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Supply Chain Management of Flyover Construction

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ABSTRACT: Supply Chain Management is a proven concept in the manufacturing industry and has to come along way in the construction industry. In the Indian construction industry, which is still considered sector, Supply chain management can be implemented with considerable improvements in the material flow and overall cost of project. In construction, procurement and procurement related activities occur during all phases of a construction project. Because of inevitable complexity and fragmentations of the construction process, suppliers of resources like equipment, labor, material and other services may not be always available on time, in right amounts and in the desired quality and price. An overall management process like supply chain management is essential to monitor and control all such logistic activities. The aim of this dissertation is to reduce the cost of project by using SCM model. To study the feasibility of this model, a case study has taken from Pune city to achieve this aim. The case study is construction of **flyover at Dhyari, Pune**. In this dissertation, a qualitative analysis has done by direct observation on site and interview with the technical staff of both consultant as well as contractor. The case study assesses the supply chain of the project in detailed, finding the problems in supply chain, highlighting the effect of these problems on supply chain. Finally a proposed supply chain is suggested to the contractor, so that he can save the cost of materials as well as lead time giving benefits and limitations of reduction of suppliers. Recommendations to use these proposed supply chain were presented including evaluation of material cost should be conducted between purchasing from supplier and purchasing directly from the material producer. These evaluations should be carried out with respect to the time, transportation cost, credit allowance and payment method etc.

KEYWORDS: CSCM, Construction Supply chain management, JIT (Just in time), profitability, under-budget.

I. INTRODUCTION

The main implementation of SCM was to standardize the supplies to the Toyota car manufacturers. The outcome of this implementation in Toyota car manufacturers was significant in the context of time and money. It enhances the supplier's communication with production line. With the successful implementation of SCM by Toyota, Japanese industry absorbs SCM as a tool in a short duration, with this adoption SCM become important topic for the researcher too and researchers try to find the possibility of SCM as a tool in different industry domains (Chevin and Cook, 2000) in parallel to SCM different new approaches also emerged for example value chain and extended enterprise. These concepts also affect the understanding of SCM in the industry. Scheduling generally defined as the inter relationship of various activities of a project.

First all the activities are finalized and then their duration is estimated on the basis of past experiences. The resources are identified and their cost per shift is specified, then these are assigned to the respective activities. The resources can be men, material or money. Each and every time the project is updated by reviewing the completed work on site, there is baseline for updating the progress of the work up to the certain date. In recent years use of software's plays important role in scheduling any construction project. Construction projects are unique in nature. Such projects are led by several agents and experts. Most of the agents involved in these projects lack overall project insight, therefore each agent assumes primary responsibility for their own work. The agents hired by clients for construction projects are designers,

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main contractors, subcontractors, suppliers, project management consultants/third-party consultants. Therefore, to manage the supply chain of construction projects, organization of the activities of different agents and effective coordination between agents is vital.

II. PURPOSE OF THE CASE STUDY

The general purpose of this study is to improve the effectiveness and efficiency of the traditional supply chain adopted by the contractors in general. The intension of this study is to find out the awareness of the industry in the use of SCM and the obstacles faced by the industry and benefits which can be realized in proper implementation of this concept. The study focuses on SCM concept concerning flyover project in Pune, its adopted SCM patterns, and providing suggestions for its possible future usage. In addition, the main target of this study is to study current strategy of the Organizations in adopting the chain management and supplier assessment practice, the usefulness of relationship between the main stakeholders of Project for example contractors, supplier and client.

III. OBJECTIVES OF THE CASE STUDY

Following on the objective of the study

- i. To study the conventional SCM along with its nodes involved in a flyover construction project.
- ii. This study is to identify shortcomings in traditional SCM used in a flyover construction.
- iii. To investigate the reasons which are responsible for the existence of the shortcomings faced by the supply chain.

