The Importance of Supply Chain Management for Ready Mixed Concrete Production and Delivery Process

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Abstract. Supply chain management is a concept originated and flourished in the manufacturing industry. Supply chain management is a link of organization network that involves many parties contributing to the development and quality of products or services delivered to the customer. But by having improper implementation of supply chain management can lower the level of the performance in terms of cost, time and quality of the product. This study explores the effectiveness of existing supply chain management process for ready mixed concrete. In this study, the material supply chain management for ready mixed concrete have been reviewed to determine the whole process of the ready mixed concrete production process. Then, the material supply risk that arise within the production of ready mixed concrete and benefits gained through implementation of supply chain management also have been identified in this study. In order to create a successful supply chain management, all parties involved in the supply chain must understand properly the concept of supply chain management, thus this project evaluate the level of understanding regarding the implementation of supply chain management in the production and delivery process of ready mixed concrete among the workers. Finally after identifying all those aspects, a framework have been created to improve the efficiency of supply chain management by coordinating the existing framework. A questionnaire survey was carried out to obtain respondent's opinion concerning the importance of product's quality and dependable suppliers, how their organization ensure the effectiveness of supply chain management practices and benefits gained through the implementation of supply chain management. An interview also was conducted to determine the detail process of the material flow within the supply chain. Analysis and discussion were then being carried out based on the data obtained.

Introduction

The production growth of Ready-Mixed Concrete in Malaysia has been on the increased because the scale of construction in Malaysia has created a demand for a large volume of building materials especially concrete, so it is easy for the contractors to use Ready-Mixed Concrete to speed up the time of construction because it is ready usable product. Therefore, it is important to study existing supply chain management of the Ready-Mixed Concrete to ensure there is no wastage and problem arises within the process of production and transportation of the product to the construction site. The importance of supply chain management sometimes always neglected by certain organization. The organization is not properly implement the supply chain management within the supply chain for the production of their product. A successful supply chain management can give a lot of benefit to an organization if it is properly plan and execute. This research is about studying the importance of supply chain management in the production and delivery process of ready mixed concrete. Then this research also need to identify the flow of the materials and material supply risk of ready mixed concrete within the supply chain before come out with the new or improvise framework to improve the effectiveness of the supply chain management. This research also evaluates the level of understanding of the implementation of supply chain management among the workers. Benefits

gained through the implementation of supply chain management also have been identified in this research.

Previous Studies

Definitions of supply chain management Supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer [1]. In [1], Coordination of the manufacturing, logistics and material management functions within organization also considered as supply chain management It also been stated that supply chain linking each element of the manufacturing and supply process from raw materials through to the end user, encompasses the entire value chain and addresses materials and supply management from extraction of raw materials to its end of useful life [2]. The objective of supply chain management is to build trust, exchanging information on market needs, developing new products, and reducing the supplier base to particular original equipment manufacturer so as to release management resources for developing meaningful, long term relationship [3]. In [3], supply chain is the total chain of exchange from original source of material, through various organizations involved in extracting and processing raw materials, manufacturing, assembling, distributing, and retailing to end customer.

Origin of supply chain management The origin of Supply Chain Management (SCM) are unclear, but its development appears to start along the lines of physical distribution and transport [4]. Supply Chain Management (SCM) concept has been used and originated from manufacturing industry. The application of SCM can be shown in the Just-In Time (JIT) delivery system which is part of the Toyota Production System [5]. The objective of this system is to regulate supplies to Toyota motor factory just in the right-small-amount, just in the right time. In [5], as early 1950, in an address to Japanese industrial leaders, Deming suggested that working with the supplier as a partner in a long-term relationship of loyalty and trust would improve the quality and decrease the cost of production.

