

CONSTRUCTION MATERIAL SUPPLY CHAIN PROCESS IN THE LOCAL CONSTRUCTION INDUSTRY

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ABSTRACT

Materials require special attention while creating a project plan, since it forms a large portion of the total cost of a construction project. The absence of materials when needed is one of the main causes of loss of productivity in a jobsite. Current materials management practices in the construction industry are performed on fragmented basis with unstructured communication and no clearly established responsibilities between the parties involved. The highly fragmentation is a result of the separation of design and construction, lack of coordination and integration between various functional disciplines, poor communication, etc. All of these are the important factors causing performance-related problems such as delay in material ordering and receiving, low productivity, cost and time overrun, conflict and disputes.

The aim of this research is to develop a framework for the best practice of material supply chain process through the project phases that suits the local construction industry in order to help contractors to have the right materials in the right quantities (at the right place) at the right moment at minimal cost. This will assist contractors to improve their productivity, minimize losses and increase competitiveness. To realize the research aim, a survey questionnaire was used to achieve the following objectives: exploring the current practices of material supply chain process, identifying the important activities that form the material supply chain process, studying the contractor/ supplier relationship, studying the impact of the Israeli closure of the India on the material supply chain process, providing solution to the risks and uncertainties inherent in the construction industry, identifying the most occurred problems facing the contractors through the project phases and finally identifying the key factors that may contribute in integrating the phases of the material supply chain process. Questionnaires were distributed to the contractors of first, second and third class. Some questionnaires were received back and analyzed.

Keyword :- Supply Chain Management (SCM)¹, Construction Supply Chain (CSC)².

1.INTRODUCTION

Supply Chain Management (SCM) deals with the management of materials and information resources across a network of organizations that are involved in the design and the production process. It recognizes the inter-connection between materials and information resources within and across the organization boundaries and seeks systematic improvement in the way these resources are structured and controlled (Trucker and Mohammed, 2001). The objective of supply chain management is to be able to have the right products in the right quantities at the right place at the right moment at minimal cost.

Construction Supply Chain (CSC) is all the construction process, from the demands by the client, conceptual design, construction and maintenance and organizations, which are involved in the construction process, such as owner, designer, general contractors, subcontractors, suppliers, consultants, etc. CSC is not a chain of construction business with business-to-business relationships but a network of multiple organizations and relationships, which includes the flow of information, the flow of material services or products, and the flow of funds between client, designer, contractor and supplier (Xue, et al., 2007).

The focus and attention in this research are given to the materials since it forms a large portion of the total cost of a construction project. In addition, materials are essential for the daily progress of a construction project. The absence of materials when needed is one of the main causes of loss of productivity in a jobsite. Therefore, contractors have to manage their materials efficiently to lower cost in order to remain in business. They should select reputable suppliers, tracking the materials to identify when materials need to be ordered based on the actual usage of materials on site and progress of the work, dealing on site with materials handling, storage, misplacement and handling of materials surplus.

1.1. Statement of Problem

Current materials management practices in the construction industry are performed on fragmented basis with unstructured communication and no clearly established responsibilities between the parties involved. The highly fragmentation is a result of the separation of design and construction, lack of coordination and integration between various functional disciplines, poor communication, etc. Furthermore, dependency of the general contractors on other parties such as suppliers and subcontractors reinforces the construction industry fragmentation. All of these are the important factors causing performance-related problems such as delay in material ordering and receiving, low productivity, cost and time overrun, conflict and disputes.

This research investigates current material management practices and develops Material Supply Chain Process (MSCP) that suits the local construction industry. The investigation considered all the activities starting with the estimating process and ending up with surplus materials at the end of the project. The supplier / contractor relationship was studied. The problems encountering the contractors during MSCP were documented. Furthermore, the investigation included the factors that may contribute in integrating the MSCP.

Still, there are many challenges facing contractors during various phases of the MSCP. During the bidding stage, contractor may decide to reduce the cost in order to win the contract; such decision will affect the subsequent phases of the MSCP. During the sourcing phase, the selection of a reputable supplier is critical for ensuring that materials are delivered in quantities needed at the specified time. During the procurement phase, contractors face many decisions that related to "when to order materials", "when to buy materials" and "how much to buy". During the construction phase, contractors have the challenge to choose the best location for delivering the material. Finally, contractors have to decide how to deal with surplus material at the end of the project at the post-construction phase.