IV. SCOPE OF THE CASE STUDY

The scope and extent of this study is a detailed study of the concept of Supply Chain Management and its application in flyover construction highlighting the key benefits of Supply Chain Management demonstrating the advantages of Supply Chain Management by illustrating a live case study and to develop a plan which would help companies implement an effective Supply Chain Management in their organization.

Supply chain management is a relatively new concept in construction industry. A few companies have implemented Supply Chain Management in India. Our aim is to develop a template which would help an organization to successfully implement Supply Chain Management.

A. LITERATURE SURVEY

1.1 Introduction

This chapter deals with the review of the research and study carried out by various researchers on the subject of SCM. This literature is taken from online journals, technical websites and conferences. Around 25 technical research papers have been referred to carry out the thesis work. This chapter covers the concept of SCM, measuring supply chain cost, cost saving from SCM, the roles of SCM in construction industry, SCM in building and construction industry, SCM relationships in construction, JIT production Systems, barriers in implementing SCM, a survey of supply chain collaboration & management in UK construction industry, supply chain modeling using simulation, coordination mechanism for construction SCM in the internet environment, global SCM, improving SCM in construction, the role of supply chain in construction industry, SCM literature review and some issues, Clients and their suppliers, E-commerce technology used in SCM, application of SCM etc. taken from journals and various papers.

2.2 Concept of SCM

Sayed Ahmed, Salman Azhar and Irtishad Ahmed (2002) explained the concept of SCM in his journal paper "Supply chain management in construction (scope, benefits and barriers)". In this paper, the author introduced the

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concept of supply chain management in construction outlining its origins in manufacturing. The author has been evaluated potential benefits of supply chain management to the construction industry. The author also presents a list of possible barriers, which may affect the application of the supply chain management concept in the construction industry. Finally, a simplified model for supply chain management in the construction industry is presented.

The author concludes that SCM is a great opportunity for the construction industry primarily to reduce cost and time, and thus improve profitability. SCM principles seem to have much strength to smoothen and integrate the construction process. The SCM divides into two major groups as materials chain and the construction chain, which would help to separate the procurement and management operations.

Lambert and Cooper (2000) differentiates SCM key decisions in three ways: these are Supply chain business process, supply chain management component and supply chain network structure. This conceptual relationship emphasize on the SCM, to fulfill the need of SCM, industry has to go through several steps to design and implement the successful integration of SCM to their existing systems.

The manufacturing industry is the pioneer industry which introduces the concept of SCM as a new and important tool to perform the business process in a systematic and well defined way to save time, enhance quality and realize profit Tan, (2001). For the construction industry the SCM concept is not new, this was introduced in the construction based industry in 1980 by Akintoye (2000), however this industry still have not fully adopts SCM as business process.

2.3 Measuring Supply Chain Cost

Annelie I. Petterson and Anders Segerstedt(2013) explained the measuring supply chain cost in Int. J. Production Economics. Organizations focus on reducing costs in their supply chains to increase net income. In order to it reduce costs a company needs to know how to measure Supply Chain Cost (SCC). The author is concerned with SCC and how measurements of SCC are and can be used in industry. The author describes a suggested model for measuring SCC. In this paper author interviewed representatives from 30 companies in 10 different business sectors about how they measure costs in their supply chains compared against this model. The focus is also on identifying the difference between SCC based on estimated standard cost compared to actual cost. A case study describes and shows the difference between measuring SCC based on calculated standard cost and measuring it based on actual cost.

After study author conclude that many companies do not measure the total SCC. Instead, they only measure parts of the SCC such as the Manufacturing cost complemented with the Distribution cost. However from interviews author conclude that general thorough cost and supply chain analyses are underdeveloped in many companies.