Concept of supply chain management Supply Chain Management is very detail because it reviews the entire supply chain, rather than just the next part or level in order to increase transparency and alignment of the supply chain's coordination and configuration, regardless of functional or corporate boundaries [5]. In [5], it also state that there are also other concept of supply chain management. First, there are development issues of supply chain management, including order information transparency, reduction in variability, synchronizing of materials flows, critical resources management and configuration of the supply chain. Second, there are strategies for supply chain management including establishment of stable partnership, modular outsourcing of components, design for suitability for manufacture, flexible manufacturing technologies, evolution of the supply chain with the product life cycle, and information acquisition and sharing. Third, there are level of supply chain management that can be distinguished, including initial partnership (e.g. building good relations with suppliers and distributors), logistic management (e.g. implementing and controlling the flow involving all actors in the chain). Implementing the supply chain concept could be a remedy for low efficiency of constructions enterprises that often suffer from schedule and cost overruns, quality deviations and poor health and safety [6]. The implementation of Supply Chain Management not only can be used on construction only but it can also be apply to manufacturing and delivery process of materials.

Types of issues in SCM It can be shown that supply chain management encompasses planning, manufacturing and operation management necessary to bring a product to the market place, from the sourcing material to the delivery of the completed product. In [3], there are many types of issues arise within the supply chain such as:

Partnership, Alliances and Cooperation Issues. An organization that practicing a good relationship with the customer can affect its success in managing the supply base as well as its performance. A key element of successful supply base management involves downstream integration of customers as well as the management of upstream suppliers. Each entity in the supply chain is a supplier as well as a customer. Supply chain can become unsuccessful without a foundation of effective supply chain organizational relationship, any efforts to manage the flow of information or materials within the supply chain.

Logistic Management. Logistic system encompasses the integration of process, system and organizations that control the movement of goods from the suppliers to a satisfied customer without waste [2]. Logistics means an integrated logistic system includes inventory management, vendor relationship, transportation, distribution, warehousing and delivery services. Merchandise must be replenished quickly and arrived where and when it is needed in smaller lot sizes, especially in a JIT system.

Trust and commitment. The cooperation arises directly from both relationship trust and commitment [7]. There are several aspects of trust in fresh produce supply chain performance such as confidence in preferred trading partner, always keep promises, always honest, good reputation, trust in preferred trading partner, believe information provided, close personal friendship, trading partner always consider best interest [3].

Benefits of supply chain management Supply chain is very important because many organizations progressively find themselves the importance of having effective supply chains or networks to successfully compete in the global market economy [8]. In [8] also stated that the main goal of implementing supply chain management is to achieve greater profitability by adding value and creating efficiencies, thereby increasing customer satisfaction. Key benefit of supply chain management includes increased inventory turnover, increase revenues, SCM cost reduction, product availability decreased order cycle time, responsiveness, economic value added, capital utilization, decreased time to market and reducing logistic costs [3].

Theoretical research framework To develop a framework, there are five consequential steps which support modelling process such as (1) define supply chain model purpose, (2) establish supply chain performance measures, (3) determine product type, (4) define supply chain configuration, and (5) characterize supply chain elements (companies, processes, and flows) [9]. It is expected that this framework will provide the necessary support for modelers to develop a comprehensive Supply Chain model that includes the model goal and metrics. The framework was constructed using entity relationship diagram (ERD). The entity relationship diagram has been widely used in structured analysis and conceptual modelling [14]. In [14], it is also stated that the entity relationship diagram is easy to understand, powerful to model real-world problems and readily translated into a database schema.

SCM in ready mixed concrete production and delivery process The application of Supply Chain Management in the production of ready mix concrete is very vital to ensure the quality of the materials, product, relationship between suppliers and customer's satisfaction. The scheduling of ready mix concrete production and delivery is essentially a problem of material logistics planning, which is a decision process for strategically managing the procurement, movement and storage of raw materials, finished product inventory and the related information flows throughout the organization and its marketing channels in such a way that the current and future profitability is maximized by cost-effective fulfilment of orders [10]. Concrete has its own time to set and harden, due to this problem, the batching and delivery of the ready mix concrete is a classic example of Just-In-Time construction system [11].

Supply chain risk management Supply chain risk management can be defined as the ability of a firm to understand and manage its economic, environmental, and social risks in the supply chain which could be materialized by the adoption of contingency planning and having resilient and agile supply chains [12]. In [12], the ability to react to an unexpected disruption and maintain operations after the event also can be considered as one of the important aspect in supply chain risk management.

Material flow risk. Material flow involves the physical movement within the supply chain. The physical movement include the transportation of goods, delivery movement, storage and inventories. There are many risks and disruptions involves in the process of material flow such as transportation incapability, halted manufacturing, lack of capacity, inability to access inventories and so on. All types risk based on [12].