1.2. Research Aim

The aim of this research is to develop a framework for the best practice of material supply chain process through the project phases that suits the local construction industry in order to help contractors to have the right materials in the right quantities (at the right place) at the right moment at minimal cost so they can improve their productivity, minimize losses and increase competitiveness.

1.3. Research Objectives

The aim of this research was realized through the following objectives:

1. To investigate the current practices of the MSCP in the local construction industry
2. To determine the important activities that form the phases of MSCP
3. To study the contractor/supplier relationship
4. To explore the impact of the Israeli closure on the MSCP
5. To provide solution to uncertainties and risks inherent in MSCP
6. To identify the most occurred problems facing contractors in the MSCP through the project phases, to diagnose the root causes of them and to develop possible solutions for them
7. To study key factors that may contribute in integrating the phases of MSCP

1.4. Scope and Limitations

The proposed research will be limited to the following assumptions:

1. The research will focus on contracting companies classified as first class, second class and third class.
2. The focus of this research is on the material supply chain process from the main contractor's perspective, as the questionnaire is addressed only to the construction contractors in the India. Clients and suppliers are not included.

1.5. Significance of the Study

The framework is significant in several ways. First, the framework identifies and describes all phases of the MSCP starting from bidding, sourcing, procurement, construction, post-construction and ending with evaluation. Second, the framework presents solutions to the uncertainties and risk inherent in the MSCP. Third, the framework documents the problems encountering the contractors through the MSCP and providing possible solutions to the most occurred ones. Finally, the framework identifies the factors that contribute in integrate the MSCP.

2. LITERATURE REVIEW

The construction industry in general is highly fragmented with significant negative impacts perceived low productivity, cost and time overruns, conflicts and disputes, and resulting claims and time-consuming litigation. These have been acknowledged as the major causes of performance-related problems facing the industry. The legacy of this high level of fragmentation is that the project delivery process is considered highly inefficient in comparison with other industry sectors (Trucker et al, 2001). The construction industry has numerous problems because of its complicated nature of operation. This industry is comprised of a multitude of occupations, professions and organizations (Milakovich, 1995). They are involved in the different phases of a construction project, which, according to Schultzel and Unruh (1996), include: feasibility, development, finance, concept development and review, estimate, detailed engineering, procurement, construction and start-up. The client, consultants, contractor and sub-contractors of a construction project all have a role to play in delivering a quality project. Failure of any of the parties will seriously affect the quality of the final project. Moreover, the parties have different objectives which keep them apart. Rowlinson and Walker (1995) point out that the construction industry is also characterized by its non-standardization. Production processes are to some extent different from each other. Hence, no universal standard or specification can be applied to the product, which leads to difficulties in quality assurance. Moreover, excessive changes to the details of the design of a project are typical throughout the construction process. They may be the result of the lack of buildability of the design produced or variations by the contractors for the sake of speed and cost of production. Rowlinson and Walker (1995) further added, quality is often at risk because of the excessive changes. As a result of the changes, delays in completion of the construction project and claims by different parties to the project often occur. Hence, the relationship between the parties tends to be confrontational.

2.1. Material Management in Construction

Efficient management of materials plays a key role in the successful completion of a project. The control of materials is a very important and vital subject for every company and should be handled effectively for successful completion of a project. Materials account for a big part of project cost. Some studies concluded that materials account for around 50% -60% of the project cost (Bernold and Treseler, 1991).

Different authors define the concept of materials management in different ways. However, all the researchers point out that materials management is extremely important for a successful project completion. The basic idea behind materials management is that the materials and/or equipment needed, in the quantities needed, meeting the standards of quality specified, are obtained at a reasonable cost and are available when needed on the construction site. The process of materials management should integrate purchasing, expediting, and inventory control. A well managed materials management system can contribute to the cost effectiveness of a project (Perdomo, 2004).

2.2. Construction Supply Chain

Construction is a multi-organization process, which involves owner, designer, contractor supplier, consultant, etc. It is also a multi-stage process, which includes conceptual, design, construction, maintenance, replacement. From this point of view, Construction Supply Chain (CSC) is all the construction process, from the demands by the client, conceptual, design, construction and maintenance and organizations, which are involved in the construction process, such as owner, designer, general contractors, subcontractors, suppliers, consultants, etc. CSC is not a chain of construction business with business-to-business relationships but a network of multiple organizations and relationships, which includes the flow of information, the flow of materials services or products, and the flow of funds between client, designer, contractor and supplier, as shown in figure 2.2 (Xue, et al., 2007).