2.4 Cost Savings from SCM

Thomas A. Crimi and Ralph G. Kauffman (1994) explained to achieve cost savings .from SCM. The author identifies and demonstrates proven techniques that achieve real cost savings from supply chain management, and provides information on how to apply these techniques in various business situations. The author has given a cost saving techniques as follows:

- Establish baseline price and costs over time
- Utilize market baskets of high spend materials or activities
- Identify cost drivers for your company and supply chain members. Do not simply try to cost-shift within the supply chain
- Over a 12-month period, how were prices and total system costs imputed.
- Build a total systems cost model with pricing as a key component.

2.5 The Roles of Supply Chain in Construction Industry

Vrijhoef and Koskela (1999) clarify the roles and possibilities of SCM in construction. The author learnt the various journals and methodological development of SCM in manufacturing and observed the present supply chain and finally the recommendations for SCM in construction are presented. The focus of this paper is on the supply chain of a main contractor.

The author gives a generic SCM methodology consist of supply chain assessment, supply chain redesign, supply chain control and continuous supply chain improvement. The author analyzed the three case studies executed in the Netherlands and Finland through the above SCM methodology. The case studies represent three, separate analyses of

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different supply chains. The case studies give some insight in the waste, problems and causes, and their interdependence presently existing in construction supply chains.

2.6 SCM in Building and Construction Industry

Sonja Petrovic-Lazarevic, Margaret Matanda and Russell Worthy (2006) explains the SCM concept in building and construction industry. The author takes a case study of Australian residential sector for his research. This paper highlights an understanding and application of SCM mainly from the project manager point of view. The paper indicates the importance of having good relationship with suppliers in terms of developed partnership, trust and bonding in order to remain competitive.

The author shows overall picture of construction system related to personnel and interrelation of them. The paper aims to find out what does SCM mean in selected BCI organizations and what role partnership, trust and bonding play in improving the organizations competitive advantage. After this introduction an explanation of the methodology is presented, followed by the findings, discussion and conclusions with suggestions for the future research.

2.7 SCM Relationships in Construction

Mohammed Saad, Martyn Jones and Peter James (2002) provides a review on the adoption of SCM in construction industry and suggest that construction experts has some knowledge of SCM, but still they need more attention towards the implementation of SCM by increasing their conceptual understanding and how new SCM can be implemented systematically.

This paper examines the early progress towards the adoption of SCM relationships in construction. The paper suggests that although construction practitioners have some knowledge of SCM they need better conceptual understanding of it and new and more systematic approaches to its implementations.

The author concludes that there is significant awareness of the importance of SCM and its main benefits in construction. This paper has demonstrated that construction is moving to the adaptation of SCM without having benefited from earlier innovations, such as JIT and TQM. For successful SCM, industry should need more collaborative relationships and integrated process.

B. SITE WORKING

Company Name-SGS India Pvt Ltd

Company Profile

- Sector: Consumer Discretionary
- Industry: Commercial Services
- Sub-Industry: Other Commercial Services
- S G S India Private Limited was founded in 2001. The company's line of business includes providing various business services.

Corporate Information

Address:

Mumbai, 400083

India

Phone: 0091-22257984

Fax: 0091-22257984

Project Name - Construction of bridge cum flyover across canal on Sinhgad at Pune.

Client- Pune Municipal Corporation, JNNURM -2

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Date of Commencement- 26th March, 2014

Date of completion- 30th April, 2017

Estimate cost-Rs. 28,10,48,863/-

Percentage Quoted-7.2% above estimate cost

Tender cost-Rs. 28,10,48,863/- (+7.2% above)

Site Photos



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V. TECHNICAL DETAILS

A. Flyover

- Row- 36.00 m
- Total Length-347.72 m
- Width of flyover-15.0 m
- Length of Viaduct portion-200.00 m
- Foundation Type- Pile Foundation

Pile Details

- i) Diameter of Pile-1200 mm dia.
- ii) Nos. of pile- 40 Nos.

Pile Cap Details

- i) Pile Cap – P5,P6,P7, P8- 8.7 x 8.7 x 1.8 mtr.
- ii) Abutment A1, A2-5.1 x 5.7 x 1.8 mtr.