Source Sourcing involves the acquisition of physical products or services. This sub-topic will cover single sourcing risk, supplier selection, and supply product monitoring/quality.

1. Single sourcing: A minor fire accident in Philips' clean room in March 2000 caused Ericsson a major loss of USD400 million. Philips Electronics N.V. is a Dutch firm in Albuquerque, New Mexico, USA that supplies 40% of their production to Ericsson and Nokia. Ericsson's failure, however, was not because of not being responsive, but was mainly due to their single sourcing strategy. Unlike Nokia, who quickly turned to alternative suppliers in the USA and Japan, Ericsson had no substitute supplier. Hence it is important to have backup suppliers because it very efficient when it comes to uncertainty situation where the main supplier cannot supply the raw materials due to certain problem.
2. Supplier selection: The supplier selection process requires many aspects to be considered. Those aspects that must to be considered during the selection process are supplier reliability, country risk, transport reliability and supplier's suppliers' reliability. Sometimes by choosing the right supplier can lower the manufacturing costs and provides better responsiveness to many situations thus it increase the variety of choices and concerns during supplier selection process.
3. Supply product monitoring/quality: The process to produce the product has limited producer's control over the process and decisions, especially if the supply chain network is extended. The incapability of supplier to produce according to the standard demanded leads to poor quality of product. This kind of incapability occurs due to limited skills and technology can be overcome when time and resources are invested in developing the required standard.

Make The major issues in this sub-topic involves three types of issues. Those issues are product and process design risk, production capacity risk, and operational disruption. Hence it is very important to determine all types of the risk, thus mitigation measure can be taken to encounter the problem.

1. Product and process design risk: The inability to adapt to product and process changes have urges the organization actively involves its key supplier at an early stage of the new product development process. Due to investing large sum of capital spent in positioning products on the market, it is important to involve supplier and customers at the early stage of the product development process to obtain higher quality of product. A well designated product and process flow will help an organization to mitigate risks which arise between production and suppliers.
2. Production capacity risk: Identifying resource capacity is very important. Technological capacity and skills. Technological risk can be encounter with early supplier involvement. It is important to have an experience or expertise with the technology; hence the organization may have better information about where the technology can be successfully applied. By having the experience, the organization may absorb the risk well, so it would not affect the whole of the supply chain.

3. Operational disruption: Based on previous study, operational disruption can be categorized into three main sources which are operational contingencies, natural disasters, and political instability. Based on February 1997 there was a fire a parts factory owned by Japanese manufacturer Aisin Seiki Co. Ltd., a key supplier for Toyota, the auto giant was forced to temporarily shut down production at most of its Japanese plants [13]. Companies can resolve the disruptions in material flow by building inventory, or by having backup suppliers because it is unlikely that all suppliers would be disrupted at the same time [13]. Disruption that affect the material flows are unpredictable and rare but often quite damaging.

Delay Delay in material flow always occurs when a supplier cannot respond to changes in demand. Other factor that caused delays are poor-quality output at supplier plant, high levels of handling or inspection during border crossing and changing transportation modes during shipping [13].

Methodology

There are two types of methods to gather information for this project which are by interviewing and doing questionnaire survey. An interview was conducted with certain respondent that involve in the production and delivery of ready mixed concrete in order to obtain all the data needed for this project. A questionnaire survey was also performed to obtain feedback about the importance of supply chain management in the production and delivery of ready mixed concrete.

Interview Data were collected by interviewing the maintenance engineer at ready mixed concrete batching plant. A set of questions were designed as a tool to gather opinions and responses from the maintenance engineer about the current problems and aspects related to the supply chain management. The questions were organized under broad headings including background information, supplier relationship, inventory, transportation, information and customer relationship. It was a face-to-face interview session and site visit to observe the material supply chain management. Semi-structured interviews allow the interviewer freedom to explore the expert's views or opinions.