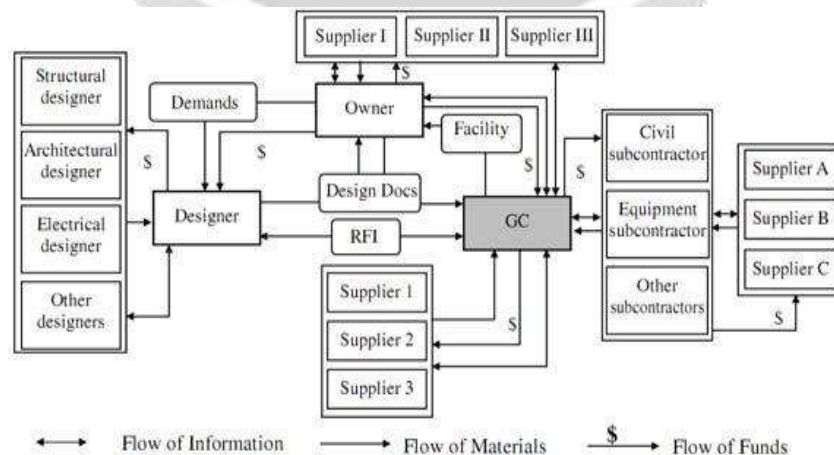


Chart-1 General Structure of Construction Supply Chain

2.4. Material Supply Chain Process

Perdomo (2004) developed a conceptual framework for the Material Supply Chain Process (MSCP). The framework was based on various discussions and interviews with office and site personnel from the electrical contracting industry in Northern Virginia, Southwest Virginia, Tennessee, Maryland and Carolina. From the information acquired from the interviews, five distinct phases that comprise the MSCP were identified which are: 1-Bidding Phase, 2-Sourcing Phase, 3- Materials Procurement, 4-Construction Phase, 5- Post Construction Phase. The following subsections will briefly discuss the five phases.

Bidding Phase: the materials management process starts from the time that the contractor receives the drawings and specifications. The materials takeoff and identification process is the first step in this phase and involves identifying the materials needed as well as any special requirements or special materials to be used in the project manufactured product.

Sourcing Phase: This phase includes the selection of reputable suppliers and manufacturers. The selection of suppliers is critical and the contractor needs to verify that the supplier is capable of delivering the right material (i.e. type, quality and quantity) when needed (i.e. at dates specified).

Material Procurement Phase: this phase includes material requisition and expediting and it is considered very critical to the success of a material management process. The person in charge of procuring materials or the purchasing department, in the case of a large company, needs to ensure that the correct materials in the correct quantities are delivered. This person also needs to verify the release dates at which the material is needed and to clearly specify those delivery dates and the location of delivery to the supplier.

Construction Phase: material delivery usually occurs during the construction phase. Material is generally requested for delivery to the jobsite. In some instances material delivery to the jobsite may not be feasible due to storage or access limitations. In this case, the material is delivered to other locations such as the contractor’s warehouse, a pre-fabrication shop or another subcontractor storage area. Material requisition problems greatly affect the construction stage and failure to manage this phase effectively could result in project disruption and possible delays due to late deliveries, stockouts due to small quantities bought, material delivered to the wrong locations, material backordered and effects in overall costs. The requisition process for miscellaneous material starts in the construction phase and is focused on how much material to buy, when to buy this material, where to deliver this material, when to deliver, which supplier to buy from, where to store on site.

Post-Construction Phase: after installation of the materials on the structure, the contractor has to manage any surplus material. The surplus is handled differently depending on the type of material and also whether or not the contractor has a warehouse. If the company has a warehouse, the surplus material is stored in the warehouse for use in future projects. Other companies return surplus material to the supplier for reimbursement.

2.5. Problems of the Construction Supply Chains

1. Client/design interface: difficulties in finding out client’s wishes, changes of client’s wishes, long procedures to discuss changes,
2. Design/engineering interface: incorrect documents, design changes, extended wait for architect’s approval or design changes,
3. Engineering/purchasing & preparation interface: inaccurate data, engineering drawings not fitting the use,
4. Purchasing & preparation/suppliers interface and purchase & preparation/subcontractors interface: inaccurate data, information needs not met, adversarial bargaining and other changes.

