

Survey of Civil Construction Execution by Supply Chain Management

Baliram Warvate *1, Abhishek Shirle*2, Gauri Patil *3, Dr. Satish S. Deshmukh *4, Dr. Sunil Thakare*5

*1, *3 & *3 Assistant Professor, Civil Engineering Department, KJ's Educational Institute Trinity Academy of Engineering, affiliated to Savitribai Phule University Pune, Maharashtra India.

*4 Professor, Civil Engineering Department, KJ's Educational Institute Trinity Academy of Engineering, affiliated to Savitribai Phule University Pune, Maharashtra India.

*5 Professor, Civil Engineering Department, Anantrao Pawar College of Engineering Pune, Maharashtra India.

Mail Id-1. baliramwarvate@gmail.com, 2. abhishekshirle@gmail.com,
3. gauri.patil2310@gmail.com 4. ssdbaramati@gmail.com 5.
prof_sbthakare@rediffmail.com

Article Info

Page Number: 2061-2073

Publication Issue:

Vol. 70 No. 2 (2021)

Article History

Article Received: 15 October 2021

Revised: 24 November 2021

Accepted: 18 December 2021

Abstract: Supply chain management (SCM) in construction is a critical discipline that focuses on the effective coordination and integration of various stakeholders, processes, and resources involved in construction projects. It encompasses the planning, sourcing, procurement, logistics, and distribution of materials, equipment, and services throughout the construction lifecycle. The goal of SCM in construction is to optimize project performance, minimize costs, improve quality, and enhance overall efficiency. The construction industry faces unique challenges in managing its supply chain due to the complexity of projects, diverse stakeholders, and the dynamic nature of construction environments. Effective SCM practices in construction involve strategic decision-making, collaboration, and the utilization of information systems and technologies.

Keywords: Supply chain management, construction project, logistic management, information system

Introduction

Supply chain management plays a crucial role in the construction industry, ensuring the efficient flow of materials, information, and resources throughout the entire construction process. It involves the coordination and integration of various stakeholders, including suppliers, manufacturers, contractors, subcontractors, and project owners, to optimize the construction supply chain and achieve project objectives. In the context of construction, supply chain management encompasses the planning, sourcing, procurement, logistics, and distribution of materials, equipment, and services required for a construction project. It aims to minimize costs, reduce project timelines, improve quality, and enhance overall project performance. The construction supply chain typically begins with the identification of project requirements, including the materials, equipment, and services needed. This is followed by the selection and qualification of suppliers and subcontractors, considering factors such as quality, reliability, cost, and capacity. Effective supplier relationship management is essential to ensure timely delivery, maintain quality standards, and manage potential risks. Once

suppliers are engaged, procurement activities come into play. This involves the negotiation and management of contracts, purchase orders, and delivery schedules. Efficient procurement processes help optimize costs, ensure the availability of materials, and minimize delays.

Logistics management is another critical aspect of supply chain management in construction. It involves coordinating the transportation, storage, and handling of materials and equipment to ensure they are available at the right place and time. Effective logistics planning and execution can help reduce transportation costs, prevent material shortages, and avoid project delays. SCM also involves the integration of information systems and technologies to facilitate real-time visibility, communication, and collaboration among stakeholders. This enables efficient tracking of materials, inventory management, and coordination of activities, leading to improved decision-making and project control. Overall, supply chain management in construction is essential for optimizing resources, reducing costs, enhancing project efficiency, and mitigating risks. By effectively managing the flow of materials and information, construction companies can streamline their operations, improve project outcomes, and ultimately deliver projects on time and within budget. Supply chain management plays a crucial role in the construction industry by ensuring the smooth flow of materials, information, and resources from the initial stages of a project to its completion. It involves the coordination and integration of various activities, including sourcing, procurement, transportation, storage, and distribution, to optimize efficiency, minimize costs, and enhance overall project performance.

