Causes of shortage and delay in material supply: a preliminary study

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Abstract. Shortage and delay in materials supply is argued to be one of the most important factors that lead to delay in construction project delivery globally. However, the relevant underlying reasons vary from country to country. As such, this paper summarises the outcomes of a study that targeted identifying causes of shortage and delay in materials supply in Brunei Darussalam. The study was conducted through fifteen semi-structured interviews of contractors and materials suppliers in Brunei. The study identified six causes of shortage of materials and nine causes of delay in materials supply in Brunei. The most important cause for shortage of materials relates to the origin or availability of construction materials. On the other hand, the most influential cause of delay in material supply was found to be poor materials procurement and inventory management system, which has other underlying reasons such as late identification of the type of materials needed. The observations are expected to help in formulating or reviewing relevant policies, in order to ensure on-time project delivery.

1. Introduction
Delays are common in construction projects. For example, Morris and Hough [1] examined more than four thousand construction projects from UK and Europe and observed that projects were rarely completed on schedule time. Similar outcomes were observed in many other countries as well[2-6]. There are many causes for such project delays, of which shortage and delay in materials supply are among the most notable in many studies. For example, Assaf et al. [4] studied the causes of delay in large building projects in Saudi Arabia and identified a group of factors relating to materials, which included causes related to shortages and delivery of materials. Abd Majid and McCaffer [7] observed that late delivery and slow mobilization of materials ranked 1 among 25 factors contributing to causes of non-excusable construction delays in United Kingdom. Koushki and Kartam[8] studied 450 small, medium and large private residential projects in Kuwait and found that nearly one-fourth of the total project delays were due to the late delivery of materials. Similarly, studies in Nigeria, Egypt, Thailand and India [9-12] observed that delay in supply, and/or shortage of, materials caused the project delay. It was also observed in Brunei that shortage and delay of construction materials were the leading causes of project delay [13]. While studies in many other countries attempted to identify the causes of delay or shortage of materials, no such study was previously conducted in Brunei, at least to the knowledge of the authors. As such, the present study was undertaken to identify the causes of delays in supply and shortage of materials in Brunei construction.
2. Research methodology
The study was undertaken in three phases. The first phase was a literature review, to extract the causes of project delays elsewhere (i.e. in other studies or countries) due to delay in supply, and shortage of, materials. This also led to the identification of a number of focus areas on which information for the present study needed to be collected. The second phase was to understand how the construction materials of both local and overseas origin, are sourced, procured and transported to construction sites. This was done by informal discussion with two industry experts. The third phase of the study identified the Brunei-specific causes of delay in supply and shortage of construction materials through face-to-face semi-structured interviews of materials suppliers and contractors. A total of 15 interviews were conducted: ten suppliers and five contractors; only two were contractors’ quantity surveyors and other thirteen were holding managerial position, such as contract manager, operation manager, marketing manager and general manager. Their experience in their ‘current’ positions varied from a minimum of three years to a total of forty years in the construction industry. Construction projects require a variety of materials. Five contractors were interviewed to cover the use all commonly used construction materials. On the other hand, not all suppliers supply all kinds of commonly used construction materials. Therefore, more (i.e. 10) suppliers were interviewed to cover the supply of all commonly used construction materials. Different organisations were approached for interview who import materials from overseas, and either use those materials in their own projects (e.g. by contractors), or supply to constructors (e.g. by suppliers). Data was analysed manually, by comparing opinions from individual interviews, and gradually compiling the causes in to different groups. The study collected a diverse range of information, but the present paper reports the summary of the key outcomes only.

3. Summary of outcomes
The study identified a total of fifteen causes of delay in supply and shortage of materials. Those are summarised in the following subsections.

3.1. Causes of shortage of materials
Six causes of shortage of materials were identified. They are summarised in the following subsections.

