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*"Accelerating Sustainable Infrastructure Development - Challenges,
Opportunities, and Policy Direction"*

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The Need of Green Construction Supply Chain Management for Delivering Sustainable Construction in Indonesia

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Abstract. One of the most important aspects in delivering sustainable infrastructures is whether the constructors build the infrastructures in a sustainable way. Recent green buildings developments in Indonesia, as examples of the implementation of sustainable infrastructure in Indonesia, has shown the need of more holistic approach in delivering the green building, including the importance of constructors in delivering the green specifications as designed by the owners through the professional designers. The concept of green construction was introduced to the construction practice as a green way to perform construction in the field by the contractors. The concept is considered as an emerging terminology for contractors that still opens various interpretations, but, on the other hand, also invites innovations. Recent innovative approaches implemented by several contractors represented the easy and more doable approaches taken by the contractors in responding the green construction concept. Recent evaluation to the implementation of the green construction found that most of the contractors have already tried to practice what so called green behavior and practices in construction. Yet, the delivery of construction has not been satisfactory to meet all green specifications with some notable weaknesses in producing the construction products efficiently and effectively due to lack of lean construction technologies and green supply chains. The lean construction approach is believed to be the vehicle for contractor to deliver the green specifications. But, without the readiness of the construction supply chain in supporting the lean construction approach, the green value would not be delivered at all. In accordance to this, a three-year research project is being conducted with its major aim to develop the management system of green construction supply chains in Indonesia. This paper discusses the needs of the research, its methodology and roadmap.

Keywords: *green building; green construction; green supply chains; sustainable construction.*

1 Introduction

It is very well accepted that the construction industry is one of the priority sectors to contribute in sustainable development because of the characteristics of the

construction process which make the industry the point of departure for necessary changes. Construction industry produces the built environment and most of the infrastructure facilities that have very long useful lives, whilst the construction process and the related activities consume the most natural resources and generate significant wastes. Moreover, the construction industry contributes to the wealth of a nation. In Indonesia, construction sector contributes about 6% of the GDP and around 5% of national labors depend on this sector (Statistics Indonesia,[1]).

Construction practices with better planning can contribute to the national energy savings. The energy need of the construction sector is estimated to continue to equal the growth of Indonesia's economy, which is in the region of 6%. As Indonesia's electricity is mostly generated by fuels, the global rising price/demand of fuel has made energy into a commodity that is increasingly expensive. Similarly, the construction process has a significant task in the perspectives of increasing water efficiency and minimizing waste. Thus, there is a real need to make changes in construction practices by implementing what so called sustainable construction (Abduh et. al., [2]).

A formal initiative to implement the sustainable construction in Indonesia has been started by the Ministry of Public Works in 2009. There are several challenges for Indonesia in establishing agendas of implementation in sustainable construction, such as the availability of reliable data related to sustainability issues that could be used as baseline for improvement; the availability of information on research activities and products related to sustainability issues; the need to have participations from all stakeholders to conduct initiatives in sustainable construction; strong commitments from all stakeholders to the implementation agenda; and coordination of stakeholders for orchestrated efforts towards effective sustainable construction agenda (Abduh and Wirahadikusumah, [3]).

Based on those challenges the Indonesian construction industry faced, it was suggested the implementation should focus on the following issues (Abduh et. al. [2]):

1. Moving from the already government-adopted weak sustainability approach to more integrated strong sustainability approach. It means that the approach should be more holistic.
2. Improving public awareness in sustainable construction to be the primary driver that could answer other challenges in sustainable construction easier. It means that implementing sustainable construction cannot be done by one party only; all parties related to the construction should contribute.

3. Research and development in construction design process, construction environment quality, re-engineering of development process, construction human resources, standard and code, and construction products. Technologies should be the drivers to the approaches of implementing the sustainable construction.

The Ministry of Public Works had been launched what it is called a draft of Agenda 21 for Sustainable Construction in Indonesia (Goeritno, [4]). This draft agenda was a result of the two-year study conducted by the Ministry and several focused group discussions between the stakeholders of the Indonesian construction industry. The document itself was developed based on the document of the Agenda 21 for Sustainable Construction in Developing Countries by du Plessis [5] with the national conditions in mind. The agenda was derived to achieving the three enablers, i.e., technology, institution, and value system enablers.