Survey The survey method was adopted to identify the importance of supply chain management for ready mixed concrete production and delivery process. A set of questionnaire were distributed to the target respondents that were involved in the production and delivery of ready mixed concrete. Then the analysis of the data was performed by using questionnaire result analysis method. The questionnaire survey focused on the importance of supply chain management in the production and delivery of ready mixed concrete. It was designed objectively to evaluate the level of understanding regarding the implementation of supply chain management among the workers and the benefits gained through the implementation of supply chain management. The data collected from the questionnaire survey was analyzed using frequency analysis and "Relative Indices" (RI) technique. RI was calculated using the following formula [3]:

$$\mathrm{RI} = \Sigma \frac{(1n_1+2n_2+3n_3+4n_4+5n_5)}{5\,(n_1+n_2+n_3+n_4+n_5)}$$

where: n_x = the number of respondent agreeing with the "x" choice

The computation of RI using this formula yields the value of RI ranging from point two to one, where point two represents minimum strength and one the maximum strength. The table below shows the categories for RI ranges

Table 1: Categories for RI

RI Range	Category
0.20 – 0.35	Very Low
0.36 – 0.51	Low
0.52 – 0.67	Neutral
0.68 – 0.83	High
0.84 – 1.00	Very High

Data Analysis

This part analyses the questionnaire survey and interpret the data obtain from the interview session. For the questionnaire survey, the collected data were analyzed by using frequency analysis and relativity index. While for the interview method, the data obtain verbally from the executive plant manager were recorded in this chapter.

Survey Results The survey data was analyzed by using Frequency Analysis and Relative Index to determine the level of importance of each question given. 10 respondents were selected to answer the questionnaires. The results from the questionnaire are presented in the following sub-section.

Section B: The importance of product's quality and dependable suppliers. This section determined the relation of product's quality and dependable suppliers with SCM based on the respondent's opinion. Table 2 shows the Frequency Analysis (FA) and Relativity Index (RI) for the importance of product's quality and dependable suppliers.

Table 2: Frequency Analysis (FA) and Relativity Index (RI) for the importance of product's quality and dependable suppliers

Questions	Totally Disagree	Disagree	Neutral	Agree	Totally Agree	Total	RI	Category
Q1. Your organization rely on few dependable suppliers	0	0	3	5	2	10	0.78	High
Q2. Your organization rely on few high quality suppliers	0	0	1	5	4	10	0.86	Very High
Q3. Your organization consider quality as number one criterion in selecting suppliers	0	0	0	6	4	10	0.88	Very High
Q4. Your organization strive to create long term relationship with its suppliers	0	0	0	7	3	10	0.86	Very High
Q5. Your organization helps its supplier to improve their product quality	0	0	0	7	3	10	0.86	Very High
Q6. Your organization has continuous improvement programs that include its key suppliers	0	0	0	7	3	10	0.86	Very High
Q7. Development of trust among partners, with suppliers taking full responsibility for the quality of their product, leading to the elimination of inspection of supplied product.	0	0	2	4	1	10	0.78	High
Q8. Your organization actively involves its key suppliers in new product development processes	0	0	2	4	4	10	0.84	Very High
Q9. Your organization certifies its suppliers for quality	0	0	0	8	2	10	0.84	Very High
Q10. Your organization regularly solve problems jointly with its suppliers	0	0	3	4	3	10	0.80	High

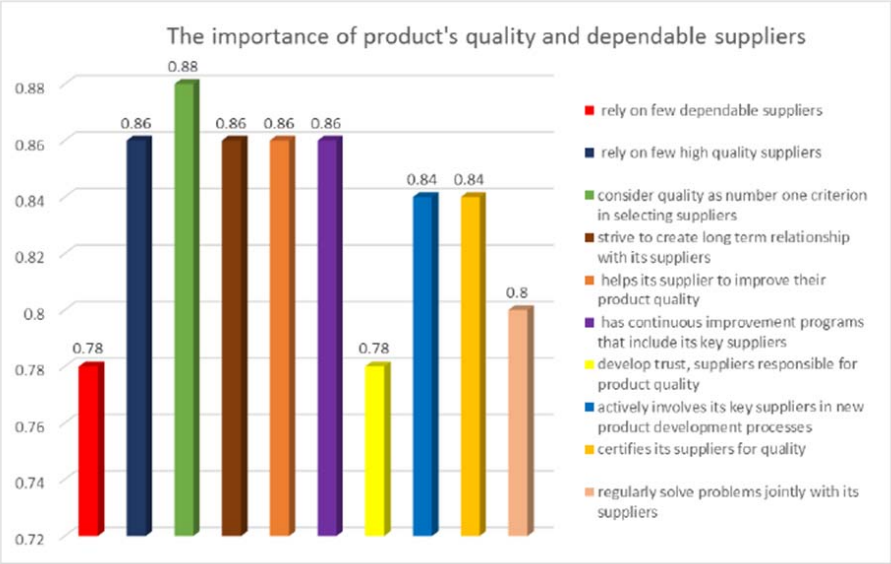

Figure 1: RI for the importance of product's quality and dependable suppliers

Section C: How your organization manage the effectiveness of supply chain management practices.