In the construction sector, supply chain management encompasses the entire lifecycle of a project, starting from the planning and design phase to construction, operation, and maintenance. It involves managing the relationships between suppliers, contractors, subcontractors, designers, engineers, and other stakeholders involved in the construction process.

The key objectives of supply chain management in construction are to:

- 1. Improve project delivery:** Effective supply chain management helps ensure that the right materials and equipment are available at the right time and place, reducing delays and improving project timelines.
- 2. Enhance cost control:** By optimizing procurement and inventory management, supply chain management helps control costs associated with purchasing, transportation, and storage of materials, leading to overall cost savings.
- 3. Mitigate risks:** Supply chain management identifies potential risks and develops strategies to mitigate them, such as by establishing alternative suppliers, managing demand fluctuations, or implementing contingency plans.
- 4. Foster collaboration and communication:** Supply chain management facilitates effective communication and collaboration among all project stakeholders, enabling better decision-making, coordination, and problem-solving.
- 5. Promote sustainability:** Supply chain management practices can be designed to

incorporate environmentally friendly materials, reduce waste generation, and promote sustainable construction practices.

6. Ensure quality and compliance: By establishing rigorous quality control measures and monitoring supplier performance, supply chain management helps ensure that materials and services meet the required standards and regulatory compliance.

To achieve these objectives, construction companies often utilize advanced technologies such as construction management software, logistics management systems, and real-time tracking systems. These tools enable real-time visibility, data analysis, and efficient coordination of supply chain activities, ultimately improving project outcomes.

In summary, supply chain management in construction is a strategic approach that focuses on optimizing the flow of materials, information, and resources throughout the construction process. By improving project delivery, controlling costs, mitigating risks, promoting collaboration, and ensuring quality, effective supply chain management contributes to the success of construction projects.

Literature Survey

The construction industry has been criticized for its wastefulness, inefficiency, low-profit margin, poor productivity, frequent schedule delays, cost overruns, and quality issues. Most of these challenges stem from interactions between construction project supply chain partners. Myopic and independent construction supply chain control, fragmentation, a lack of coordination and communication between participants, adversarial short-term relationships, separation of design and construction, and mistrust are causing performance issues.

Academics also study material and information flows and the feasibility of SCM in Europe, Asia, and Oceania. Their analysis demonstrated that most studies focus on very specific locations but fail to provide a comprehensive response. Due to this, building SCM research is lacking [1].

This subject covers "planning and control of material flows" and "integration of materials and information flows". The project spends a lot on constructing material logistics. Inefficiencies in material flow planning and management, such as late delivery, incomplete orders, and quality issues, disrupt construction operations and increase costs [2].

This issue area contains 43% of the components, including "procurement," "objectives alignment," "top management support and long-term commitment," "trust," "collaboration," "communication," "problem solving," and "risk sharing." Due to the competitive environment, construction companies must concentrate on their core capabilities and outsource their requirements. Suppliers—materials, equipment, and services—have a major and lasting influence on project completion, thus companies are becoming increasingly dependent on them.

The sector's conservatism requires deliberate change management. Organizations must be willing to change [4]. Strategies should emphasize dissatisfaction with the status quo, the

need for transformational change, and the benefits of SCM to enterprises and their SC. Criticize the status quo.

Only papers from Thomson Reuters publications were examined for classification, and quality was one of the criterion. 240 items remained in the sample. After this, the abstracts of the publications that passed this phase were examined and placed through a two-part selection filter to avoid researcher bias [5]. The sample dropped to 130 articles. The principal author screened abstracts and eliminated certain papers. The secondary author verified the selection and double-checked the borderline cases. The omitted publications either did not address the construction sector, used "construction" in a different context (such as "sample construction" and "construction of pairwise comparison"), or were irrelevant to the study issue (since they did not explore CSCM-underlying features).