The Ministry of Public Works promoted and suggested the draft Agenda 21 for Sustainable Construction in Indonesia be used by other stakeholders as an initial document to be referred in discussions to develop more detailed and implementable agendas. Moreover, the document should also be a reference for developing strategic actions by all stakeholders as they have the same vision on what each party should contribute to the implementation of sustainable construction.

While the government has set an initial and necessary initiatives in implementing sustainable construction in Indonesia, the practitioners has also been beginning to consider sustainable practices, especially in the area of green buildings. It seems that 'green' terminology is more tempting to be used instead of 'sustainable', and buildings are more controllable compared to other types of construction.

du Plessis [6] pointed out that construction companies had to change or even remove current practices that were considered as standard practices in construction in order to implement the sustainable construction principles successfully. There should be a technology leap in construction, reinventing the construction industry, and rethinking of construction products. According to that statement, the constructors play very important roles since most of the transformation will also be happened in the field of construction projects. Moreover, Glavinich [7] mentioned that one of the most important aspects in delivering sustainable infrastructures is whether the constructors build the infrastructures in a sustainable way. Yet, the performance of the constructors depend mostly to the performance its supply chains (suppliers and sub-contractors).

The concept of green construction was introduced to the construction practice as a green way to perform construction in the field by the contractors. The concept is considered as an emerging terminology for contractors that still opens

many interpretations, but, on the other hand, also invites innovations. Recent innovative approaches implemented by several contractors represented the easy and more doable approaches taken by the contractors in responding the green construction concept.

However, recent evaluation to the implementation of the green construction found that most of the contractors have already tried to practice what so called green behavior and practices in construction. Yet, the delivery of construction has not been satisfactory to meet all green specifications with some notable weaknesses in producing the construction products efficiently and effectively due to lack of lean construction technologies and green supply chains. The lean construction approach is believed to be the vehicle for contractor to deliver the green specifications. But, without the readiness of the construction supply chain in supporting the lean construction approach, the green value would not be delivered at all.

2 Recent Development of Green Construction in Indonesia

Some large contractors, as the main subjects in the construction field, had shown their awareness and stewardships to the environment by declaring themselves as green contractors. They have implemented reduce, reuse and recycle (3R) principles, as well as the reducing the use of energy in their construction projects. International certifications for environment management (ISO 14000s) have been their marketing weapons besides the certification of health and safety management from OHSAS nowadays. The practices of reducing the use of papers, catering waste, the use of air conditioning, the use of water and electricity has been their day to day operation in their project sites. Moreover, they tried to introduce their innovations in transportation for project's labors, the use of alternative materials that are environmental friendlier, such as plywood, aluminum, light weight steel, and precast concrete.

Recently, there was a study conducted by the Ministry of Public Works that was aimed to measure the readiness of Indonesian large and medium-size contractors to implement the sustainable construction. In general, they are ready to implement the sustainable construction concept with the average score of 74, out of 100 (Wirahadikusumah and Ario, [8]). However, there are big differences in score of readiness for contractors that are located in Java Island and the ones that are not. The large and medium contractors located in Java are more ready since the demand to implement the sustainable construction is higher from the owner of the projects. This finding is, of course, very encouraging for the implementation of sustainable construction in Indonesia, but it is also shown that only maximum 10% of the registered contractors in Indonesia that are ready, while the rest (90%) are small-size contractors and they would have lower level of readiness.

One of other prominent movements in sustainable construction in Indonesia is the establishment of Green Building Council Indonesia (GBCI) in 2008. This is a not-for-profit and independent organization established by 50 core founders, who were individual professionals and practitioners, and 20 corporate founding members. Those founding persons and organizations are developer, designer, architect, building and facility management, contractor, supplier, architects, mechanical and electrical engineer, interior designer, and landscape. The GBCI is also representing the World Green Building Council (WGBC) in Indonesia. Until now, there are more than 120 corporate members joined this organization, 3 new green building projects and 3 existing building that had received platinum level of certification, and there are more than 16 green building projects that had received design recognitions. The assessment system that is published by the GBCI is called Greenship rating tools which consists of three rating tools: for new buildings, for existing buildings, and for interior spaces (Abduh et. al., [2]).