Type of Substructure

- a) Elliptical Pier 3 x 2 m
- b) i) Pier Cap P5, P6, P7, P8
- 9.20 x 3.3 x 1.8 mtr.
- ii) Abutment A1, A2 – 15 x 2.7 x 1.4 m

Type of Superstructure- PSC Box Girders

Size of Box Girder- 2.10 mtr

Pedestal & bearing-0.50 m

Carriageways-2 x 6.825 m (2 x 2 Lanes)

Median-0.450 m

Anti-Crash Barriers-0.450 m

Crust Details

- i) BC- 50 mm

Headroom at Dhayari Junction-5.75mtr

B) Minor Bridge:

- Total Length-129.98 m
- Width of Minor Bridge- 10.50 m
- Foundation Type- Pile foundation

Pile Details

- i) Diameter of Pile-1200 mm dia.

Pile Cap Details

- i) Pile Cap- 180.900 x 2.40 x 1.80 mtr.

Type of superstructure

- i) Girder Size- Girders 30.700 x 1.200 x 1.85 m

Deck Slab Details- 180.90x 31.4 x 0.25 m

C. METHODOLOGY

Present study involves developing a plan, assigning resources to tasks, managing budget and analyzing. A project involves numerous function independent activities to be completed in definite time span. It is therefore essential to carry out a detailed planning of the project activities keeping in view the sequence, time element, and frontage and

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resource availability. This planning forms the foundation for the execution of the project and also for monitoring and controlling the project activities.

The statistical forecast in Flyover Construction is based on several types of formula:

- Formulas on which the forecast models are based
- Formulas that are used to evaluate the forecast results
- Formula to calculate the tolerance lane for automatic outlier correction

Principles of Supply Chain Management Checklist	
<input type="checkbox"/>	Adapt your supply chain based on the needs of customer segments (by product, industry, or trade channel)
<input type="checkbox"/>	Customize logistics network for each of the above segments
<input type="checkbox"/>	Align demand planning across the supply chain, so that all partners benefit by not keeping unneeded stock on hand
<input type="checkbox"/>	Differentiate products SKUs close to the customer for choice, and standardize SKUs to deliver to many different regions while meeting different regulations
<input type="checkbox"/>	Outsource strategically while keeping core competencies in-house
<input type="checkbox"/>	Develop information tech that supports multi-level decision making, and tie it into business processes so you fully understand your deficiencies and needs
<input type="checkbox"/>	Adopt both financial and service metrics using “Time-Driven Activity-Based Costing” which determines your customers’ profitability and drives value

- 1) **Border Adjustment Tax:** Also known as a destination-based cash flow tax (DBCFT), it is a tax levied on imported goods which is important to know in global supply chains.
- 2) **Customer Relationship Management:** Also known as CRM, this concept refers to providing ongoing service to customers and collecting data about their likes and purchases. There are also CRM tools that help automate and record interactions with customers.
- 3) **Cumulative Mean:** A figure for knowing how much or how little to produce in advance, involving mean orders with all previous data treated as equally useful.
- 4) **Demand Management:** Understanding customer behavior and patterns to control how much is ordered and produced at each link in the supply chain, with the goal of eliminating wasted production.
- 5) **Financial Flows:** Credit terms, payment schedules, accounts payable and receivable, and other factors that you must monitor to determine if a supply chain is profitable or not.
- 6) **Information Flows:** Transmission of orders, delivery status, and other data that influence the supply chain’s responsiveness to demand.