The distribution analysis of the selected papers by the first author's research institution's location shows that publications may be located in many places. Europe, Asia, and Oceania accounted for roughly 88% of the gathered publications, corroborating Tiwari et al.'s geographical variances in research [6]. This assessment from 30 nations on six continents found that Europe, Asia, and Oceania were the main suppliers of knowledge. When split down by country, China, England, and Australia produced 18%, 12%, and 11% of the articles, respectively.

This operational method was implemented. The initial author manually coded the elements into Croom et al.'s [7] subject categories. Decisions were rechecked to ensure code correctness. The second author then checked the scripts against the initial data set and framework topics. Disagreements were discussed until resolved, which reduced errors and strengthened the findings.

This research used an SLR. SLRs discover previous research, choose and assess contributions, analyze and synthesize data, and publish the evidence in a form that permits reasonable judgments about what is and is not known. This research documented information clearly enough to draw judgments about what is and is not understood. The systematic technique was initially utilized in medical research, but it today advances knowledge in many fields, including supply chain management [8].

PRISMA flow diagram criteria were used to categorize the results [9]. The original classification criteria limited the search to English-authored peer-reviewed journal papers published in 2019 or later. Thus, proceedings papers, reviews, editorial material, and German, Japanese, Russian, and Spanish texts were excluded. 321 items were sampled.

This work's descriptive analysis involves constructing an extensive keywords co-occurrence network using VOSviewer. Keywords simplify and summarize research results [10]. A network map of keywords may depict a field's knowledge structure, including new features and its dynamic character. Thus, a five-term network of often occurring phrases was created. The frequency and correlations between keywords may be shown by the size, distance, and connecting lines of the nodes [11]. Nodes are weighted by their size and linked by their

distance. Two nodes linked by proximity are stronger. Similar-hued items form a cluster. The terms in a cluster are more closely connected.

Four clusters arranged the data. Red and green clusters focused on logistics and connecting component bodies, respectively. Both clusters contained 10 keywords. Instead of "strategic management," the blue cluster included "management," "framework," and "system." Finally, the yellow cluster highlighted the need of a sustainable building supply chain. The keywords co-occurrence network shows these are the main SCM literature component bodies in building.

Research Methodology

About six percent of India's Gross Domestic Product is generated by the construction sector, which is often regarded as a key economic driver. This enterprise is well-established and extensive, with several critical connections to other sectors of the economy. The construction industry as a whole is extremely disorganized, which has many negative consequences. These include a general perception of low productivity, inertia, cost and time overruns, conflicts and disputes leading to additional claims, time-consuming litigations, quality deviations, poor health and safety management, and many others. These are the main reasons why the construction business has performance issues (Bane et al., 2008). The significant degree of fragmentation in the industry has left a legacy of a project delivery procedure that is exceedingly inefficient when compared to other fields. Supply Chain management (SCM) must be used in order to eliminate these inefficiencies and achieve full integration of the building process as a whole. In order to maximize value creation potential while reducing costs, SCM may be used to establish horizontal and vertical integration throughout the design, construction, and operating phases. The clients, collaborators, consultants, primary contractor, and other team members must all adopt a strategic mindset for the application to be successful. The SCM is comprised of three distinct flows: Material flow encompasses not just the forward movement of goods from producers to consumers, but also their subsequent return, refurbishment, and eventual disposal. -

- Forecasting demand, placing orders, and creating a report on delivery status are all examples of information flow.
- Commercial information, payment schedule, consignment specifics, and ownership agreements are all part of the cash-flow picture.
- Construction SCM is shown in Figure 1 to illustrate typical upstream and downstream flows of resources (money, labor, and data).

Figure 1 depicts a typical SCM used in the construction industry, with arrows illustrating the movement of money, work, and information upstream and downstream.

