

Developing Indicators of Green Initiation and Green Design of Green Supply Chain Management in Construction Industry

Mochamad Agung Wibowo^{1*}, Naniek Utami Handayani², Nur Farida², Asri Nurdiana³

¹Department of Civil Engineering, Faculty of Engineering, Diponegoro University, Indonesia

²Department of Industrial Engineering, Faculty of Engineering, Diponegoro University, Indonesia

³Study Program of Civil Engineering, Vocational School, Diponegoro University, Indonesia

Abstract. Project is a set of interrelated activities and requires skills from different professions, and also project is involved the various of stakeholders in each phase of the Project Life Cycle. Implementation of Green Supply Chain in construction projects meant to bring the concept of eco-friendly in every process from the initiation phase, planning phase, the construction phase, and the operation and maintenance phase. It is necessary to identify indicators of green initiation and green design and how to explain the relationship between the role of initiation by the owner and the design process by a design consultant. This study aims to identify the indicators of green initiation and green design concept as part of Green Supply Chain. The method used for this study is a descriptive research that identifies and develop a framework for implementing green initiation and green design in construction industry that consists of concept, dimensions, elements, and indicators. GSCM in construction projects was determined by 9 indicators in the green initiation phase and 40 indicators in the green design phase. The success of green concept in construction project is very determined from these two phases as the beginning of the process, and the most important parties are the owners and design consultants.

1 Introduction

The construction industry has an impact on the environment in the form of natural resources used and solid waste produced, and they can damage the surrounding environment [1]. The previous research states that the sheer number of solid waste generated by the construction is 20-30% of construction projects in Brazil, and 1-10% in the Netherlands [2]. To anticipate the issues related to environmental impacts, it is necessary to use waste management as part of the construction project management [3].

On the other hand, the employee of construction project should also pay attention to Supply Chain management that is an activity or a network of cooperation related to one another to create and distribute goods or services [4]. In construction project, the proper of supply chain management is very influential on performance improvement project [5]. The construction project is often improvidence (waste) in the form of activities that use resources but do not produce any value [5]. The concept of waste reduction in construction projects is called lean construction. Supply Chain Management (SCM) is closely related to avoid construction waste [5], so SCM can support lean construction on the construction project.

Implementation of Green Supply Chain concept in construction projects need to be studied in order to create a lean construction that is friendly to the environment.

This is evident from the development of the concept of Green Building and Green Construction. In manufacturing, Green Supply Chain Management (GSCM) is defined as a purchase, process, materials management, distribution, and marketing with environmentally friendly, and also reverse logistics [4, 6, 7]. The purpose of the green supply chain is to consider the environmental impact caused by the production process. Implementation of Green Supply Chain in construction projects meant to bring the concept of eco-friendly in every process from the initiation phase, planning phase, the construction phase, and the operation and maintenance phase [8].

Researches related to GSCM in the field of construction projects was adopted from the successful implementation of GSCM in the manufacturing industry. Based on previous studies, the GSCM concept consists of Green Products Design, Green Material Management, Green Manufacturing, Green Distribution and Marketing, and Reverse Logistics [9]. The concept of Green Practices was built by Green Procurement, Green Manufacturing, Green, Distribution, and Green Logistics [10]. GSCM practices into five categories, i.e. intra-organizational environment management, product eco-design, green supplier integration, green customer cooperation, reverse logistics [11]. Meanwhile, in the construction industry research field, the GSCM concept consists of Green building design, Green purchasing, Green transportation, Green construction, and End-of-life

* Corresponding author: agung.wibowo@ft.undip.ac.id

management [5]. The concept of green practices includes green purchase, green production, green logistics, and reuse [12]. On the other hand, regulating the green concepts from the beginning of the construction process is important, because the green concept can be realized if there is a continuity in each project life cycle. That is, the concept of green construction cannot be applied to each phase separately, the green concept is a unit that must be designed from the initiation phase. Every phase in project life cycle is interact with each other [13]. Life cycle of a project includes the following phases: initiation planning and feasibility studies, design and engineering, construction, and operation and maintenance [14].

In the construction industry, the design process cannot be separated by the initiative of the project owner. The design idea of a project is always started by the owner, so every detail of the design must involve an agreement between the owner and the consultant of design. It is necessary to identify indicators of green initiation and green design and how to explain the relationship between the role of initiation by the owner and the design process by a design consultant. This study aims to identify the indicators of green initiation and green design concept as part of Green Supply Chain.