3.1.1. Origin or availability of materials. Only very few construction materials are locally available in Brunei, so it relies on imported materials in general. The only available materials locally are: ordinary Portland cement, sand, aggregates, timber, bricks and glass. However, their local supplies cannot wholly meet the demand of the local construction industry. Therefore, these materials, along with other construction materials, are imported to meet the demand, mainly from China, Indonesia and Malaysia. This takes longer time for sourcing, procuring and transporting of the materials. Moreover, land transport is the only delivery method available within Brunei that results in a long lead time for materials. With higher demand of materials, for example during the construction of national housing projects, which involve the construction of hundreds or thousands of houses, local suppliers experience shortages of their stock. Saudi Arabia also experienced project delays due to similar causes during their booming construction industry in 1990s [4, 15]. On the other hand, locally available materials may also encounter shortage in production. For example, one of the Brunei industrial areas had suffered power failure for several days a few years back, resulting in temporary stoppage of cement production and the factory ran out of stock. During the times of higher demand (i.e. increased number of ongoing projects), Brunei also suffers from shortage of bricks at times and contractors need to import bricks from neighbouring provinces of Malaysia. Moreover, local authority limits timber logging to only 17% by the year 2045, although 75% of Brunei is covered with forest [14]. This may cause shortage in timber supply and Brunei may need to import it from neighbouring countries to cater for current needs.
3.1.2. Poor estimation of materials quantity. Poor estimation causes either shortage of supply or oversupply. Shortage of supply disrupts construction progress on site, as reordering can cause prolonged delay and additional costs, especially if the material needs to be imported from overseas. Reordering might cause other problems too, such as inconsistency in colour and size tolerance. On the other hand, oversupply incurs additional costs / losses to contractor.

3.1.3. Poor workmanship. This occurs due to lack of care by the contractor while installing the material (e.g. imported fittings and fixtures, and modular parts), resulting in poor finishing and the product (i.e. material) being non-functional. Similar to Brunei, rework of bad quality performance was found to be one of the most significant factors causing project delays in India [16]. However, the problems in Brunei come from contractors’ installers, by not installing the product in the proper way (i.e. according to the instructions of suppliers), as they want to complete the work faster. Some materials need certain techniques to install, but some contractors ignore these and use their own way to complete the job faster. When problems arise, such as cracking or malfunction, an investigation by the supplier then takes place. The outcomes of the investigation decide whether the supplier should replace the materials or the contractor needs to compensate for the losses. In either case, such problems delay the project activities as the investigation process first needs to be done, followed by negotiations (between the contractor and the supplier), and the ordering of new product results in more waiting time.

3.1.4. Quality of material. The quality of materials can delay their usage on site if the materials do not meet the standard or contain defects. The defect can be due to improper handling during packaging, shipment or delivery. This was also observed in a study in Iran [17]. Some materials may have minor defects that can be repaired, but some materials may have major defects that cannot be repaired and therefore cannot be used at all, e.g. broken sanitary appliances. This happened with one of the interviewed companies, when they ordered a manufactured door from Malaysia. The procurement/ordering process was made online, where the items were viewed through the manufacturer’s website, and appeared to be nice products with good quality. However, when the doors arrived on site, they were found to be of poor quality with holes throughout the door panel, possibly due to insects or termites. The interviewed company made a report to the supplier within three days of receiving the doors, with proof of defect, to arrange for compensation. This consumed more time due to the need to wait for the new doors to arrive. If it is already the time to install the door, then there is no choice other than to wait for the next delivery.

3.1.5. Inconsistent demand. Inconsistent demand occurs when the sales of a material or product do not depend on the demand of the local market. Paint is one such material. It is hard to know which colour is saleable, because sometimes clients look for a certain colour of paint that is not in stock at that time. If the quantity/volume required by the client is large and the local distributor is also without stock, the material needs to be imported from overseas, usually from Singapore. The manufacturer starts producing the paint once they receive the order, and it normally takes one month to arrive in Brunei. But by the time the ordered colour is available, some different colour that is unavailable is then demanded by the client. Therefore, the paint of unwanted colours is kept in stock. However, once there is demand, the paint will be sold out quickly and a new order then has to be made. This seems to be a unique problem to Brunei, probably due to smaller volume of its construction industry.

3.1.6. Special materials. An example of such materials is special appliances, fittings and lightings that are used in buildings that have differential needs, e.g. prison, hospital or for diplomatic offices. One of the interviewees is the sole distributor of specialised and sophisticated lighting appliances in Brunei. Therefore, they should ensure the availability of this material to cater the local demand. However, the technology of such appliances change very fast, so they cannot take the risk of keeping a large stock due to the fear that they cannot sell those after a few months. Therefore, they only order the products
when demanded by certain projects. Moreover, this special material/appliance is imported from all over the world, as the factories of these lighting appliances are in places as diverse as Hungary, Holland, China, Thailand and Malaysia. Each factory produces only certain kind of appliances. Therefore, there involves very long lead times. If orders are not placed sufficiently long before by certain projects, delay in supply is likely to occur, which then leads to project delay. In this regard, Seboru [18] observed that the nature of demand for materials is both project specific and client specific.