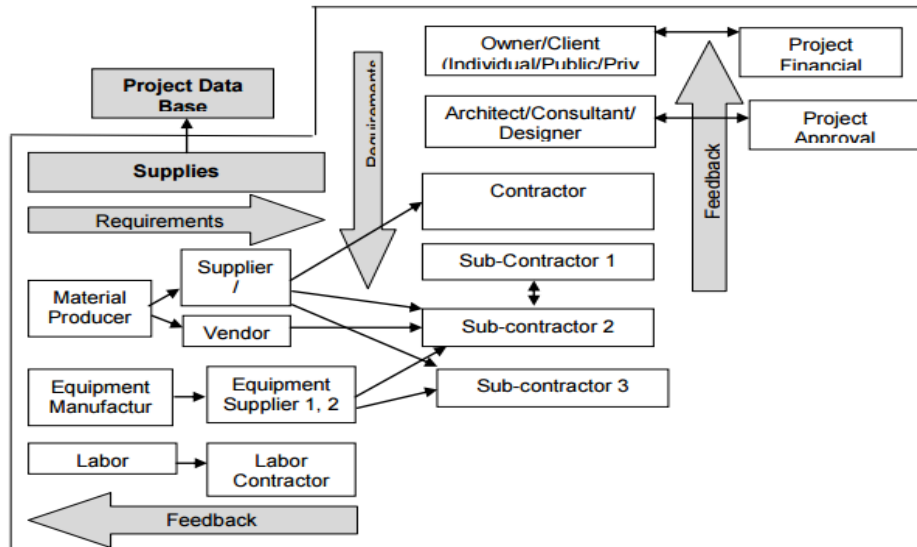


Fig. 1: Typical Construction SCM

Importance of Supply Chain Management

The importance of supply chain management (SCM) in construction cannot be overstated. It plays a crucial role in ensuring the smooth and efficient execution of construction projects. Here are some key reasons why SCM is essential in the construction industry:

1. **Cost Optimization:** Effective SCM practices help in optimizing costs throughout the construction supply chain. By strategically sourcing materials, negotiating favorable contracts, and managing logistics efficiently, construction companies can reduce procurement and transportation costs. This cost optimization contributes to improved profitability and competitive advantage.
2. **Timely Project Completion:** SCM facilitates the timely delivery of materials, equipment, and services required for construction projects. Proper planning, coordination, and logistics management ensure that the necessary resources are available at the right time and place. This helps prevent delays and ensures that construction projects are completed within the scheduled timeframe.
3. **Quality Control:** SCM enables better quality control by ensuring the availability of high-quality materials and equipment from reliable suppliers. Through supplier qualification processes, construction companies can select vendors who meet quality standards, leading to better overall project outcomes. Additionally, effective SCM practices enable the tracking and monitoring of materials to prevent the use of substandard or defective items.
4. **Risk Mitigation:** Construction projects are inherently prone to various risks, such as supply disruptions, price fluctuations, and unforeseen events. SCM helps mitigate these risks by diversifying suppliers, establishing backup plans, and implementing risk management strategies. By having contingency plans in place and actively managing risks, construction companies can minimize project disruptions and financial losses.

5. Collaboration and Communication: SCM fosters collaboration and communication among various stakeholders involved in construction projects. Through efficient information sharing and coordination, SCM enhances communication between suppliers, contractors, subcontractors, and project owners. This leads to better coordination of activities, improved decision-making, and faster problem resolution.

6. Sustainability and Environmental Considerations: SCM can contribute to sustainable construction practices by promoting environmentally friendly materials, reducing waste, and optimizing transportation routes to minimize carbon emissions. By considering sustainability factors in the supply chain, construction companies can align their operations with environmental objectives and regulations.

7. Stakeholder Satisfaction: Effective SCM practices contribute to higher stakeholder satisfaction. Timely delivery, cost optimization, and quality control result in satisfied clients, subcontractors, and project owners. This enhances reputation, fosters long-term relationships, and increases the likelihood of securing future projects.

In summary, supply chain management is of paramount importance in the construction industry. It helps construction companies optimize costs, ensure timely project completion, control quality, mitigate risks, foster collaboration, address sustainability concerns, and enhance stakeholder satisfaction. By implementing robust SCM strategies, construction firms can achieve operational excellence and deliver successful construction projects.