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- 7) **Integrated SCM:** This is a method of SCM wherein all of the links are tightly integrated, operating almost as one company rather than a loose association of buyers and sellers.
- 8) **Inventory Management:** Monitoring and controlling orders, storage, and use of owned components to create the products your company sells.
- 9) **Lean Six Sigma:** A data-backed philosophy of continuous improvement that focuses on preventing defects and mistakes rather than discovering them later, which reduces waste and production time via standardization. Read *Everything You Need to Know About Lean Six Sigma* to learn more about this methodology.
- 10) **Logistics:** The physical movement of products from one link in the supply chain to the next, and the practice of improving their efficiency.
- 11) **Make vs. Buy:** A simple evaluation of whether it is more cost-effective and time-efficient to produce a required product with your company's existing resources, or to outsource the need.
- 12) **New Product Development:** The creation of new products both in response to and in anticipation of customer demand, using data gleaned from CRM and the whole supply chain. Read *Innovation for Everyone: Everything You Need to Know About New Product Development* to learn more about this process.
- 13) **Operational Accounting:** Accounting for a company that focuses on planning, directing, and controlling of daily activities by their costs and eliminating waste.
- 14) **Physical Flows:** The actual movement of parts and products throughout the supply chain, which the Logistics team must manage and analyze to keep going without pause.
- 15) **Project Management:** The process and tools involved in ensuring that a codified piece of work (project or product) gets done on time while keeping all contributors aware of their next step.
- 16) **Reverse Supply Chain:** Aftermarket customer service, which may involve accepting returns, refurbishing and discounting, or otherwise finding use for the reacquired inventory.
- 17) **Risk Management:** Identifying, evaluating, and then choosing which risks to address first, with the goal of reducing overall risk in a supply chain.
- 18) **S&OP:** Sales and Operations Planning is a management process that aligns its constituent parts to ensure that the organization is only focused on operations that improve sales. Learn more about S&OP here.
- 19) **Strategic Sourcing:** Formalizing a company's information gathering in order to use its purchasing power to take advantage of the best values in the marketplace of suppliers.
- 20) **Theory of Constraints:** A methodology that identifies the largest limiting factor in production, then finding a way to remove it to improve the efficiency of the entire production.

The need for SCM in Flyover construction

- 1) Managing the supply chain involves understanding the breakdown and traceability of products and services, organizations, logistics, people, activities, information and resources that transform raw materials into a finished product that is fit for its purpose. Buildings are becoming increasingly complex, and require more design input by specialist suppliers. At the same time there is increasing fragmentation of the industry as can be seen from the growth of specialist suppliers/contractors, the proliferation of products and the fragmentation of design and control activities.
- 2) The supply chain is relatively unstable, and the industry is project-based with defined start and end points, and a traditional separation between design and construction. Demand is treated as a series of competitively tendered prototypes constructed by temporary coalitions. This all has an impact on organizational relationships.
- 3) Project relationships are short term and have defined start and end points; they are usually informal/ad-hoc and focused on the project not the business. Relationships between competencies vary from project to project. The resulting lack of continuity prevents the innovation and improvement of process as well as the development of more complex relationships. The client may also have an impact on the procurement route and choice of strategic suppliers.
- 4) On large or complex projects, responsibility and performance generally cascades down the supply chain to a plethora of suppliers sometimes unknown at the top of the chain. The first and second tier of the supply chain

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may sign up to fairly onerous agreements but as the chain develops, so the contractual liabilities decrease until suppliers at the end of the chain are often not locked in at all.

- 5) Changing the perspective from delivery of a 'project' to the process of 'project delivery' requires the building of long-term relationships (formal and informal), partnering, and alliancing.
- 6) Companies offering continuity in construction have taken an increasing interest in establishing relationships beyond direct, first tier suppliers. Framework contracts and partnering agreements have pioneered this approach, encouraging the involvement of selected suppliers at relatively early stages of projects while offering continuity of work. This has led to greater collaboration between lead designers and product designers to the advantage of all parties.
- 7) The Government Construction Strategy, recommended three different procurement routes that aimed to improve the SCM process; private finance initiative (PFI), prime contracting and design and build. With each of these, the client enters into a relationship with a single integrated supply team, which may include the main contractor, designers, sub-contractors, suppliers, facilities managers and so on.