2 Project Life Cycle

Construction projects are some activities that have complex and diverse properties. To overcome difficulties in managing and coordinating, the project is divided into several stages from beginning to end, known as Project Life Cycle (PLC). In general, PLCs consist of several phases: initiation / conceptualization, planning,

implementation, and operation / maintenance [14, 15, 16]. This term is usually modified based on the project area, as presented in Fig. 1. Projects in the construction industry are temporary and follow the life cycle of a particular project. In the traditional management model, all of these stages are less coordinated with each other. This is one reason why the construction industry is much segmented.

The initiation phase involves owner as key stakeholders in the process. The initiation phase needs assessment, data collection, surveys, and feasibility studies. Feasibility studies are taken at the beginning of the construction project to decide whether a project is feasible. In addition, a feasibility study was also conducted to determine alternative possibilities and assist in the development of supporting project documents. The whole process will then be developed as a project proposal [17, 18, 19].

Furthermore, the planning phase will produce project planning documents commonly known as work plans (eg. Detail Engineering Design (DED), Work Breakdown Structure (WBS), Gantt Chart, PERT) and other planning documents (eg. quality / specification, risk management). The construction phase is the execution process which includes execution of plans, project resource management, monitoring, and reporting. In a traditional perspective, the construction phase is the overall focus of the PLC, while greater influence actually comes from the operational and maintenance phases. The operational and maintenance phases can show the success of the project which usually also consists of evaluation and assessment after completion of the project [14, 15, 16].

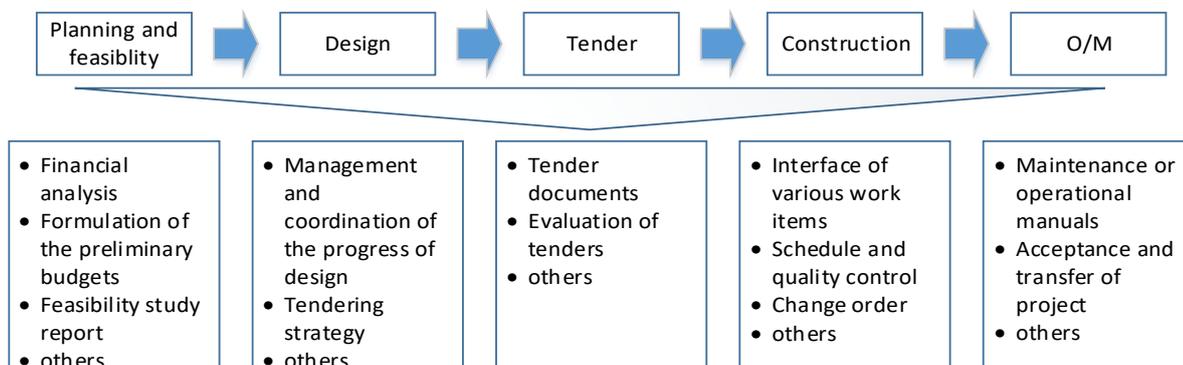


Fig. 1 Project Life Cycle

3 Green Supply Chain Management in Construction

GSCM implementation plays significant roles for manufacturers. Many studies have been conducted to prove the success of GSCM application in the manufacture scope. For example, eco-design has the function of making or repairing products while reducing the environmental impact that the product makes [20]. GSCM is defined as the integration of sustainable practices into upstream and downstream SCM to bring about long-term benefits through the application of responsible environmental and social behaviour among

all supply chain members [9, 21, 22]. One example of how GSCM has been applied in the construction industry is in green construction. Green construction is carried out according to the following guideline. On the premise of ensuring quality, safety and other basic requirements, scientific management and technological progress should be used in engineering construction to maximise the conservation of resources and reduce the construction activities which will bring negative impacts on the environmental, and to improve the goal of four savings (energy, land, water and materials) and environmental protection [23]. Therefore, GSCM implementation in construction practice would be an excellent way of reducing construction waste.

In this study, the framework of Green Supply Chain Management in the construction industry is explained in detail as follow [24].

Green Initiation. Green initiation has been identified as a primary requirement for determining where developers need to design and build sustainable projects that can provide lower energy, save water consumption, and a healthy environment in their projects [25]. Green initiation closely related to project owner commitment. To achieve successful project delivery of sustainable construction project, owner commitment is the most important thing because owners are the decision maker, and the key to making a sustainable project happen in the construction industry [26]. The other factor that must be considering is the feasibility of development project. So that a feasibility study must be conducted in initiation phase. Feasibility study is the assessment for the proposed project that consists of economic assessment, financial assessment, risk assessment, social, and environmental issue. The result from this study will help the project owner to decide whether or not the project is feasible and worth to embodied [27].