Supply Chain Management Today

If we accept the viewpoint that Supply Chain Management is what individuals who work in Supply Chain Management do, then in the year 1997 Supply Chain Management has a solid grasp over all areas of physical distribution and materials management. At least 75% of respondents listed the following responsibilities within the purview of their company's Supply Chain Management department functions:

- Management of inventory
- Procurement of transportation services
- Material handling
- Management of inbound transportation
- Management of transportation operations
- Management of warehouses and storage facilities

In addition, it is anticipated that the Supply Chain Management department would broaden the scope of its tasks. This will most likely be in accordance with the way of thinking that considers the order fulfilment process to be a single, unified collection of operations. Therefore, the services that are most often mentioned as being planned to officially include in the Supply Chain Management department are as follows:

- Order processing/customer service monitoring
- Customer service performance monitoring

- Supply Chain Management financial projections for the budget

On the other side, there are some duties that some of us would believe logically belong to Supply Chain Management, but organizations feel are the legitimate province of other departments. These functions might include things like ensuring that inventory is accurate and meeting customer demands. The following are among the most challenging to bring within the purview of supply chain management: the payment and audit of invoices from third parties; sales forecasting; and master production planning.

The approach of supply chain management (SCM) requires a number of additional components in addition to evaluating and enhancing the supply chain. It is possible to infer an SCM approach that is generic by integrating and generalizing the characteristics that are shared by many SCM methodologies. The SCM technique may be thought of as being comparable to the Deming Cycle, as can be shown in Figure 1.4.1. The SCM approach may be broken down into four primary categories, which are as follows: First, there is an analysis of the supply chain, then there is a redesign of the supply chain, then there is supply chain control, and finally there is continuous supply chain improvement.

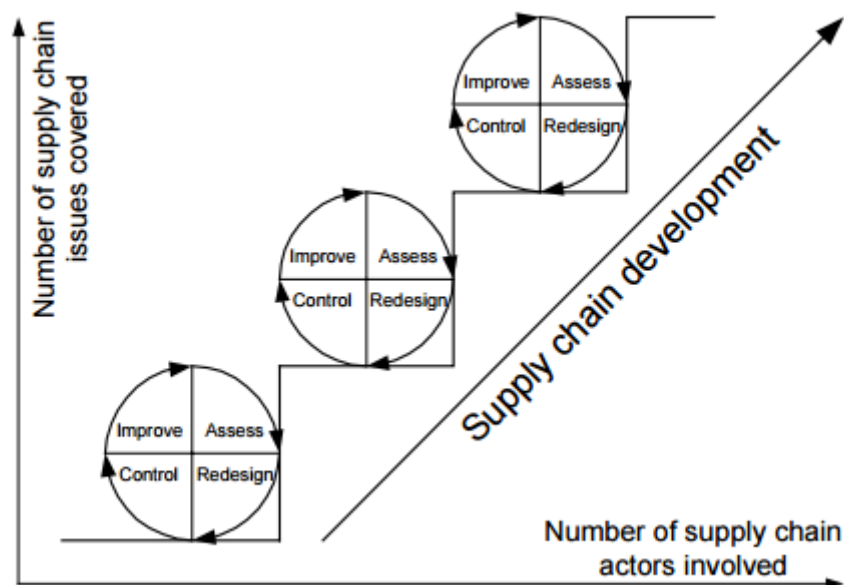


Figure 2: General Approach to Supply Chain Development

The first thing that has to be done is an analysis of the present procedure across the whole supply chain in order to identify any genuine waste and issues. The challenge here is to identify the chain of events that led to the difficulties and to zero in on the factors that were ultimately responsible for them. Redesigning the supply chain in order to implement structural solutions to the issues at hand is the next step that must be taken after it has been determined that causation exists and that the underlying causes have been identified. This entails reorganizing the roles, duties, and responsibilities held by each player in the supply chain as well as conducting an audit of the processes already in place. The next thing that has to be done is to regulate the supply chain in accordance with its new setup. Installation of a

monitoring device to continually evaluate the functioning of the supply chain is an essential component of the control that is being exercised here. This includes feedback systems that may be used to discuss and assess the underlying issues, as well as systems that can quantify and estimate waste throughout the whole supply chain process. Finding innovative ways to expand the supply chain and consistently seeing fresh possibilities are the goals of this endeavor.