On the other hand, the government, represented by the Ministry of Environment, has issued a regulation on criterion and requirements for an institution that could publish an assessment system for certifying green buildings in Indonesia. The government, represented by the Ministry of Public Works, has been developing a manual to deliver green projects, a standard of green buildings and green roads in Indonesia as a complementary of the previous regulation, and a rating tool for implementing green construction in the field. In fact, starting year 2012, in the city of Jakarta, as the capital city, green building certification is a mandatory for new as well as existing buildings based on a Governor Decree. Even though the requirement to adopt green building concept in Jakarta is considered mandatory, it is a minimum level of green specifications that are achievable and processed as part of getting building permits for new buildings and operation permits for existing buildings.

Furthermore, what-so-called green contractors in Indonesia already had their own assessment systems to measure the level of greenness of their projects. As an example, P.T. Pembangunan Perumahan (PP), the pioneer of green contractor in Indonesia, has an instrument that is called Green Contractor Assessment Sheet. This sheet is a form-based assessment for measuring the following categories: appropriate site; energy efficiency and conservation; water conservation; site environment management; material sources and cycle; and site health and comfort. Other green contractors have their own systems that are slightly different but most of them have the same principle categories of measurements.

Other movements related to green construction in Indonesia is coming from the universities with their research agendas. Advanced researches in the use of recycle

materials, especially concrete since it is the major construction material in Indonesia, have been done several years ago and this time is the time to realize the benefit of this kind of research to the construction projects. The high volume fly ash (HVFA) concrete, geo-polymer concrete, recycle aggregate concrete, and pervious concrete have been very exciting fields of research areas recently. Some applications have been seen in the construction projects in Indonesia.

3 Improvements Needed

Besides enthusiasm from seeing the recent conditions of Indonesia in implementing sustainable construction, some issues should be addressed as a result of some studies conducted recently on the assessment systems, i.e., green building certification and also green contractor assessment. Those assessment systems are formal products that are available nowadays and could govern most of the practitioners in Indonesia. Even though the government has stepped into the playing field, especially for green building assessment, to influence the direction of initiatives, the practices still heavily focus on the design phase of the building. Whilst, the green contractor assessment tools also have their focuses on the way the contractors practicing their house keeping works on site. Those assessment systems were developed to be implementable easily and then to award the predicate to the assessed parties or projects. They are mostly document-based systems. So, they just become exciting new businesses, and seem to be a monopoly since those assessment systems are the only one available, and the first one to be developed in Indonesia.

While they measure many categories of green buildings and green construction, they are not intended to measure how green operations and processes are during the construction phase. Those assessments systems would be beneficial only to develop green designs as well as greenhouse-keepings and behavior during construction, but they lack of incentives for the contractors to search for innovations of their operations during construction. For some green projects or green buildings, they might get the green design recognitions and are constructed by green contractors, but the contractors should deploy the project acrobatically in order to fulfill the green specifications already recognized. The contractors' acrobat considerably will produce waste all the time during construction. At the end, the green construction projects may not be green anymore, even though they received green certifications afterward.

By analyzing the categories used in the Greenship for new green building, there are only 4.5% of them are related to assessing the operation during construction. The rest categories are related to building design (62.2%) and operation of building (33.3%) (Erviyanto et.al.,[9]). This findings showed the emphasis of this rating tool

more to design and operation of green building compared to construction process of the building itself. Moreover, Abduh and Fauzi [10] studied the process of assessment using Greenship in a real case study of green building project. It was found that the categories related to the operation and process during construction, i.e., material resources and cycle category and building environment management, are hardly to be implemented properly due to unsupportive construction supply chains in Indonesia to the green movements and lack of inspection activities during construction in a document-based assessment system like Greenship. The green contractor assessment sheet lacks of the same issues of the Greenship, since its categories are very comparable to the Greenship's.

Those findings showed an improvement opportunity for the construction practitioners in implementing green construction in Indonesia. The assessment system, even though it is not the most important thing, eventually could give incentives and drivers for changing the practices. Therefore, an improvement of the available assessment systems related to the green construction should be introduced and developed. Abduh and Fauzi [11] proposed three important aspects or components of green construction to be implemented: Green Behaviour and Practices; Green Construction Process; and Green Supply Chains.

In principle, the assessment of green construction should begin with the individual behavior and contractor organization practices. This aspect is called Green Behavior and Practices (GBC). The big challenge for the contractor to implement this aspect is related to how to manage paradigm shift of the individual and changes in the organization to be greener. In the assessment system, this category should measure how well the contractor personnel behave in a green way and how well the contractor organization introduce the green practices as an standard operating procedure.