Table 3: Frequency Analysis (FA) and Relativity Index (RI) on how the organization manage the effectiveness of supply chain management practices

Questions	Totally Disagree	Disagree	Neutral	Agree	Totally Agree	Total	RI	Category
Q1. Your organization has continuous quality improvement program	0	0	0	2	8	10	0.96	Very High
Q2. Your organization produces only what has been ordered by customers	0	0	0	0	10	10	1	Very High
Q3. Your organization pushes suppliers for shorter lead times	0	0	0	7	3	10	0.86	Very High
Q4. Your company organized properly ordering, receiving and other paper work from its suppliers	0	0	0	9	1	10	0.82	High
Q5. Your organization's products are stored at appropriate distribution points close to customer in the supply chain	0	0	0	7	3	10	0.86	Very High
Q6. Your organization frequently interacts with customers to sets its reliability, responsiveness and other standards	0	0	0	4	6	10	0.92	Very High
Q7. Your organization has frequent follow-up with its customers for quality	0	0	0	3	7	10	0.94	Very high
Q8. Your organization strive to reduce time wastage in operations	0	0	0	1	9	10	0.98	Very High
Q9. Your organization frequently evaluates the formal and informal complaints of its customer	0	0	1	4	5	10	0.88	Very High
Q10. Your organizations periodically evaluates the importance of its relationship with its customer	0	1	2	2	5	10	0.82	High

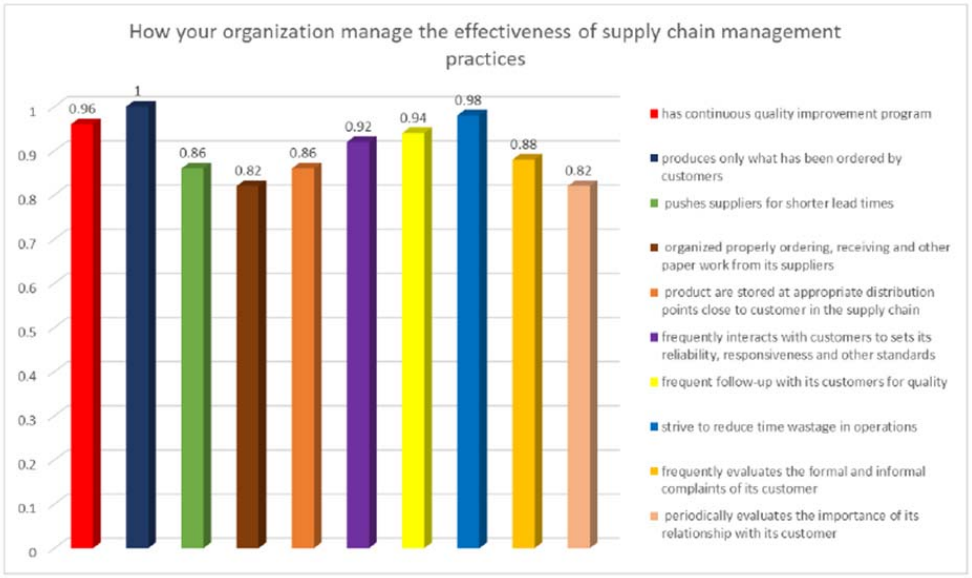

Figure 2 : RI on how the organization ensures the effectiveness of supply chain management practices

Benefits gained through the implementation of Supply Chain Management (SCM).