3.2. Causes of delay in material supply

Nine causes of delay in supply of materials were identified.

3.2.1. Labour productivity. The Brunei construction industry largely relies on overseas labour, mainly from India, Indonesia and Bangladesh. The labourers work in every sphere of construction related activities: materials production, transportation, loading-unloading and on construction sites. Most of them are unskilled, especially when they first come to work in the construction sector. Some time is needed to train them, but even after training, many of them remain less motivated, especially in materials production activities. They seem to be idle for prolonged time, resulting in reduced productivity. The situation worsens after servicing, cleaning and adjusting the machineries; the older the machines, the more episodes of servicing and adjustment, therefore higher frequencies of prolonged idle time. Furthermore, in Brunei, renewable labour work permits are limited up to two years and therefore labourers are usually appointed on two-year contract terms. Many labourers go back to their home country after one or two contracts, but not all of them come back to Brunei. Hence, many new and unskilled labourers are required to make up the shortfall, meaning a continuous need for training and reduced productivity. Similar situation was observed in Saudi Arabia and Turkey [15, 19].

3.2.2. Inclement weather. Inclement weather affect materials supply in two ways: while importing materials from overseas via sea freight, and during delivery to the project site. Shipment via sea freight depends on the weather condition of source country of the materials, as it influences the loading, and of Brunei as it influences unloading. Moreover, it is not safe for ships to sail in the sea during bad weather. As a result, delays are common during monsoon season. On the other hand, Brunei is a tropical country with rain throughout the whole year, and the rain comes with little notice. Rain can prevent the supply of some materials to construction sites. For example, ready-mixed concretesuppliers do not produce concrete during the spells of rains, because the water ingress cannot be controlled. If heavy rain starts when concrete carrying vehicles reach the site, the concrete cannot be placed, because the concrete will have excessive water content, and hence be too workable or too weak (once hardened), or the concrete may even be washed away. As fresh concrete is perishable, there is no turning back once the cement in the concrete has been mixed with water. Such negative impact on schedule from undesired events like rainy weather seems to be common in tropical or semi-tropical countries, e.g. in Malaysia [20] and Sri Lanka [21].

3.2.3. Government restrictions. Certain materials (e.g. timber) need permit approvals from government departments before placing import orders, which may be time-consuming if not planned well in advance. Permit approvals mainly deal with the declaration of type, source, quantity and quality of materials to be ordered. This is to ensure that only certain materials are imported, and exactly the declared type and quantity of materials are imported. The economic planning control policy of the country also prohibits importing cheaper materials and selling the same at higher prices. Therefore, the importing companies have to specify correctly the type of material in order to receive approval of their permits. If the permit is not granted, more time is needed to get a new permit approval, resulting in to delayed delivery of materials to site.
3.2.4. Slow decision-making. Slow decision-making delays the project completion as the contractor waits for confirmation to carry out certain works. Similar observation was made in a study in Kenya: slow decision-making was identified as one of the most important factors for delay [18]. However, this usually happens in Brunei while selecting finishing products and patterns, such as the tiles. An owner can simply decide to change the scope of work in a project and also can dramatically impact project schedules by failing to respond to requests for information or change orders, or making decisions on material selections. Any last moment decision leads to delayed order for materials from overseas and consequently delayed supply/delivery of materials on site. This certainly takes more time, but allows much lower prices than local market. Some materials at local market cost higher, but can make up project time to some extent. However, those materials may not be available in the local market, and if by any chance they are available, may not have sufficient stock, in which case import from overseas is the only option, resulting in to prolonged delay.

3.2.5. Shortage of raw materials. Not all the materials imported from the overseas manufacturers are 100% produced by them. The raw materials (i.e. ingredients or components) of certain materials are sometimes ordered and collected from some other countries. For instance, paint is imported from Singapore, and its manufacturer imports relevant raw materials from other countries. The manufacturers usually maintain a certain amount of storage of the raw materials, but they may also suffer from shortage. If manufacturers receive orders from Brunei when they are experiencing shortage of raw materials, they will have to delay manufacturing of the paint. This will in turn lead to delayed supply of paint to Brunei.