Procurement in SCM

This research center its discussion on one of the procedures that is a part of supply chain management (SCM), namely procurement, which is also referred to as supplier relationship management (SRM). This process will be evaluated from the point of view of the dyadic interaction that exists between the contractor (building construction) and the supplier, with a special focus put on the coordination effort that is necessary in this process. Specifically, this process will be analyzed from the perspective of the coordination effort that is required in this process. The current investigation makes a significant contribution to the advancement of knowledge in spite of the fact that this topic has been the focus of a number of previous attempts at research. Rather than attempting to conduct an all-encompassing investigation of the subject, the current study focuses on the specific activities that comprise the procurement process. This approach allows the investigation to narrow in on a more specific aspect of the topic. This will make it possible to have a deeper knowledge of how the performance of the Resource Based View (RBV) framework is impacted by the influence of each activity in the procurement process coordination or SRM. In addition to that, the focus of this specific research will be on possible enablers such as market orientation that might serve as inputs for effective supply chain coordination (SCC).

It is not a new phenomenon for SCM to be applied to industries such as manufacturing, retailing, and distribution. Previous research in these fields has shown that SCM leads to improvements in a company's competitiveness as well as its profitability. Nevertheless, implementing this idea into the building trade is a novel problem, and it is difficult to do so because of the characteristics of the construction business, such as the specialisation of the labour and the fragmentation of the whole process among the participants in the supply chain. When contrasted with other sectors such as manufacturing, for instance, the construction industry involves a diverse variety of component elements that must adhere to varying degrees of specific site or project criteria. Because of the product's size and the fact that it is immobile while it is being constructed, it must be put together at the location where it will be consumed. In addition to that, it requires the participation of several professional groups within a project, such as engineers, designers, and suppliers, in order to successfully complete a particular activity or project. It is thus not reasonable to believe that a single company would have the authority or the capacity to independently coordinate the whole supply chain; rather, each component of the supply chain may impact and be influenced by the other members of the supply chain. Consequently, the results of this specific research would assist in closing the gap. This article will begin by discussing the topic from a conceptual standpoint, followed by a short analysis of some relevant investigations that were conducted

in the past. After that, the findings of a pilot case study that was carried out in the building construction sector are discussed.

Construction Industry and Its Characteristics

Building construction, heavy and civil engineering construction, and specialty trade construction are the three primary sub-industries that make up the construction industry. Building construction comes in first, followed by heavy and civil engineering construction, and finally specialty trade construction. The term "building construction" refers to the construction of both residential and non-residential structures, such as commercial and industrial buildings. It has been suggested that this sector is a pioneer in terms of outsourcing, seeing as how it heavily depends on suppliers of construction supplies and subcontractors. It has also been thought of as being unique from other types of businesses, for a number of reasons, including the fact that it is fundamentally a project-based activity that is located in a particular location. Due to the fact that it had such a distinct trait, it compelled the industry to take a two-pronged approach to analysing the interaction that exists between channel members. Also the project level and the company level are both viable options for the SC collaboration in the construction business. This partnership on the project level is seen as a transitory or short-term working arrangement, which will generally obstruct the process of invention development. On the other hand, firm-level relationships allow for the development of long-term relationships, which might potentially lead to the introduction of innovation for the purpose of gaining a competitive advantage. In addition to these findings, more recent research indicates that there is a shift toward a relationship-based approach to the construction supply chains. These studies show that the construction industry engages in industry-specific relationship marketing (RM) practise within their project environments. According to, it is only a matter of time until the capacity to design and maintain strong partnership relationships will become a prerequisite for doing business in the construction sector. These revelations were made possible by. In addition to this, they said that major enhancements may be attainable if contractors focused on consolidating their purchases with a smaller number of vendors and used a partnership development procedure.

