

Critical Factors in Supply Management of Industrialised Building System Components for Island Construction Project: A Case Study of Perhentian Island

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Abstract

The importance of construction based on the industrialised building system (IBS) approach in accelerating the achievement of development objectives cannot be denied, including in countries such as Malaysia. In fact, this system has been given a new lease of life in the construction industry development plan lately to strengthen its contribution to the country. The availability of building materials from the mainland of Peninsular Malaysia is a crucial factor for the successful installation of IBS components at construction sites. Therefore, the objective of this study is to identify the critical factors in the supply management of IBS components at the Pulau Perhentian, Terengganu's construction site. In order to achieve the objective of this study, a qualitative study that is a structured interview with sixteen (16) construction contractors, three (3) each from supplier companies and transport ships/vessel or 'barges' that are directly involved in the supply of this IBS components have been carried out. Seven (7) critical factors have been identified which are: 1) compliance with government directives; 2) accuracy of work planning and scheduling; 3) the contractor's current financial position is good; 4) good relationship (tolerance) between contractor and supplier; 5) availability of components; 6) availability of transport ship/vessel or 'barge' and machinery; and 7) able to predict weather conditions. These critical factors can be used as a useful basis in providing a more effective industrialised building system-based project implementation environment in the future on Perhentian Island in particular and other islands in general. The findings of this study have opened up a new research space towards providing a more perfect environment for the implementation of management activities for the supply of IBS components at the construction site.

Keywords: critical factors, components, industrialised building systems, Perhentian Island, Terengganu.

1.0 INTRODUCTION

The Shared Prosperity Vision 2030 is a long-term commitment that aims to make Malaysia continue to develop sustainably. It is in line with fair, equitable and inclusive economic distribution at all levels of income groups, ethnicities, regions and supply chains (Ministry of Economic Affairs, 2019). This commitment will continue towards strengthening political stability and increasing the prosperity of the country. In addition, it aims to ensure that the people are united without prejudice by celebrating the diversity of races and cultures as the basis of the unification of the nation state. To ensure that all these visions, aspirations and commitments can be successfully achieved, once again the construction industry is given a great responsibility. Construction is one of the most important industries because of its ability to provide fixed capital for other industries to thrive in the future. In addition, the construction industry requires the supply of production resources from other industries such as agriculture, production, mining and transportation towards effectiveness in the management of its production chain. In fact, the construction industry is also a major contributor towards creating a more perfect land transport network system such as roads and highways, light and fast mass transit, commuter and monorail; including the preparation of other civil engineering related constructions such as bridges, tunnels and dams. All of them are aimed at the positive development of the economy of a country including Malaysia as a whole. Unfortunately, construction is often labeled as a backward or backward industry because of the 3D syndrome of 'Dirty', 'Dangerous' and 'Difficult' that it suffers from.

This situation will inhibit the great contribution that should be played by the construction industry in a country. In fact, the real potential of the construction industry towards meeting the wishes and aspirations of this government is not able to be highlighted perfectly, especially since conventional operations are still maintained at construction sites. The implementation of construction methods based on industrialised building systems, whether prefabricated components are produced in a manufacturing plant, or produced on a construction site or using a steel, plastic or certain combination of mold systems. It is able to increase the capacity of the construction industry towards providing more effective services to a country. However, the effectiveness of the construction industry's contribution can still be disputed if the implementation of this industrialised building system is not implemented as well as possible. The scope of this study is Perhentian Island, Terengganu which is one of the most famous tourist locations in Malaysia. This study that has been carried out has its own uniqueness because all the components of the prefabricated industrialised building system involved need to be obtained from the mainland of peninsular Malaysia. The components of this industrialised building system refer to the production process of the components produced in the manufacturing plant before they are transferred to the construction site. Any mistake in planning, determining and controlling the supply of components of this industrialised building system will affect the overall performance of the implementation of these construction activities. Therefore, the objective of this paper is to identify the critical factors of the successful management of the supply of industrialised building system components at the construction site. The identification of these critical factors will provide useful guidance to construction industry trustees. It is important towards the effectiveness of the implementation of the industrialised building system, especially in the Malaysian islands.