D. PROCESS FLOW

1. Store Department

The store department controls and monitors the steel, diesel and hardware materials. The store department is situated 2 km from the working site. All the activities like Loading & unloading of steel, preparing & checking indent of steel, diesel and other hardware materials, data entry of materials on ERP software, checking and comparing the actual rate and market rate of materials.

The department is also maintaining the stock of steel, diesel in register book. There is separate register for different materials. The register includes available stock, date of issue and departure of material, Suppliers purchase order.

Store in charge is responsible for delivery of materials and maintaining the buffer stock of materials. The purchase order of the steel and diesel is drawn from Shivajinagar main office. All the rates and selection of suppliers are decided by main office. H.R manager of the main office decide the rates and select the suitable suppliers. Then they prepared purchase order of materials and send one copy of that to the store office. In store department, this purchase order is checked manually as well as on ERP software.

During steel work on site, the project manager gives the quantity of steel. Then the store in charge checks the buffer stock of steel and as per quantity, he check the quantity of steel and manage the delivery of steel as per drawing on site safely. The store supervisor handles the stock of materials, delivery and undelivered of material on store room.

2. Supply Chain of the Flyover Project

By observation on site, interview with the project engineer, site engineer and other personnel staff a detailed supply chain of the project is drawn and presented. The case study analyzes the different supply chains involved in the project. The case study applied to the part of supply chain coordinated by the main contractor. The case study assesses the supply chain in three parts i.e. material, labour and equipment.

The following fig.5.4 (Source: Tender Documents) shows a material, labour& equipment cost in % of total project cost. This % costs are obtained from the tender document of the project.

3. Supply Chain Assessment

The supply chain of the project is assessed by direct observation, personal interview with the technical staff. While assessing the supply chain of project, mainly concentration is made on material department as material cost of project is about 65 % of total project cost.

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Firstly with the help of the supply chain model of construction taken from the journal paper have studied in detailed. On the basis of that model, a supply chain model of the project was made containing the procurement chain and construction chain. After designing the supply chain model of project, a separate supply chain of the different materials are design and study in details. In this project, supply chain of the repetitive materials are take in to consideration i.e. Cement, Aggregate, Sand, Steel, Admixture and Diesel.

4. Material Chain

This chain is very important because material cost of the project is approximately 65% of total project cost. The proper and efficient management of material chain increases the profit of overall project. The material chain starts from raw materials, material producers, material suppliers/vendors, bidding of suppliers and finally material reach on site.

For the construction of flyover, a different materials are used i.e. repetitive and nonrepetitive which are cement, sand, aggregate, admixture, steel, bearing plate, prestressing cables, expansion joint, etc. For assessing the material chain only a repetitive materials have taken into consideration i.e. cement, sand, aggregate, steel, admixture, diesel. Following fig. 5.6 shows the general material supply chain in construction industry. With reference to following general material chain a different material chains are presented for the project.

5. Cement Chain

The company uses ACC, Birla Super & Ultra Tech cements for the project. The company procured this material from supplier. All three cement are procured by same supplier. All these three cements have used as per tender documents. The cement bags (50kg each) are directly loaded by supplier from the factory and it is unloaded on store yard. The monthly procurement of cement of the company is around 500 tons (10 thousand bags). Fig. 5.7 shows the cement chain of the project.

The maximum capacity of the store yard to store the Cement is 300 tons (6000 bags) and minimum stock i.e. safety stock is 100 tons (2000 bags). As soon as the stock goes below 100 tons the order has given to the cement supplier. The maximum capacity of truck is 20 tons (400 bags) at a time. The store incharge keeps the record of quantity of cement in separate register consists of no. of bags available in stock, date of issue of the cement bags to the different project, daily consumption of cement bags etc. For this project, the quantity engineer of the contractor estimates the quantity of concrete for the work, and prepares a material requisition list consist of quantity of concrete required, quantity issued and where used. Prior sending to the RMC plant, it is checked and signed by the site incharge & sent to RMC plant. At the RMC plant, the material requisition list checked and signed by the store incharge of RMC plant.