Results and Discussions

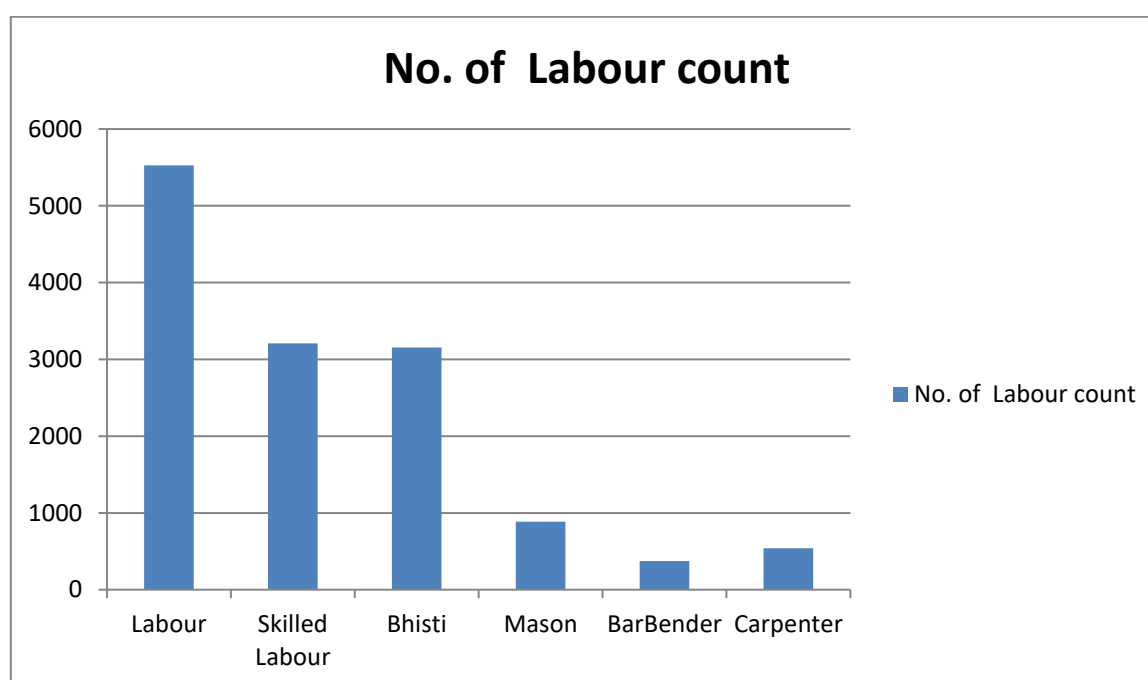
Table 1: Resources table for conventional methods in SCM

Resources	Days	Rate/day	Total cost
Labour	5528	400	22,11,200
Skilled Labour	3210	600	1926000
Bhisti	3152	550	1733600
Mason	886	600	531600
BarBender	373	600	223800
Carpenter	541	700	378700

Electrician	28	650	18200
Total			70,23,100

Table 2: Time required for conventional construction of SCM

Sr.No	Description	Duration
1	Sub Structure -(Excavation, Foundation, Plinth)	58 days
2	Super Structure – (Column, Beam, Slab, Wall)	506 days
3	Painting and electricity establishment	68 days
Total Duration		632 days