1.1. Supply Management of Industrialised Building System Components at Construction Site and Tourist Attraction Island

Industrialised building systems based on prefabricated post-beam frames are often used especially in Malaysia (CIDB, 2006; Hanafi et al., 2018). Industrialised building systems in general have shown various advantages compared to conventional construction. The advantages include having better sustainability characteristics. This is because this system is able to reduce activities on construction sites that will reduce environmental pollution, be more systematic and reduce the production of construction material waste. Product quality through the implementation of this approach also becomes higher quality because it is produced in a controlled environment from the effects of the weather and the implementation of the quality management system is better. In fact, the overall construction time is getting shorter. This is because its implementation involves the activities of installation, fixing and integration of prefabricated components at the construction site only. The cost of construction becomes less and less if the same structures are used in the long term due

to the existence of an environment called 'economy of scale'. It can be achieved due to the existence of efficiency in financial management, raw materials and component mold handling, machines and machinery, workforce, including a more efficient supply cycle system. It can be achieved through the repeated production of products that will produce effectiveness, compatibility and efficiency. Various efforts have been made by previous researchers to ensure the effectiveness of management in the factory that is in producing the product, producing effective logistics, creating a more robust project team (Nawi et al., 2012), sustainability (López-Guerrero et al., 2022) in the activities of component assembly-components of the industrialised building system at the construction site (Zairul, 2021; Abdul Razak et al., 2022). At the same time, research efforts were also carried out by previous researchers in the context of stability in order to avoid failure in the connection and load-bearing capacity of the components of this industrialised building system (Yip et al., 2019; Lee and Ma, 2021)

However, the management of the components of this industrialised building system has become increasingly complex, especially involving supply activities using land and water transport systems continuously. This is because the prefabricated components of this industrialised building system are large in size and the load is heavy. Any failure to supply these components has a negative impact on the level of effectiveness of the management of the industrialised building system as a whole. According to previous researchers (such as Abdul Kadir, et al., 2005; Ovararin, 2001; Park, 2002, and Rojas and Aramvareekul, 2003) asserted that factors related to the management of the supply of construction materials greatly affect the performance and productivity of labor at construction sites. In fact, a study carried out by Hanafi et al. (2010) proved that factors related to the supply management of industrialised building system components are the third largest contributors after factors related to the accuracy of work planning and scheduling and the availability of machinery to the performance of labor productivity on construction sites. This situation exists because these components eventually become part of the final product of a building that is built. In fact, the direct effect of the problem of inefficiency in the management of the supply of industrialised building system components at the construction site is that the workers are not able to perform the activities they should be doing. In other words, the workers will be in an idle position while waiting for the components to arrive at the construction site. If this situation happens continuously, it will have a greater negative effect which is the problem of weak motivation. According to Ng et al. (2004), the problem of weak motivation among the workers occurs as a result of the absence of these building materials and it takes a long time to recover.

Tourism is one of the economic activities that can bring income and benefits to the community and the country. Tourism is a field of investment that plays a role in the development of the country. According to the Fourth Edition of the Dewan Bahasa Dictionary (2005), tourism is about traveling and related services. One of the most famous tourist locations in this region is Perhentian Island which is located approximately 10.8 nautical miles or 20km towards the Northeast of Kuala Besut, Terengganu; about 40 miles (64 km) south of the Thai border. It has a cluster of islands with high authenticity including Perhentian Besar, Perhentian Kecil, Pulau Susu Dara and several other small islands around. To get to Perhentian Island, visitors need to take a boat from Kuala Besut Jetty located on the border of Kelantan state. The journey to reach the destination takes about 30 – 45 minutes. The geographical position of Perhentian Island, Terengganu is shown as Figure 1. This island originally did not have a specific name but it acted as a stopover for merchant ships that often went back and forth from China to Southeast Asia such as Singapore, Java and some places in the Malay Peninsula. In addition, this island is also used as a stopping point for salt ships from Singgora (Southern Thailand), to send salt to Kuala Terengganu. As a result of the stopover activities of these cruise ships, this island was later named Perhentian Island which until now is still used as a shelter for ships from strong winds and big waves. The clarity of the water and the panoramic beauty of Perhentian Island in Kuala Besut, Terengganu make it a popular tourist destination for locals and foreigners alike. The diversity of marine life in addition to its convenient location makes this tourist center under the administration of the Besut District Council popular with activities such as snorkeling, boating, camping, sports and watching turtles lay their eggs. This situation directly and indirectly boosts tourism activities in Perhentian Island in particular and the country in general. Therefore, construction is once again the most important industry towards realizing the wishes and aspirations of tourism operators including the state and central governments. Therefore, the management needs to provide a more systematic management platform to prevent this from happening on the construction site. In fact, the