Table 4: Frequency Analysis (FA) and Relativity Index (RI) for the benefits gained through the implementation of supply chain management

Questions	Totally Disagree	Disagree	Neutral	Agree	Totally Agree	Total	RI	Category
Q1. SCM can reduce the cost of operation	0	0	0	2	8	10	0.96	Very high
Q2. SCM can reduce the inventory level	0	0	0	7	3	10	0.86	Very High
Q3. SCM can reduce lead time of the production process	0	0	2	5	3	10	0.82	High
Q4. SCM can increased the quality of the product	0	0	0	3	7	10	0.94	Very High
Q5. SCM can improve customer service	0	0	0	7	3	10	0.86	Very High
Q6. SCM can increase the delivery speed of the product to the site	0	0	0	2	8	10	0.96	Very High
Q7. SCM can increase the efficiencies for the whole production process	0	0	1	1	8	10	0.94	Very High
Q8. Lead to better sequence of process, so increasing production efficiency	0	0	1	6	3	10	0.84	Very High
Q9. SCM can improve quality of supplier's service and commitment	0	0	0	6	4	10	0.88	Very High
Q10. "Just In Time" delivery of materials on site, avoiding the problem of storing and double handling of materials	0	0	1	5	4	10	0.86	Very High

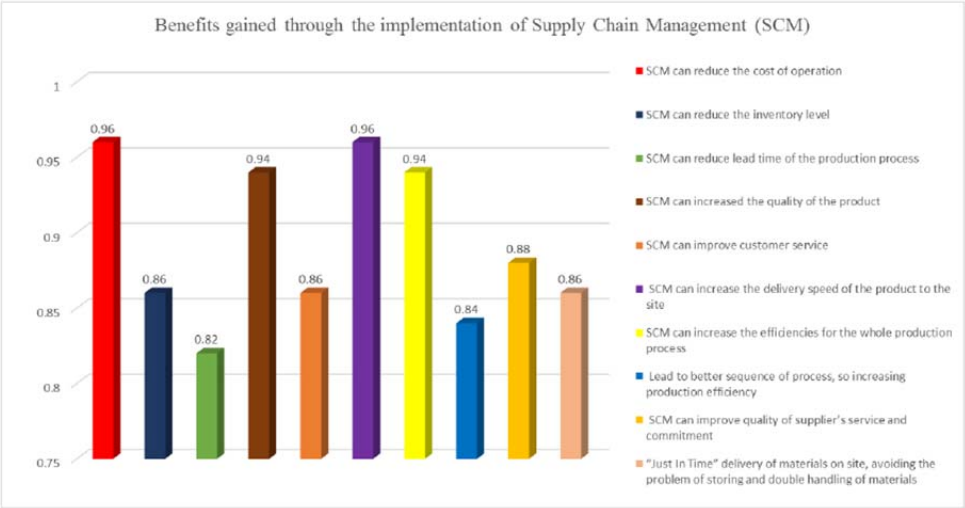

Figure 3: RI of the benefits gained through the implementation of supply chain management (SCM)

Interview Results

Supplier Relationship. Based on the interview, the number of suppliers involves in the supply chain are four. Types of the supplier comprise of aggregate supplier, sand supplier, admixture supplier and cement supplier. Holcim Sdn Bhd practicing one source for one supplier, it is means that every source of raw materials such as aggregate, sand, cement, and admixture only has one supplier for each material. There are also supplier related issues and challenges within the supply chain. Lack of quality and shortage of the quantity of raw materials delivered to the concrete batching plant seems to be the major problem for the manufacturer of the ready mixed concrete. As an example, sometimes the aggregate's supplier deliver the aggregate to the batching but the size of the aggregate sent by the supplier does not meets the criteria given by the manufacturer. The size of the aggregate must be sent by the supplier must be in the range of 5 – 20 mm. For sand, it is important to check moisture content, organic content and silt content to assure that the quality of the sand delivered by the supplier is of high quality because it is possible for the supplier to cheat the manufacturer by giving low quality of sand to them. The manufacturer makes arrangement or orders all raw materials through phones and email. Both methods are considered as the fastest way to deal with the supplier. The information can be transferred effectively and fast. Hence all the raw materials ordered by the manufacturer can be delivered on time and in the right quantity to the concrete batching plant.