The store incharge prepares the indent on ERP, from quantity obtained from the site through material requisition list, and send to the plant incharge. Plant incharge prepares purchase order of that material after checked and signed. The plant manager gives an order to the transporter for procuring the cement as per purchase order. The quantity of cement measured by weighing machine on factory and also it is measured on site by physically counting the no. of cement bags.

6. Aggregate Chain

The quantity engineer of the contractor estimates the quantity of aggregate for the work and listed in the material requisition list. This material requisition list checked and signed by the site incharge & send to the RMC plant. The store incharge checked and signed the material requisition list and prepared indent on ERP and send to the plant incharge. Plant incharge checked and signed the indent.

After checking the indent, a comparative statement have prepared consists of different suppliers; there phone no., rate of each supplier, and total amount of the aggregate of supplier. After considering the tax, freight, delivery period in days, term of payment, and quality of material, a comparative statement is prepared and a negotiation of the suppliers have been done. Finally the suppliers are decided by the store incharge and plant incharge. As the aggregates

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are used for both in-house and commercial purpose, the plant incharge prepared purchase order on the basis of the indent from both in-house as well as commercial.

7. Sand Chain

The sand is purchases from two suppliers. For this project, river sand as well as crushed sand have used. The maximum capacity of storage yard is 60m³. When stock of the sand goes down to 30m³, the plant in charge gives an order to the suppliers for procuring sand. Following fig. 5.9 shows the sand chain of the project.

8. Steel Chain

The company procured steel from three different suppliers. The company used three types of steel namely, Jindal steel, Tata steel & JSW steel. The company used 10mm, 12mm, 16mm, 20mm, 25mm, 32mm dia. Bars. The following fig. 5.10 shows the steel chain of the project.

The maximum capacity of the store yard for steel is 50 ton. The store in charge prepares an indent on ERP as soon as the stock goes down to 20 ton. Then the required quantity of steel estimated by quantity surveyor for the work is supplied to the working site.

9. Admixture Chain

In case of admixture, the suppliers are marketing their product on site. In the presence of quality engineer and consultant, the trial and testing of admixture is takes place. The quality engineer check its characteristics like, initial setting time (Normally 2 hrs.), retarding and accelerating agents and then finally consultant decide the supplier for admixture

10. Diesel Chain

The procurement of diesel takes place as per requirement. The diesel is procured from one supplier for this project. The monthly procurement of diesel is 20,000 liters. The maximum capacity of diesel on site is 2000liters. The 200 liters barrels are available for storing the diesel on site. The storage in charge gives an order of diesel, when the stock of diesel goes down to 400liters.

11. Increases Material Costs

As the suppliers are present in the material chain of the project, the contractor should pay additional charges to the supplier for procuring the material from producer to the store yard. These charges are in the form of margin of the suppliers. The margin includes the loading & unloading costs, transportation costs, storage charge, wastages etc. These margins vary from supplier to supplier and material to material. The margin also depends on how far the suppliers firm from the store yard. Following table 5.3 shows the original rates of repetitive materials and rates after including the margin of suppliers.

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Materials		Original Rates (Rs. Per unit of material)	Suppliers Margin (in %)	Rate to the Contractor (Rs. Per u nit of material)
Cement		280 per bag	10-12	3 1 0 per bag
Sand	River Sand	1 700 per cum	8-10	1853 per cum
	Crush Sand	2000 per cum	6-8	2 140 per cum
Aggregate	10mm	650 per cum	9-10	7 1 2 per cum
	20mm	600 per cum	9-10	657 per cum
Steel		52,250 per MT	12-14	59043 per cum

Table 1 Material Costs without Supplier &with Supplier

From the table it is seen that, due to the supplier's margin, the contractor pay additional charges to the materials. The supplier's margin for cement is in the range of 10-12 % of original prize of the cement. Similarly, the margin of river sand, crush sand, 10mm aggregate, 20mm aggregate and steel are in the range of 8-10%, 6-8%, 9-10%, 9-10%, 12-14% respectively. Due to the margin of suppliers, the total cost of the project increases drastically.