supply of industrialised building system components will become increasingly challenging if it is done on islands. The transport ship or ‘barge’ is used to supply the components of this type of prefabricated industrialised building system from the peninsular mainland (Besut) to Perhentian Island, Terengganu.

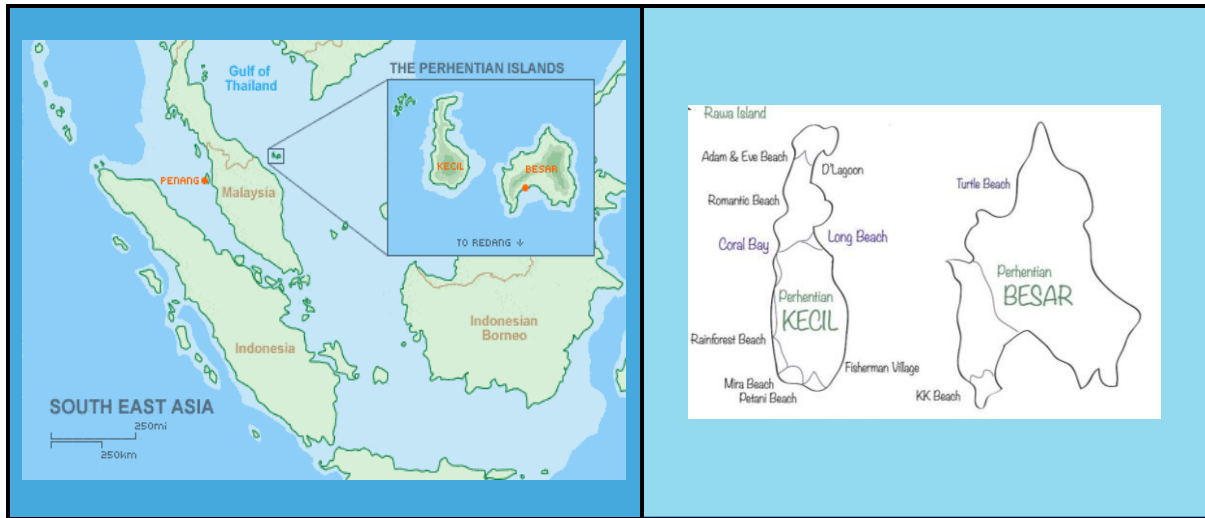


Figure 1. Geographical position of Perhentian Island, Terengganu

2.0 RESEARCH METHODOLOGY

A structured interview method was used with the parties directly involved in the supply operation of industrialised building system components at the construction site. These involved parties include project and construction managers, surveyors, engineers and site supervisors in the contractor's organization. Apart from that, supplier managers and barge transporters were also involved in this study to give their views on the critical factors of the availability of industrialised building system components at the construction site. This qualitative research approach is used because these critical factors have never been studied before. In addition, the parties are the respondents of this study because they are the parties directly involved in the supply activities of the components of this industrialised building system. Specifically, their selection as respondents is based on criteria including: a) directly involved in the supply of industrialised building system components at the construction site; b) have at least a bachelor's degree in a field related to construction; c) have 10 years of experience in the construction industry; and d) cooperate in giving opinions independently. These criteria have actually been adapted from previous studies (such as Hanafi et al., 2017; Abdullah, 1999). It is important that the research carried out is in line with the implementation procedures of previous studies.

