and contribute a lot to the development and economic sustainability. More importantly, green transportation forces its users to live a healthy lifestyle. With the reduction of pollution to the environment, especially the work environment, the immune system of workers will be better.

Table 5. Green transportation questionnaire result.

| Green Transportation Practices | Respondents | Conclusion |
|--------------------------------|-------------|------------|
| Provision of accommodation to employees near project sites [4] | √ × √ | Relevant |
| Use of video conferencing [1] | √ - √ | Relevant |
| Employees are encouraged to use shared transport and public transport [4] | √ - √ | Relevant |
| Materials are transported in full truckload quantities [4] | √ √ √ | Relevant |
| Materials are transported in fuel efficient vehicles [4] | √ √ √ | Relevant |

5. Conclusion
This study concludes that there are ten green design practices, six green purchasing practices and five green transportation practices that are relevant to be applied in the construction sector in Indonesia. These practices do not only come from the literature on GSCM in the construction sector, but also from the literature on GSCM in the manufacturing sector. Based on the research by Malviya and Kant [23] the manufacturing sector has benefited greatly from the adoption of GSCM, so the construction sector needs to consider participating in implementing GSCM. Further research could develop the detailed measurement scale to complete the measurement tools and then conduct empirical studies in construction projects to validate the practices.

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