The above mentioned repetitive materials have measure role in the RCC. These materials are the major source of the concrete. For the construction of flyover the concrete plays an important role because almost all element of the flyover required different grades of concrete.

Grade of Concrete	Elements	Total Quantity (in cum)
M 45	Superstructure (Box & I Girder, Crash Barrier)	24000
M 35	Pile Foundation	3000
M 30	Substructure (Pier and Pier Cap)	670 (Pier) 150 (Pier Cap)
M 25	R.E. Wall	6000
M 15	PCC	875

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Table 2 Total Quantity of Different Grades of Concrete

Materials		Original Rates (Rs. Per Unit of Material)	Quantity	Estimated Cost (inRs.)
Cement		280 per bag	478800 bags	13,40,64,000
Sand	River Sand	1700 per cum	16100 cum	2,98,33,300
	Crush Sand	2000 per cum	16320.5 cum	3,49,25,870
Aggregate	10 mm	650 per cum	16177 cum	1,15,18,024
	20 mm	600 per cum	16173.5 cum	1,06,25,989.5
Steel		52,250 per MT	600.53 MT	3,13,77,692
Total				22,09,67,183.5

Table 3 Total Estimation of Materials without suppliers

Materials		Original Rates (Rs. Per Unit of Material)	Quantity	Estimated Cost (inRs.)
Cement		310 per bag	478800 bags	14,84,28,000
Sand	River Sand	1853 per cum	16100 cum	2,98,33,300
	Crush Sand	2140 per cum	16320 cum	3,49,25,870
Aggregate	10 mm	712 per cum	16177 cum	1,16,15,086
	20 mm	657 per cum	16173 cum	1,06,25,989
Steel		59,043 per MT	600.53 MT	3,54,57,093
Total				24,54,28,245

Table 4 Total Estimation of Materials with suppliers

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From the table 4 and table 5 it is seen that, the materials costs of the total project decreases from Rs. **24,54,28,245** to **Rs22,09,67,183.5**. i.e. the material costs of the total project is decreases by 9.031% if suppliers are reduced from the material chain.

12.Increases Lead Time

From the observation and practical survey on site, it was found that, due to the suppliers in the material chain, the lead time of material increases, as the lead time is the time an indent is submitted to the purchase department, to the time that ready for use materials are received at project stock yard for storage. The lead time vary from material to material. During observation, the lead time of the repetitive materials with suppliers and without suppliers was found as shown in following table 5.5.

Table 5.5 Lead Time of materials with and without suppliers

Materials	Lead Time without Suppliers (In days)	Lead Time with Suppliers (in Days)
Cement	3	6
Aggregate	3	5
Sand	2	5
Steel	3	7

From the table, it is observed that on an average the lead time of the materials with suppliers is almost two times (2.09) the lead time without suppliers.

VI. CONCLUSION

This study demonstrates how systematic application of Supply Chain Management can improve material chain of project and their by reducing the cost and time of the project. This study is applicable to contractor and giving valuable information of saving the cost of materials. Thought the whole work, attempts have been made of reducing the time and cost of project by compressing the unnecessary nodes in the chain. This study is conducted when the project was it in under construction. Since this study is an individualistic academic effort in restricted time, natural shortcomings will creep in. Still this work has been possible with constant, appreciating guidance of experts manufacturing field and construction field with considerable experience. From the detailed case study, it was found that the supplier reduction is the criteria to reduce cost as well as lead time of the materials.

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