In total, a total of twenty-two (22) respondents were involved in this study. They are among the contractor organizations which are sixteen (16) people and three (3) people each from the supplier organization of industrialised building system components and the operator of the transport ship or ‘barge’ as shown in Table 1. The interview session with the respondents of this study was conducted informally to give them the opportunity to recall previous experiences for the use of this study. These interviews are conducted from October 2023 to March 2024 with each session taking 45-75 minutes. Prior to that, an appointment was made 2 weeks before the interview session took place. Research questions on the availability factors of industrialised building system components in general which are manipulated from the abbreviations 4 ‘W’ which are ‘What’, ‘Who’, ‘When’, and ‘Why’ and 1 ‘H’ which is ‘How’ was also sent a short message note through the “WhatsApp” application to the respondents. The main purpose of these general questions sent is to give a comprehensive picture of the purpose and tendency of this study. Only six (6) interview sessions were conducted face-to-face and fourteen (14) were conducted online with the help of google meet and zoom applications. Meanwhile, two (2) respondents are more likely to undergo an interview session with the help of a hand phone call only. This interview session was conducted in Malaysian; in fact, often use the Kelantan accent because they are more friendly in channeling their opinions in the language of the market.

Table 1. Composition of Research Respondent.

Respondent		Total
1) Contractors' Organisation		
a) Project Managers	5	
b) Civil Engineers	4	
c) Quantity Surveyors	4	
d) Site Supervisors	3	16
2) Suppliers		3
3) Transport Operators or 'barge'		3
Grand Total		22

Once the raw data is collected, it is transferred and converted manually as transcription data to facilitate data analysis at the next stage. To ensure the validity of the transcription data, the voice data that has been recorded is observed repeatedly and revised to the notes that have been written. The analysis method used is manual which is 'pattern-matching'. The notes that make up the transcription data are screened, compared, matched, and combined with each other to see the shape or tendency of the facts that stand out. Then, match the facts to give an idea of the strength of the attributes involved. These attributes refer to the critical factors of the availability of industrialised building system components on the construction site. So, the factors that are often emphasized by the respondents with various backgrounds will be produced from this manual analysis procedure. Please refer to Figure 2.