Inventory. Every first day of the month there is an inventory check because it is important to make sure that the incoming and outgoing materials tally with the records in the book stock. Loss and gain of the inventory stock are considered as common inventory related issue and challenge faced by the manufacturer. Sometimes the total loss is higher than total gain due to shortage of raw materials delivered by the suppliers. It is important to keep the inventory stock checklist updated gradually to prevent any loss.

Transportation. There are three owned trucks by Holcim Sdn Bhd and another four trucks comes from the third party logistic. Hence the total number of trucks operate at the Senai concrete batching plant are seven units. During the interview, the plant executive manager also explained about the advantages and disadvantages of using owned trucks and third party logistic to deliver the ready mixed concrete to the client. The third party logistic binds by contract with the manufacturer of the ready mixed concrete for a certain period of service. Table 5 shows the advantages and

disadvantages of using owned truck while Table 6 shows the advantages and disadvantages of using third party logistic.

Table 5: Advantage and disadvantage by using owned truck

Advantage	Disadvantage
• Truck is available when required • Cost of idle time caused by inclement weather, work being behind planned programme or delay in deliveries of material will generally be less on owned plant than hired	• High maintenance cost • High operation cost includes fuel, operator and oil

Table 6: Advantage and disadvantage by using third party logistic

Advantage	Disadvantage
• Hire firms are responsible for repairs and replacement • Hire rates can include operator, fuel and oil	• Potential loss of reputation because the firms is responsible for one of the most critical functions of its business. • Loss of direct control because the manufacturer relies on the competency, reliability and honesty of the hired firms and its staff.

The manufacturer also has a logistic department managed by one fleet assistant and one logistic superintendent. The manufacturer also utilized Global Positioning System (GPS) in their trucks, hence it is easy to locate their client's location wherever the trucks travel. The manufacturer also takes the attendance of their truck's drivers in order to make sure the drivers come at work on time. One of the issue related to the transportation is driver issue. Some of the drivers especially from the third party logistic are always having delays in the process of delivering ready mixed concrete to the client.

Information. With the aid of modern technologies, a software can be developed to simplify the supply process. To maintain the raw data such as customer information and record of purchase order, the manufacturer uses SAP Business One Software to manage and record all sort of data. The software organizes the inventory data, monitors and manages delivery of the product information, and creates electronic invoices easily.

Customer Relationship. Most of the customers are from the construction companies that required the ready mixed concrete for the construction process to build concrete structure. By using ready mixed concrete the customers can speed up the process of the construction because they do not have to mix the concrete manually. There are many customers' related issues and challenges within the supply chain such as slump test issue, low cube test strength, and shortage of ready mixed concrete. Sometimes the reading of the slump test of the fresh concrete delivered does not meet the requirement of the customer. Then the manufacturer has to deliver again new ready mixed concrete to the site because the manufacturer provides two hours warranty to the client if there is any defects on the ready mixed concrete. The two hours warranty is given in order to maintain the customer's satisfaction. If the value of the cube strength test after 28 days achieve below the target strength, the

customer has the right to reject the ready mixed concrete that has been delivered to the site and request for the new order. It is important to check the quality of the product before it is approved to be delivered to the customer. Shortage of ready mixed concrete delivered to the customer occurs because of there is no double checking before it is delivered to the customer.

Research Framework. Based on the observation and the information obtained from the plant executive manager, a research framework can be developed to show the process of the ready mixed concrete's material flow. Holcim Sdn. Bhd. practices one source for one supplier only to obtain the raw materials to produce ready mixed concrete such as aggregate, sand, admixture and cement. They did not have any backup supplier if there is any disruption occur at supplier stage. As an example, the supplier cannot supply the raw materials due to certain problem. Thus a new improvised research framework has been developed by adding backup supplier for each raw materials within the supply chain. By doing that, it can reduce the material supply risk. Figure 4 shows the theoretical Research Framework for the production and delivery process of ready mixed concrete.