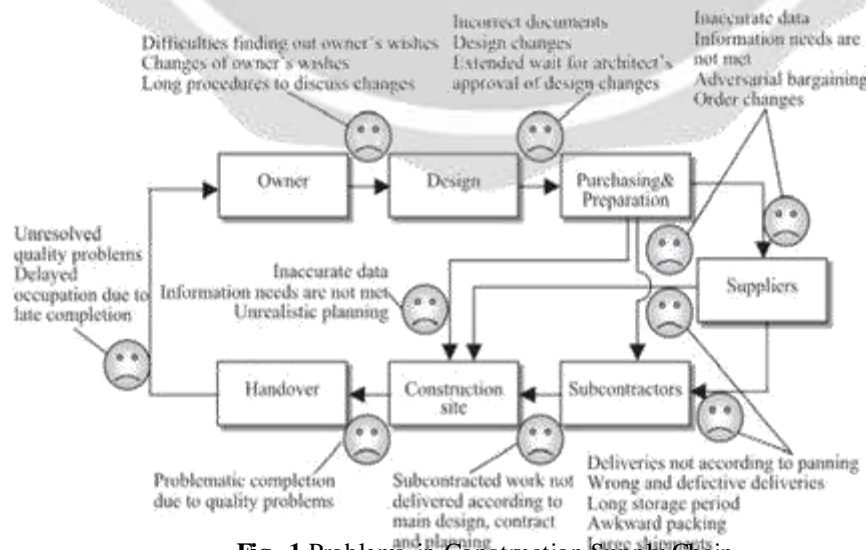


Fig -1 Problems in Construction Supply Chain

Furthermore, Dey (2001) noted that the common issues related to materials management are as follows (cited by Kasim et al, 2005):

1. Receiving materials before they are required, causing more inventory cost and chances of deterioration in quality
2. Not receiving the materials at the time requirement, causing loss of productivity
3. Incorrect materials takeoff from drawings and design documents
4. Subsequent design changes
5. Damage/loss of items
6. Selection of type of contract for specific materials procurement
7. Vendor evaluation criteria;
8. Piling up of inventory and controlling of the same
9. Management of surplus materials

3.METHODOLOGY

This chapter describes the methodology that was used in this research. The adopted methodology to accomplish this study uses the following techniques: review of literature related to construction supply chain management, information about the research design, questionnaire design, pilot study, research population, research sample size, and graphical representation of the material supply chain process, evaluation of the material supply chain process, conclusion and recommendations.

3.1. Research Design

The first phase of the research thesis proposal included identifying and defining the problems, establishing the objectives of the study and developing the research plan. The second phase included a summary of the comprehensive literature review. The third phase included a field survey which was conducted from the viewpoint of contracting companies. The fourth phase focused on the modification of the questionnaire design (pilot study), through distributing the questionnaire to experts

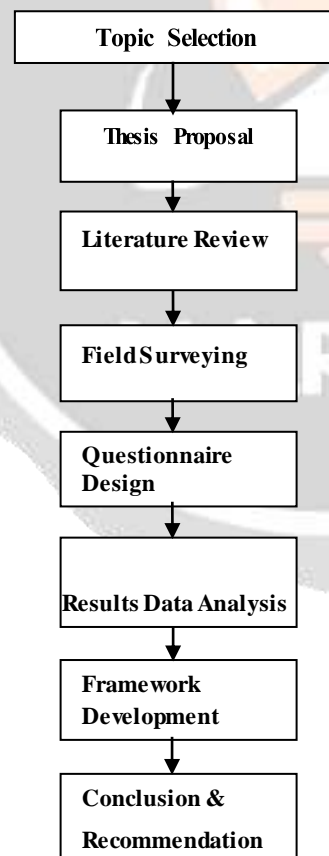


Chart -2 Reaserch Design

4. DATA ANALYSIS AND DISCUSSION

In this chapter, the results of the questionnaires are presented and discussed. The chapter illustrates and discusses the characteristics of the study population, current construction materials supply chain management, the important factors that form the MSCP that are appropriate for the India construction industry, contractor-supplier relationship, the impact of the Israeli closure on the MSCP, some concepts that mitigate the uncertainties and risks in the construction industry, the most occurred problems facing contractors through the MSCP and the factors that may contribute to integrate the phases of the MSCP.

1	Company Establishment Year	
2	Company Specialized Sector	
3	Company Degree of Classifications	
4	Average Number of Employees Within the Last Five Years	
5	Number of Executed Projects within the Last Five Years	
6	Person or Section in Charge of the Material Procurement	

Table -1 Sample Questionnaire Regarding Company Background

4.1. Questionnaire Regarding Bidding Phase (Estimating, Preparation, Submission)

This section contains items that form bidding phase of the MSCP. The respondents were asked about their usage degree for these items and the importance degree from their point of view.