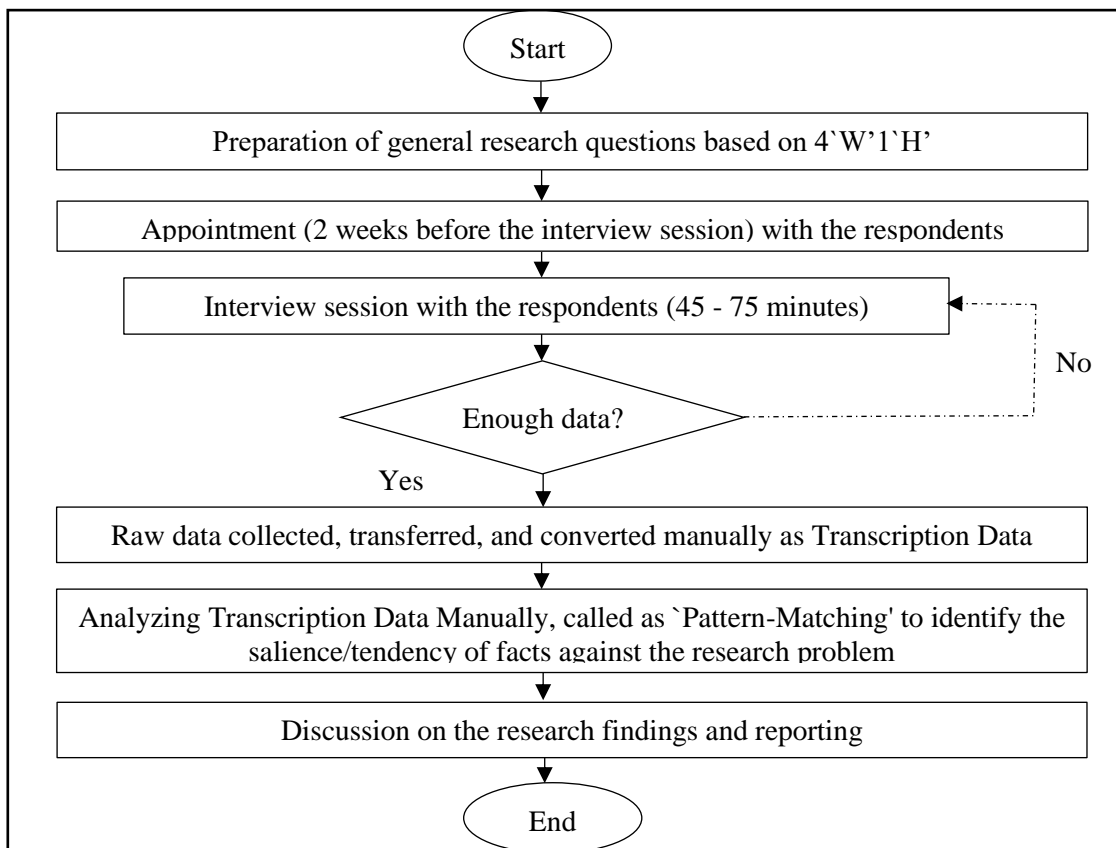


Figure 2. Research Methodology Chart.

3.0 FINDINGS AND DISCUSSIONS

Various factors of the supply management of industrialised building system components at the construction site have been successfully identified through this research approach. In conclusion, all the factors that have been presented by the respondents of the study can be categorized into three (3) main parts which are factors related to the organization of contractors, suppliers and the external environment. After experiencing the process of screening, comparison, matching, and combining one factor with other factors presented by the study respondents; then the critical factors of the supply management of industrialised building system components at the construction site are as follows: -

- 1) Compliance with government directives (*frequency value (fv) = 0.95/1.00*);
- 2) Accuracy of work planning and scheduling (*fv = 0.86/1.00*);
- 3) Good current financial position of the contractor (*fv = 0.82/1.00*);
- 4) Good relationship (tolerance) between contractor and supplier (*fv = 0.73/1.00*);
- 5) Availability of components (*fv = 0.64/1.00*);
- 6) Availability of transporter/vessel or 'barge' and machinery (*fv = 0.55/1.00*); and
- 7) Able to predict weather conditions (*fv = 0.50/1.00*)

3.1. Compliance with Government Directives (*fv = 0.95/1.00*)

This factor of compliance with government directives is noted as an increasingly critical factor now that Perhentian Island, Terengganu has been gazetted as a Marine Park Island based on the Fisheries Act 1985 (Act 137) (Ministry of Housing and Local Government, 2012). Various rules must be followed by the trustees of the construction project involved because it has been listed in an area that protects and conserves various habitats and aquatic marine life. It is not a surprise because Perhentian Island is rich in various types of coral reefs, where loggerhead turtles and turtles lay their eggs, including the existence of swallow species that make nests in the caves around Teluk Baru Tabir and Guaya Buaya. In fact, the route to carry the components of this industrialised building system using a transport ship/vessel or 'barge' is perfectly observed by the authorities involved towards the effectiveness of compliance with the act.

3.2. Accuracy of Work Planning and Scheduling (*fv = 0.86/1.00*)

Work planning and scheduling in the contractor organization category was also listed as a critical factor in the availability of prefabricated components at the construction site. At the initial stage, the management should determine the requirements of the components of the industrialised building system that are effective and perfect at the construction site. The installation of these components is usually done based on the combination approach of column, beam and floor components in a specific 'bay' sequence. 'Bay' refers to a number of grid lines that form a complete structure if the installation is done to the three types of prefabricated components, namely columns, beams and floors. All the components of the industrialised building system that are required which follow the order of these requirements are important to ensure their availability before the installation operation is carried out on the construction site. Any mistake in designing and determining the right type will slow down the installation operation at the location due to the absence of the components of the industrialised building system.