Green Design. Green design is the most important phase because decisions made in the design phase will have a significant effect on the lifecycle environment of the project system. Design should become a prime deliberation for identifying any possible effects on the project regarding environmental impacts [28]. The benefit of green design concept is to diminishing the environmental impact caused by construction design and processes. Designing construction projects in environmentally friendly ways is the purpose of green design. Green design consists of two main elements, there are *life cycle analysis* (LCA) and *environmentally conscious design* (ECD). LCA is used to strengthen the construction development so that all environment negative impact from construction activity can be minimized, while ECD is used to design construction activity while protecting the environment. The Building Green US Council state that green design provides savings of up to 30% for energy, 35% for carbon, 30–50% water usage [29]. The parts of green design are sustainable sites choices, design considerations to reduce the use of materials, design considerations to reduce the use of materials, as well as reducing and recycling water [30].

Green Materials Management. Green materials management is about the change of potentially hazardous activities or materials with more environmentally friendly ones. It is consisting of two processes, as follows: green materials procurement and green materials selection. The specification of materials selection that can be processed in green materials management include the materials used in construction, which should be easy to separate, and adaptable or useful in existing processes [9, 24].

Green Construction. Green construction has the aim to optimizing the resources conservation and reducing construction activities that have negative impacts for the environment while achieving the goal of savings in the four resource areas (energy, land, water, and materials). Resource consumption reduction, waste reduction and emissions reduction are the general concepts that are

integrated to establish green construction. There are several barriers to green construction, as follows: additional costs for green construction, lack of awareness, lack of knowledge, and lack of green suppliers [23]. Several approaches have been emerged to reduce these negative features in construction. These approaches are efficient machines, separate use of waste to allow reuse / recycling and fabrication using automation [5].

Green Operation and Maintenance. Green operation and maintenance techniques consist of training, clearance, work application and control to conserve 'green' materials in the project in conforming with environmental needs [14, 31].

4 Research Methodology

The method used of this study was a descriptive research that identifies and develop a framework for implementing green initiation and green design in construction industry that consists of concept, dimensions, elements, and indicators. Data collection method that was used is observation through literature review and also interview with experts from academic, design consultants, project owner and ministry. The coverage topics of literature review that conducted was about waste management, project life cycle, and green supply chain management in construction industry.

Developing Indicators of Green Initiation in Construction Projects. Green initiation has been recognised as a main requirement for determining where developers need to design and build sustainable projects that can provide lower energy, water savings and a healthy environment in their projects [25]. Green initiation is a discussion process between owner and consultant of design about building concepts based on green because many owners do not understand about the severity of construction waste. The indicators of Green Initiation in Construction [26, 27, 32 - 35] as shown on Table 1.

Table 1 The Indicaators of Green Initiation

No	Element	Indicator	Reference
Dimension: <i>Environment Conscious Design</i>			
1	Project owner commitment	Educating project team participants to achieve sustainable construction and building concepts. Provide vision statement on the reason to develop GSCM project. Facilitating the integration of other project participants. Introducing green intention early	26, 32, 33, 34
2	Feasibility study	Perform area, demographic, and neighbourhood	27, 35

		analysis.	
		Perform site review analysis that evaluate the size, topography, amenities, and Governmental impacts.	
		Perform market analysis.	
		Perform financial analysis.	
		Perform valuation analysis of propose development in project that calculated through a discounted cash flow.	

Developing Indicators of Green Design in Construction Projects. Green design is the most important phase because all decisions that made in the design phase will give significant impact to environment life cycle in the project system. Zhang, et al (2011) declare that design must become a primary consideration to identify the environmental effect that may happen to project. Green design concept benefit is reduced the environmental effect from construction design and processes. The purpose of green design is to design a construction project with environmentally friendly ways. Green design consists of two main elements, there are life cycle analysis (LCA) and environmentally conscious design (ECD). LCA is used to strengthen the construction development so that all environment negative impact from construction activity can be minimized, while ECD is used to design construction activity while protecting the environment. The indicators of Green Design in Construction [36 - 59] as shown on Table 2.