3.2.6. Logistics. There are instances that the quantity of ordered materials/products is insufficient to be placed in a standard shipping container. Such orders are delivered as Loose Cargo Load (LCL), which means that the shipped volume will either be palletized or crated using heat-treated lumber following customs regulations. Local suppliers in Brunei manage such pallets. Once they order some materials, they send those pallets to the forwarder, who then sends the order to Brunei through Singapore (or the source country). Thus, the travelling time for the shipment from source country to Brunei doubles, plus the packaging time. So, the overall time taken would be, for example, roughly about ten days, assuming that the manufacturer has the stock. If the manufacturer is out of stock, more time is taken. This problem of logistics can be of particular relevance to Brunei, as it is a relatively small country with a population of 411,900 [14], and notwithstanding its high gross domestic product per capita, it also has a commensurately small construction industry and construction materials supply market.

3.2.7. Poor planning and scheduling. Planning and scheduling (P&S) of activities plays an important role in time management of a project. It is normally done before the construction begins, and should entail sourcing and procuring/ordering (i.e. P&S) of relevant materials. Otherwise, construction delays are likely to befall, along with corresponding impact on cost. It is therefore important to ensure that materials are available on site when they are to be used. In order to achieve that, one of the interviewees suggested ordering materials as early as six months before the actual start of relevant activities. This was due to uncertainty over what could happen when the materials are about to be used. For example, materials may be out of stock or no production in both local and overseas markets (e.g. for lack of supply order from agents or users), or manufacturers may be unable to supply (e.g. due to excess order than their production capacity), hence demanding a search for alternate sources, and the need to procure materials usually with higher prices. The interviewee recalled that they experienced a shortage of rebar supply from China during the Beijing Olympic 2008 construction works. China, which is usually the cheapest supplier, was unable to export rebar due to their internal high demand at that time. Early P&S of rebar would have spotted the low chance of getting sufficient supplies in time, and allowed procuring rebar from other neighbouring countries. Although this would have come with a slightly higher price, this could have saved them from delays that came with higher financial consequences. However, some materials cannot be ordered too early, e.g. cement, as
they need to be used within days or a few weeks. Early order of such materials would make them unduly aged after delivery and therefore unusable, requiring a new order for the same materials, with additional cost and possible delays. Therefore, P&S of materials has to be both project and materials-specific [18], while appreciating their availability both in local and overseas sources, trends of market demands, and continuously monitoring alternate sources. Any deviation to such practice, i.e. poor P&S of materials, may delay their delivery and thereby lead to project delay and incur extra cost. P&S is seen as an important issue not only in Brunei, but also in many other countries, including India [12] and Malaysia [20].

3.2.8. Unrealistic construction duration. The duration of construction project is normally set by clients or their representatives, which refers to the work programme of the project. The contractor has to follow the set time in order to prevent any penalty due to time overruns. While taking into account of such project duration, the contractor should ensure during tendering that all materials are ordered in good time and that they can be readily available when needed to be used. However, occasionally some projects are set with unrealistically short duration, due to the urgent cases such as the preparation for international meeting, or to meet any emergency situations. Contractors have to face those challenges, by exploring sources for urgent supply of materials and ensuring their installations / construction, by some special arrangements, and certainly with higher costs, since such projects must not be delayed.

3.2.9. Variations and changes. Variation orders and changes to tendered scope of works are common to construction projects in many countries, e.g. in India [12], Iran [17], Kenya [18] and Malaysia [20]. In Brunei, they emerge due to a range of reasons, including missing information, changes in client decisions, inability to build as specified, changes to the design, unforeseen conditions, or procurement issues in sourcing a required product. Whatever the reason is, changes have impact on materials. The change may be an addition to any existing item of work that will require previously ordered / used materials, or a new work that will require different materials, new orders may need to be placed in any case. However, if the materials are not available in local market, or available stock is limited, they have to be imported from overseas. This will lead to delays in materials supply and eventually project execution. Many interviewees mentioned this issue, which may be considered as indicative of the severity of the problem.

4. Concluding observations
The reported study attempted to identify the causes of delays in supply and shortage of materials in Brunei construction industry. The semi-structured interview-based study identified a total of fifteen causes. Lack of locally available materials, that compels import from overseas, seems to be at the core of shortage of materials. On the other hand, inability to timely procure and maintain a suitable inventory system seems to be the most important cause of delay in materials supply. This is due to the late identification of what materials to be required, which in turn originates from change orders and very late changes in decisions. However, not all the causes were present in all the projects, but some projects shared only a few causes, while a few causes may be unique. The outcomes are expected to assist policy makers for taking effective measures to improve the timely delivery and available stock of materials at local market. The next step in this study will be to quantify and prioritise the causes of shortage and delay in materials supply, which will further help policy makers to more specific measures for improved supply of materials and timely delivery of construction project in Brunei Darussalam.

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