3.3. Good Current Financial Position of the Contractor (*fv = 0.82/1.00*)

The price of industrialised building system components is expensive and the contractors involved usually have to pay it in cash or credit payment in a short period of time before it is supplied by the supplier. In fact, the cost of using a barge service is also high, requiring the contractor to have stability in the context of this financial resource. Building construction and civil engineering construction involves large and heavy structures, involving high costs especially industrialised building systems are used. Stronger financial conditions are required if the implementation is done in the islands; the components of the industrialised building system are obtained from the mainland of peninsular Malaysia such as Perhentian Island, Terengganu.

3.4. Good Relationship (Tolerance) between Contractor and Supplier ($f_v = 0.73/1.00$)

The relationship factor (tolerance) between the two parties, namely the contractor and supplier involved, is also listed in the critical factor of the availability of industrialised building system components at the construction site. This good relationship can be achieved if both parties, the contractor and the supplier, trust and believe each other in carrying out their business affairs. This relationship of mutual trust and confidence can be fostered from relationships that have been established before. When there is a good feeling between them, the implementation of the supply of industrialised building system components becomes easier and more effective.

3.5. Availability of Components ($f_v = 0.64/1.00$)

The availability of industrialised building system components is very sensitive to the use of molds in manufacturing plants. It is usually difficult for manufacturers to produce components of various shapes at one time and supply them to various construction sites. The critical factor of the availability of industrialised building system components at the construction site is very sensitive to the latest status of the required components from the supplier. If the components that are in the manufacturing plant are not needed at a certain time because the contractor is not able to form a complete grid line of the building involved; then if it had to be sent to the construction site on Perhentian Island, it would also result in the smoothness of the installation process being disrupted. Finally, there is a possibility that there will be more resource consumption because the handling of work has to be done repeatedly on the construction site such as the use of cranes, oil and so on.

3.6. Availability of Transporter/Vessel or 'Barge' and Machinery ($f_v = 0.55/1.00$)

Industrialised building systems involve large and heavy components. This kind of work implementation environment requires the use of mobile crane machinery to load these components into the transporter and unload them at the designated place on the island before they are transferred to the construction site involved. The transporter will bring all the components that have been loaded to the location. Any damage or absence of transport ships and crane machinery will have a negative impact on the availability of the components of the industrialised building system that will be installed at the exact location on the building or civil engineering construction involved. The high dependence on the availability of transport vessels and machinery causes this factor to be critical in determining the success of the availability of industrialised building system components on the construction site.

3.7. Able to Predict Weather Conditions ($f_v = 0.50/1.00$)

The link between the mainland of peninsular Malaysia in Kuala Besut and Perhentian Island, Terengganu is the sea which is greatly affected by various weather effects such as strong winds, typhoons, waves and natural laws such as tides and ebbs. In fact, all tourism activities are stopped throughout the monsoon season to avoid the dangers of being exposed to tourists and local residents. In an effort to deliver prefabricated components on Perhentian Island, the driver of the transporter needs to pay close attention to the daily tides and ebbs. The transporter can reach closer to the shore to deliver the components of the industrialised building system if the current conditions there are high tide. If the carrier reaches the coast of the island in low tide; then it is not able to be closest to the coast which is the location close to where the components of the industrialised building system are transferred. Please refer to Figure 3.

The critical factors of managing the supply of industrialised building system components at the construction site are mostly owned by the contractor's organization, followed by the supplier's organization and the external environment. The contractor needs to plan and schedule the work perfectly, ensure stability in supply and financial management, and always establish a good relationship with the supplier to create high trust between the two parties. At the same time, the supplier also needs to ensure that they are available to supply building construction system components if needed at the construction site; including transport ship/vessel or 'barge' and machinery. Factors related to the external environment such as compliance with

government instructions and the weather cannot be taken lightly in the implementation of building construction and civil engineering activities on Perhentian Island. This is because the contribution of these two factors is very critical towards the success of supplying industrialised building system components effectively on the construction site.