Table 2 The Indicators of Green Design

No	Element	Indicator	Reference
Dimension: Design			
1	Design changes	Number of design changes in a project.	36
		Percentage of additional cost due to design changes.	
		Percentage of additional time due to design changes.	
2	Design and detailing complexity	Detailed Engineering Design (DED) give all the needed information completely.	37, 38
		Detailed Engineering Design (DED) content is clear, easy to read, and understood.	
3	Design and	Doing thorough	39, 40

	construction detail errors	review of all design calculation to avoid inadequate design.	
4	Unclear and unsuitable specification	Specification is not use awkward phrases such as "and/or".	41, 42, 43
		Specification is not contain conflict requirements.	
5	Poor communication and coordination	Joint planning between designer and constructor to decrease design inconsistency.	44, 45
6	Prefabricated use	Use component or something which has been built or made offsite and is ready for use.	46
Dimension: Innovation Capability			
7	Resource conservation	Using non-toxic or less toxic materials in design specification.	47, 48, 49
		Consider material durability in design specification.	
8	Design support for waste management implementation	Make coordination design to minimize excess cutting and jointing of materials.	46
		Make design with standard material dimension.	
		Building element and material design easily disassembled.	
9	Appropriate site development	Percentage of basic green area.	46
		Placing sustainable building project within easy access of public facilities.	46, 47
Dimension: Product Safety			
10	Occupational health and safety	There are emergency assembly point in building design.	50, 51
		There are emergency routes and exits in building design.	
		There are access to working spaces for construction, cleaning, maintenance, and	

		repairs in building design.	
11	Indoor health and comfort	Minimum height of ceiling building from the floor.	52
		Air conditioner or fan must be provide if the indoor climate estimation > 28°C.	
		Equipment for humidity maintenance must be provide if the indoor humidity estimation < 40% or > 60%.	
		Percentage total wide of ventilation from the floor wide.	
		The design of nature and artificial lighting do not cause glare and have proper intensity as the purpose.	
Dimension: Environmental Control			
12	Pollution prevention	Minimize the different types of material which reduces the complexity and number of separation processes.	53
		Separate the structure from the cladding to allow for increased adaptability and separation of non-structural deconstruction to structural deconstruction.	
		Use bolted, screwed, and nailed connections instead chemical connections.	
13	Design support for energy efficiency and conservation	Use sun shading or another medium to reduce energy for air conditioning.	46
		Use mirror ducts or light shelves to reduce energy for artificial lighting.	46
		Use solar chimney	

		ventilation, cross ventilation, or another ventilation system for better air circulation	
14	Design support for water conservation	Project design shall include soil analysis and specification appropriate to the geographic region (include landscape planting selection) to maximize water retention.	54
		Design of rain water harvesting system must consider the location, filters, harvesting area, maintenance, and integration with building plumbing.	55, 56
		Make a proper design of grey water system for toilets flushing and irrigation.	55
		Setting water pressure in order to optimize water flow rate of taps and showers.	
15	Material resource and recycle	Use high quality reused materials that encourage the markets for the reclamation of materials.	47, 48
		Avoid composite materials and make inseparable product from the same materials that are then easier to recycle.	
Dimension: Building and Environment Management			
16	Environment collaboration	Conducting joint planning to anticipate and resolve environmental related problems.	57, 58, 59
		Making joint decisions about ways to reduce the environmental impact of construction activities.	

17	Environment assessment (AMDAL)	Availability of AMDAL document	46
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5 Discussion

The application of the GSCM concept in construction requires continuity and relevance to various processes in the project life cycle. In the phase of green initiation and green design, the role of owner and design consultant is the key of the Green concept in construction projects. Green initiation and green design are different phases, so they have different green concept indicators.

In the green initiation phase, the owner plays a very dominant role in determining the application of GSCM. The owner must have the insight and ultimate goal for the Green concept, because without it, this a very small opportunity to apply the green concept. In this phase, the output is the document of Feasibility Study (FS). In the FS document, several feasibility analyses such as technical, costs, investment, and environmental studies are expected to be based on the Green concept.

In the green design phase, consultant of design are the parties most instrumental in determining GSCM's application. In preparation of planning documents or Detail Engineering Design, it is expected to be based on the green concept.

GSCM indicators in both phases can be used as references in drawing up Green concepts from the beginning of the phase in the project life cycle. There are 9 indicators of Green Initiation and 40 indicators of Green Design to support GSCM in construction project.

In the application of GSCM in construction, the owner is the main driver. Phase of green initiation is the initial phase and plays a very vital role because it will be followed by the next phase. The owner becomes the main stakeholder who initiates the philosophy or value that will be applied when the project is built or implemented in the construction. The role of the consultant planner is also a critical point in the selection of design concepts and the selection of materials suitable for the Green concept.

6 Conclusion

Based on the results of the study, the application of GSCM in construction projects was determined by 9 indicators in the green initiation phase and 40 indicators in the green design phase. The success of green concept in construction project is very determined from these two phases as the beginning of the process, and the most important parties are the owners and design consultants. The further research could develop indicators for Green Material Management, Green Construction, and Green Operation and Maintenance which linkage to Green Initiation and Green Design.

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