Other aspect to be considered in delivering green construction is related to the operations or processes of construction itself at the field. This is a production problem. Therefore, the operations or processes of construction at the field should minimize waste and on the other hand should maximize value to be delivered. This aspect is called as Green Construction Processes (GCP). However, this aspect is already known as lean construction principle. In the assessment system, this aspect should be addressed by measuring the waste produced by each operation or process of construction in the field and how good is the achievement to the value defined by the succeeding operations or processes and the final customer.

The last but not the least, there is another aspect that is very important to support two previous aspects of green construction, it is called Green Supply Chains

(GSC). This aspect is important due to construction operation or process need materials as the major input for transformation to the final product of construction. The green materials should be managed by a proper green supply chains. Every member of the construction supply chains should contribute to the achievement of green value defined by the final customer. In the assessment system, therefore, there should be categories to measure the process of procuring green suppliers and how good their performances are.

4 Green Construction Supply Chains Management

Since most of the production factors of a construction project are related to the availability of materials or commodities (about 70% of construction cost), the management of construction supply chains is very important. This is true also for green construction. As stated by Glavinich [7], the performance of the construction depends mostly on the performance of its supply chain; therefore, the green construction supply chains management is very important aspect to be considered in green construction.

The terminology of green supply chains management (GSCM) has been introduced to the supply chains management and green manufacturing for years back. Green et al. [12] defines GSCM as a framework in which innovations in supply chain management and purchasing industry are focused to minimize the environmental issues. Moreover, Purchasing and Supply Agency defines GSCM as a process where the organization satisfies the demand for products, services, works, and utilities to achieve value for money in all stages of its life cycle, and benefit not only the organization but also community and economic by minimizing bad impacts to the environment. Therefore, GSCM is related to the efforts to improve environment performance of products and services purchased or delivered by the suppliers (Bowen et al., [13]). By those definitions, GSCM is aimed to identify the benefits, costs, and risks related to the environment performance of products and services. For initial step, an organization tries to adopt ISO 14001 in its supply chains processes; it would recommend the availability of policy to ensure the suppliers' awareness of green practices and responsibility to the environment (Rao, [14]).

Moreover, Sarkis [15] presented components of GSCM as shown in **Figure 1**. It is shown in **Figure 1** that each component of the supply chains with its process should be delivered by always considering the following activities in mind: reducing the use of natural resources and energy; and reducing the waste generated from the processes. The environmental impact from each component of supply chains could be in the form of direct impacts, shared impacts, and indirect impacts to the parties involved in each process of the supply chains.

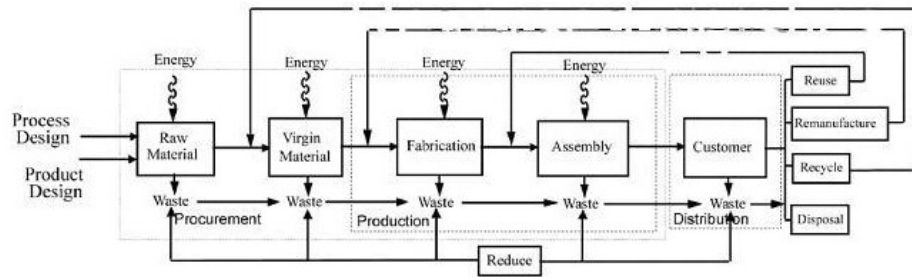


Figure1 Framework of GSCM (Sarkis, [15])

In current practice, Srivastava[16]identified two types of GSCM: the one that uses product-based approach and the other is the one that uses process-based. The product-based approach tries to modify the product purchased and its by-product:e.g., eco-design, reducing the package, reducing the hazard materials, and accepting the return of its product for recycles.On the other hand, the process-based approach relates to the efforts to modify the practices that are usually performed by the suppliers: e.g., policy of organization in reducing environmental impact, the use of additional criteria in selecting the supplier, and requirement for environmental audit.