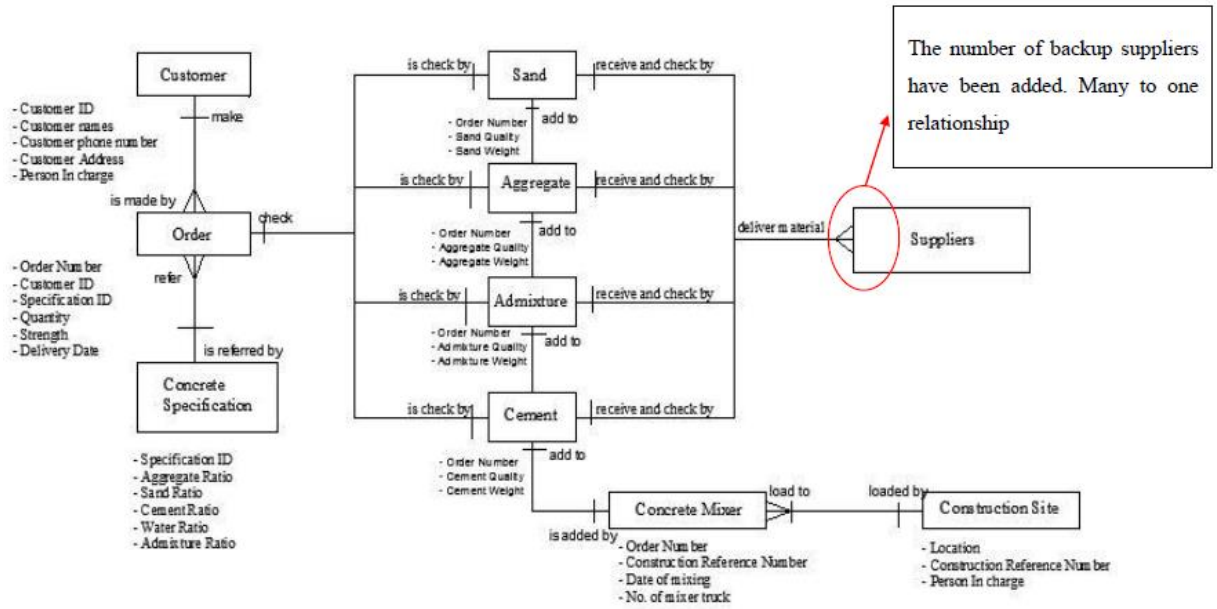

Figure 4: Theoretical Research Framework for the production and delivery process of ready mixed concrete

Conclusion

Based on the questionnaire distribution, interview and result analysis, five objectives of this research have been achieved. Conclusion is made according to the five objectives.

1. To study or review the material supply chain management (SCM) for Ready-Mixed Concrete.

The first objective was to study or review the material supply chain management for ready mixed concrete. The material supply chain management for ready mixed concrete has been studied through, literature review, observation and interview session with the ready mixed concrete plant executive. From the literature review, observation and information obtained from the interview session, material supply chain for ready mixed concrete includes many entities such as supplier, manufacturer and customer. Material supply chain is a process which starts from the extraction of raw materials such as aggregate, sand, cement and admixture to the production of a product called ready mix concrete, then the delivery of the product to the customer.

2. To identify the benefits gained through the implementation of supply chain management in the production and delivery process of ready mixed concrete among the workers.

This project also identified the benefits gained through the implementation of supply chain management in the production and delivery process of ready mixed concrete among the workers. The results from this project show that there are benefits gained through implementation of supply chain management in the production of ready mixed concrete. However, based on the analysis, it is indicated that there two main benefits gained through the implementation of supply chain management. The two main benefits are:

a. SCM can reduce the cost of operation
b. SCM can increase the delivery speed of the product to the site

3. To evaluate the level of understanding regarding the implementation of supply chain management in the production and delivery process of ready mixed concrete among the workers.

This research has also evaluated the level of understanding of supply chain management among the workers. Based on the data analysis from the questionnaire survey, it can be concluded that all the workers have high level of understanding regarding supply chain management because the analysis tables show almost high category for every question given.

4. To identify material supply risk within the production of ready mixed concrete.

Based on the interview that was conducted before, there are many material supply risks that have been identified within the supply chain in terms of supplier relationship, inventory, transportation, and customer relationship. By having material supply risks, it can reduce the effectiveness of supply chain management of the production and delivery process of ready mixed concrete due to uncertain disruptions.

5. To develop a framework to improve the efficiency of supply chain for Ready-Mixed Concrete production.

This objective has been achieved by making an improvement to the existing process. Refer to Figure 4: Theoretical Research Framework for production and delivery process of ready mixed concrete.

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