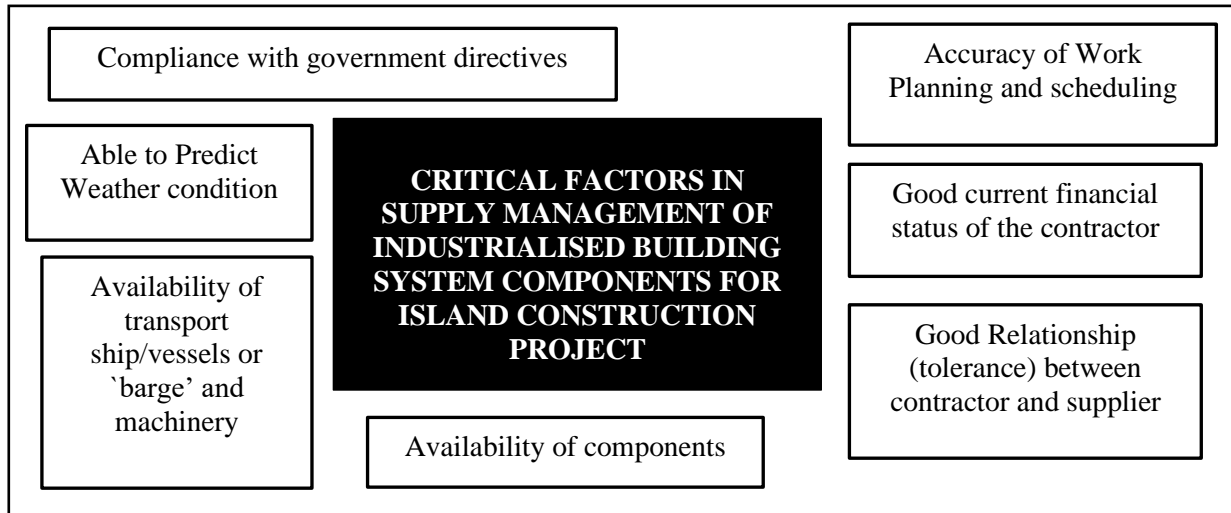


Figure 3. Critical Factors in Supply Management of Industrialised Building System Components for Island Construction Project

4.0 CONCLUSION

Stakeholders related to the implementation of the industrialised building system, especially in Perhentian Island, need to ensure that all the instructions set by the government and the bodies that have been responsible for preserving these sea-related resources are perfectly obeyed. This is the most important factor that needs to be emphasized because failure to comply with it will have a negative impact on the smooth implementation of the industrialised building system as a whole. Failure to comply with all the strict guidelines and procedures will result in warnings, fines and termination of contracts issued by the relevant authorities. If such a situation exists, it will prevent the smooth supply of industrialised building system components at the construction site. Competent contractors, strong financial status and good relationships with suppliers are also factors in the success of the supply of industrialised building system components at the construction site. The implementation of projects in this more complex environment requires the contractor's ability to plan, implement, control and solve various resulting problems effectively. The components of the industrialised building system are large in size and the load is heavy requiring a large capital because in many cases, it has to be paid for before the components are loaded into the lifting vessel/vassal or `barge'. Every inch of the space of the lifting ship/vessel or `barge' that is tied up is very valuable and needs to be manipulated by both parties, namely the contractor and the supplier of the components of the industrialised building system. The good relationship between these two parties is important and it needs to be maintained to ensure the success of the supply of the building system components of this industrialised building. The supplier must ensure that all components are always available when ordered and requested by the contractor involved.

The same thing needs to be emphasized in ensuring the successful supply of the components of the industrialised building system, which is to always ensure the availability of transport ships and machinery at the location. Again, the tolerance relationship between these two parties plays an important role towards the effectiveness of the activities of loading and transporting the components. The weather condition factor is also important to be fine-tuned in carrying out activities that are related to the supply of industrialised building system components at this construction site. Turbulent sea environment especially may occur around the monsoon season for the implementation activities of the supply of the components should be avoided. More careful planning needs to be done by contractors, suppliers and operators of lifting machinery or `barge'. It

aims to avoid delays in the supply of components due to delays and failure to transport them to Perhentian Island as previously stipulated. Therefore, all stakeholders need to join hands and cooperate with each other towards the effectiveness of the implementation of the supply of the necessary components of the industrialised building system. The findings of this study have opened up a wider research space for future researchers to explore and find solutions towards the effectiveness of the implementation of construction operations of the industrialised building system as a whole.

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