Some studies related to GSCM have been conducted in recent years and will develop rapidly in near future. Trigos [17] had successfully portrayed the GSCM practices in UK construction industry. In general, in UK there were only small numbers of contractors that had commitment in implementing GSCM due to low interest of the construction industry to any innovations, including GSCM. But, the most important thing that the study revealed was that the demand from the owners in UK was still considered low to the contractors for implementing the GSCM in the projects.However, the potential of GSCM in delivering sustainability and economics to the construction companies is very well understood. Moreover, from the study, it was found that the process-based was the most common approach for implementing GSCM in UK construction industry. Some notable problems faced by UK construction industry in implementing GSCM were lack of human resources, short-term planning, limited access to information and expertise, and low demands from owners and government. Ofori [18] also mentioned the same conclusion for Singapore construction industry with an emphasis in that the GSCM was the key for Singaporean construction industry in delivering green value to the community.

Moreover, it is advisable to consider that in managing the green supply chains its performance is depending on the interaction between its structures and conducts (Martin, [19]). This approach is widely used in managing supply chains of

construction industry in many countries to describe the existing conditions of the structures and members of the supply chains for the purpose of policy development related to managing the supply chains for the construction industry (London, [20]).

5 Need of Research on GCSC in Indonesia

Researches in the area of construction supply chain in Indonesia have been there for years. Wirahadikusumah et. al. [21] studied several high-rise building construction projects in Jakarta and portrayed the construction supply chain patterns, general as well as specific patterns found in those projects. This initial understanding of the characteristics of construction supply chains was then followed by a study on developing their performance indicators. Wirahadikusumah et. al. [21] have also used the performance indicators to obtain general portrayal of the construction supply chains on high-rise building projects. The study found that in general, Indonesian large construction firms have managed their supply chains but mainly for the purpose of getting done with converting raw materials to the finished products. These companies have maintained long-term relationships with major suppliers and subcontractors. The companies use centralized procurement for main materials and distribute them to projects around the country as needed.

Another research by Abduh et al. [22] was aimed at identifying the cost structure of construction project supply chain and the influencing factors. The cost structure or account for construction projects in general was not yet satisfactorily developed. It appears that the firms do not require classifying the level of detail of its cost structure in view of the fact that there is no necessity to maintain job cost information as well as to adequately control the project. In general, it seems that the less competitive environment of Indonesian construction industry would be the biggest major factor that caused the findings. Furthermore, the study also found that the cost of purchasing was very significant in supply chain activity due to merely cost of material purchased. To the contrary, costs of transportation and inventory were trivial. From this finding, it can be concluded that efforts to reduce supply chain cost by reducing costs of inventory and transportation would not be effective. Factors that could influence the cost of supply chain, especially cost of purchasing, therefore are much related to management of supply chain, such as procurement policy, material requirement planning, supplier qualification, selection process, contract, and supplier development.

On the other hand, researches in the area of green construction are emerging (Wirahadikusumah and Abduh [23], Ervianto et al. [9], [24]). In the last 3 years, the researches related to green construction, carbon foot-print calculation for construction projects, optimization of construction processes for reduction of CO₂ emission, and green supply chains have been developed and become a research

agenda of a research group in Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung (Figure 2).