Item No	Material Supply Chain Process
1.1	Identifying the needed materials for each item once you receive the project's drawings and specifications
1.2	Estimating the quantity of the needed materials per each item (quantity take off)
1.3	Defining any special requirements and/or special materials to be used in the project
1.4	Classifying the materials that are off-the-shelf and the major materials that need to be prefabricated
1.5	Identifying the local available materials or locally manufactured materials and the materials that are needed to be imported

Table -2 Sample Questionnaire Regarding Bidding Phase

4.2. Contractor / Supplier Relationship

The relationship of a contractor with his suppliers is critical for the successful of any construction project. This section aims at studying the contractor / supplier relationships. It is divided into two subsections. The first subsection shows the criteria that the contractors adopt to select the suppliers. The second subsection shows the likely or preferred course of action that contractors use when the supplier deliver materials late or deliver materials do not meet the required

4.3. Criteria for Selection the Suppliers

A long-term relationship with the suppliers is one of the fundamental concepts of the construction supply chain management. Such relation should be built on cooperation, trust, fairness, commitment and done in win-win basis for all the parties involved. In this subsection the respondents were given nine criteria and they were requested to rank it in accordance with their concerns to select the suppliers. Table presents the results

Criteria	Percentages	Rank
Competitive pricing- Cost	78.44	1
Reliable delivery	65.33	2
Good Quality	64.22	3
Availability	49.56	4
Flexibility in accommodating contractor's changes/request	38.67	5
Financial facilities	32.89	6
Sign long term agreement/enter into partnership	31.56	7
Personal relationship	25.33	8
Mutual interests	13.33	9

Table -3 Criteria for Selection the Suppliers

5. MATERIAL SUPPLY CHAIN PROCESS FRAMEWORK

The main aim of this framework is to enable contractors to deliver the right materials, in the right quantity, in the right time with minimal cost through controlling the material supply chain through the project phases as an integrated process-oriented approach rather than a series of individual activities or activity – centered approach

The framework is developed based on the study by Perdomo (2004) and other literature review and the findings of the questionnaire. The framework is designed to include all the project's phases which are: bidding phase, sourcing phase, procurement phase, construction phase, post-construction phase and finally the evaluation phase. Each phase contains the process or the steps that contractors should consider, most occurred problems that encounter contractors and the possible solutions for them, the integrating factors of material supply chain process and finally the decisions nodes that may raised in any phase.

5.1 Bidding Phase

This phase includes bid estimate, preparation, submission and winning.

Process

- Identifying the needed materials for each item once the project's drawings and specifications are received
- Estimating the quantity of the needed materials per each item (quantity take off)
- Defining any special requirements and/or special materials to be used in the project
- Classifying the materials that are off-the-shelf and the major materials that need to be prefabricated
- Identifying the local available materials or locally manufactured materials and the materials that are needed to be imported
- Using software packages or computer applications such as Microsoft Excel for preparing the estimate
- Involving the project manager or construction team in the estimation process in order to prepare a realistic estimate
- Estimating the project cost using the prices of suppliers or manufacturers
- Verifying the prices used in the estimate prior to submitting the bid
- Scheduling a meeting that includes the project manager and the construction team to re-estimate the project quantities once you win the bid
- Generating a preliminary material requisition schedule, specifying material types, quantity needed, dates, when the material should be delivered and any additional information needed for clarification

Key Integrating Factors

- The design team should be expanded such that to include contractors, subcontractors and suppliers. This could be done after winning the contract.
- Entering a partnership relationship with clients based on mutual information sharing, trust, openness, and dedication to common goals.
- Understanding the client needs and objectives.
- Establishing a protocol with the owner for dealing effectively with disputes and problems.
- Establishing a system with the owner for communication and share project information in timely and accurate manner

5.2 Sourcing Phase

Pre-qualifying the suppliers and keep lists of the reputable suppliers

Process

- Verifying that the supplier is capable of delivering the right materials (type, quality and quantity) when needed (i.e. at dates specified)
- If materials are provided by specified suppliers; these materials need to be acquired from those suppliers by negotiation
- If there is multiple suppliers, contractors can select the supplier either through bidding or negotiating the prices directly with the supplier
- In case a contractor chooses the bidding process, then quotations should be requested from the pre-qualified suppliers and from suppliers who worked with on previous projects
- Selecting the winner supplier based on lowest price or considering suppliers with higher prices but who will provide better services or who have a record to supply the right materials in the quantities needed at the times specified

Key Integrating Factors

- Entering a partnership relationship with suppliers and subcontractors based on commitment over extended time period, mutual information sharing, trust, openness and dedication to common goals.
- Negotiating contracts with the suppliers and subcontractors rather than using competitive tendering.

5.3 Procurement Phase

Obtaining a copy of the material requisition schedule, specifying material types, quantity needed, dates and when the material should be delivered that was prepared by site personnel.

Process

- Verifying the availability of requested materials stocks before requesting additional materials from the suppliers.
- Requesting a submittal (material sample) from the supplier or manufacturer and approving it by the Engineer prior to materials delivery
- Issuing purchase order to the winner supplier (setting an agreement) in order to organize the relationship between the contractor and the supplier
- Ordering 100% of the estimated items quantities at once or ordering the estimated item quantities as per the work progress on the site. The decisions should be taken by a contractor

- Specifying to the suppliers the release dates at which the material is needed and the exact location of materials delivery to avoid materials re-handling
- Following up the status of the ordered materials to make sure that the delivered materials comply with the specifications, in the quantities needed and within the timeframe specified

Key Integrating Factors

- Aligning the system and procedures of your own company with that of the suppliers
- Establishing a protocol with the suppliers and subcontractors for dealing effectively with disputes and problems that may arise during the course of project implementation
- Establishing a system with the suppliers and subcontractors for communication and share project information in timely and accurate manner.

6.RESULT

The objective of this survey is to validate the developed material supply chain process framework. To achieve this objective, a face-to-face questionnaire survey was conducted to achieve the maximum response. A sample of 10 contractors who are experienced in the related subject were visited and the researcher explained to them the Material Supply Chain Process Framework. Then, a questionnaire has been distributed to them and they were asked to rate the agreement of each issue below on a 5-point Likert Scale using 1 for very weakly agree, 2 for weakly agree, 3 for quite agree, 4 for agree and 5 for strongly agree. The result of the survey presented in Table

Moreover, the respondents were asked to rate the following issues on a scale of 0-100%, the average results of the respondents are given below

- The sufficiency of the framework activities -95%
- The clearness of the framework activities - 94%
- The practicality of the framework activities-94%
- My overall degree of satisfaction with the framework is -95%

Table shows that most of the respondents strongly agree that the activities that form the Material Supply Chain Process Framework will enable contractors to have the right materials in right quantity at the right place at the right time with minimum cost. The results also show that the activities of the framework are sufficient, clear and particle. The responses obtained confirm the validity of the Material Supply Chain Process Framework

No	Issue	Strongly Agree	Agree	Quite Agree	Weakly Agree
1	Promote completing the project as per the specified quality	8	2		
2	Contribute in implementing the project with minimum cost	7	3		
3	Contribute in implementing the project with specified time	8	2		
4	Stimulate the attitude to	10	0		

	optimize the benefits of the other project participants				
5	Promote cooperation between the project participants	10	0		
6	Promote sharing project information and data between the project participants	8	2		

7.

Construction fragmentation and among the project organizational

materials, wrong deliveries and inaccurate information transfer in materials supply chain process, which result in miss performance. Efficient material supply chain process is crucial for the success of any construction project and can be the deciding factor between a successful project and a project full of delays and claims.. The primary aim of this research was to develop a material supply chain process framework that enables contractors to have the materials needed, in the right quantities, with the quality and time required.

Bidding Phase

- Lack of communication between the parties involved o ambiguities between plans and specifications
- Incomplete drawings and details are missing

Sourcing Phase

- Incomplete proposals (Suppliers did not include all the documents with the proposal)

Procurement Phase

- Poor communication between the parties involved o Unavailability of required material
- Incorrect of submittals by the suppliers
- Late approval of submittal by the Supervisor Engineer

Construction Phase

- Late deliveries (Materials do not arrive as scheduled)
- The delivered materials do not comply with the required specifications
- Poor communication between the parties involved

CONCLUSION

industry has been characterized with poor communication and coordination participants. There are many inter-problems, such as late deliveries of

It has been found that most of the problems are caused in another (i.e. earlier) stage of the MSCP other than where they are detected. The root causes of the most occurred problems are found in previous activity executed by a prior actor.

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