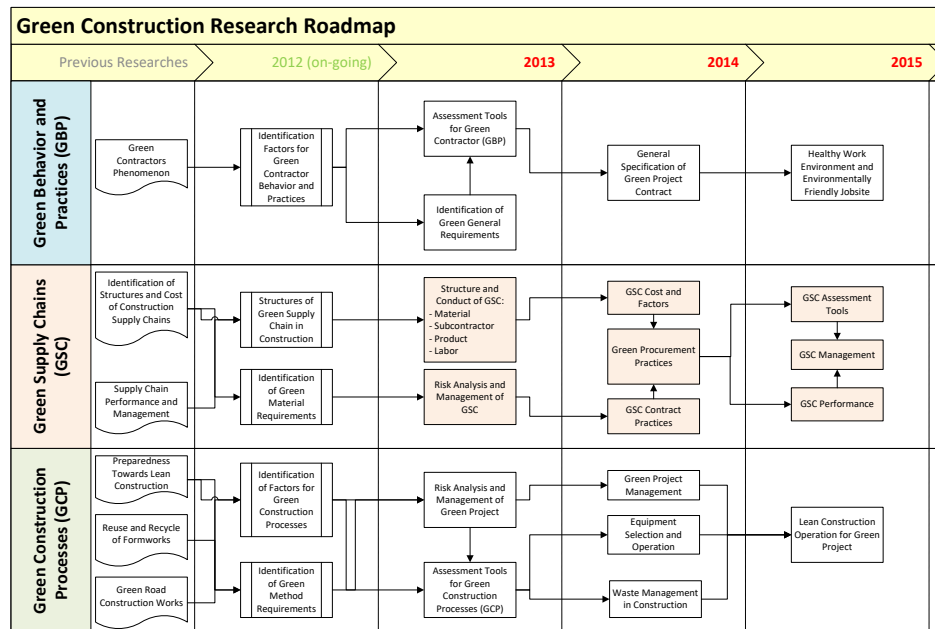


Figure 2 Roadmap of Research on Green Construction

Based on the previous research efforts in construction supply chains and also in green construction, the next research theme would be related to how green supply chains in Indonesia could be managed in order to contribute significantly to sustainable construction. Some issues related to the management of green supply chains in Indonesian construction industry are identified as follow:

1. What is the structure of the existing construction supply chain for commodities that could support the green construction in Indonesia?
2. What kind of interaction that have happened between members of green construction supply chains in Indonesia?
3. How the performance of the green construction supply chains could be measured as the result of the existing condition of the structure and conduct of its supply chains?

Therefore, there is a need for conducting a research with the objective to portray a comprehensive picture of green construction supply chains' structure, conducts, and performance to support the implementation of green construction in Indonesia.

By so doing, the strategies and policies needed to implement green construction, especially the management of green construction supply chains, in Indonesia could be derived from.

6 Research Methodology

Since the research is intended to support the agenda of green construction research, the methodology should be in line with it. Moreover, since there are three questions to be answered, the methodology and topics follow the needed information of green supply chain in Indonesia as depicted in **Figure 3**, i.e., its structure, conduct, and performance.

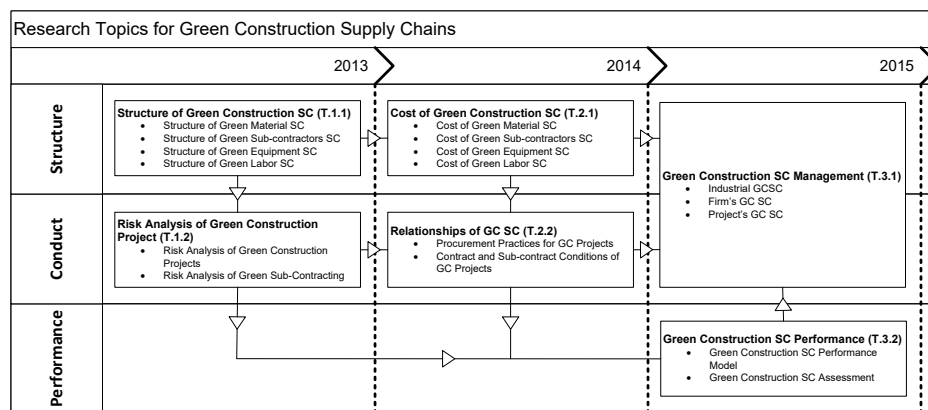


Figure 3 Research Topics in GSCM

However, even though the structure and conduct of supply chain are related to each other, those topics of research are treated as separated to be performed at the same time. Nevertheless, the research topics of performance of green construction supply chain are preceded by those two topics. At the end, the results of all research topics could contribute to the development of government policy in managing the green construction supply chain, and to the development of green construction supply chains management system for contractors in Indonesia.

7 Conclusion

This paper discussed the recent developments of green construction concept in Indonesia that was introduced to the construction practice as a green way to perform construction in the field by the contractors. The concept is considered as an emerging terminology for contractors that still opens various interpretations, but, on the other hand, also invites innovations. Recent innovative approaches implemented by several contractors represented the easy and more doable

approaches taken by the contractors in responding the green construction concept. Based on the evaluation of current practices and products related to green construction, it was concluded that most of the contractors have already practiced only one component of green construction, i.e., green behavior and practices. This is not adequate since there are two other important components to be implemented in order to fully realize the green construction concept, i.e., green construction process and green supply chains.

The green construction process, also known as lean construction, is believed to be the vehicle for contractor to deliver the green specifications. But, without the readiness of the construction supply chain in supporting the lean construction approach, the green value would not be delivered at all. In accordance to this, there is a need to do a research with its major objective to develop the management system of green construction supply chains in Indonesia.

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