**Figure 3 : Manpower requirement for conventional method**

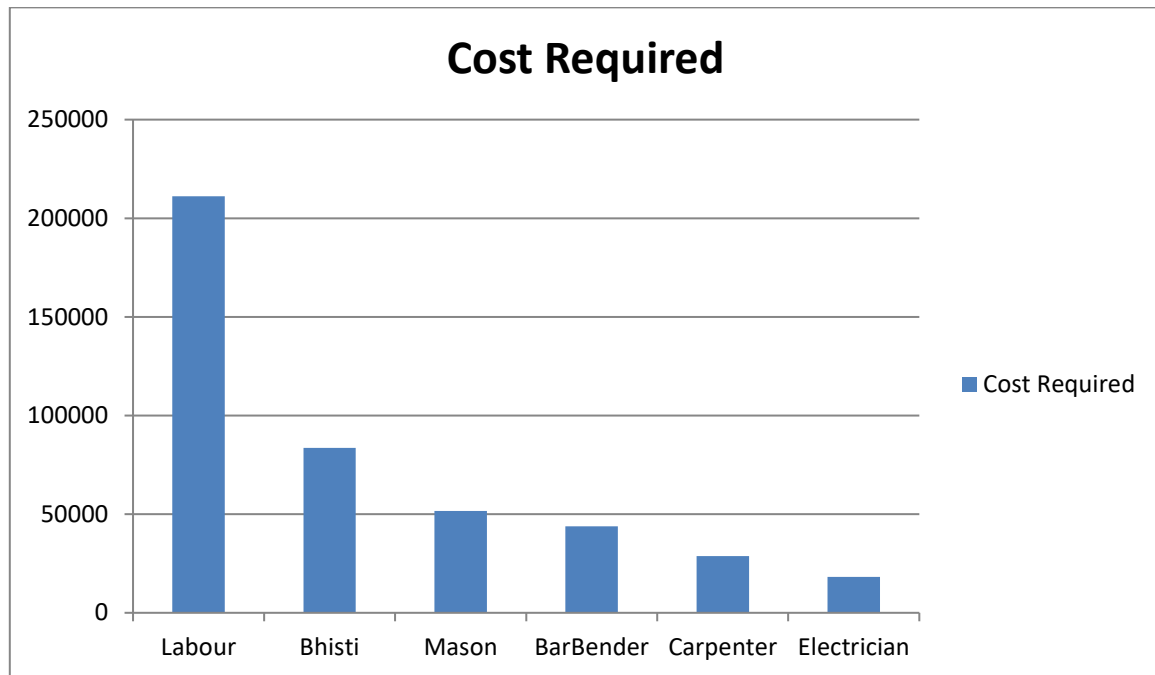


Figure 4: Manpower requirement for Conventional method

Table 3: Overall construction cost for conventional approach with SCM

Resources	Total cost
Material Cost	3,12,44,789
Labour Cost	1,18,23,452
5% Contingencies	24,93,215
Vat, Service Tax etc. @ 20%	1,44,564
Total Cost	4,57,06,020

Conclusion

Supply chain management's ultimate goal is to provide clients with more value than rival firms. Together, the steps of identifying customer value, building relationships with suppliers, integrating activities, cooperatively controlling costs, creating mechanisms for continuous improvement, mobilizing, and developing people will lead to this goal being met. Supply chain management (SCM) may and has been used in a variety of contexts, most notably to cut down on expenses (particularly logistical ones), turnaround times, and stock on hand. This is a reasonable priority given the disproportionate weight that these expenses carry in the building industry. Second, supply chain effects on onsite operations may be examined. Here, we aim to cut down on site expenses and time spent there. Thirdly, in order to prevent the subpar circumstances of the site, attention may be shifted from the site to the upstream stage of the supply chain. Therefore, a holistic and integrated supply chain view is necessary for

the construction industry to successfully react to the difficulties of the present and capitalize on the possibilities of the future. Value is increased and competitive advantage is gained via an integrated supply chain.

References

1. Love, P.E.D.; Irani, Z.; Edwards, D.J. A seamless supply chain management model for construction. *Supply Chain Manag.* 2004, 9, 43–56.
2. Vidalakis, C.; Tookey, E.J.; Sommerville, J. Demand uncertainty in construction supply chains: A discrete event simulation study. *J. Oper. Res. Soc.* 2013, 64, 1194–1204.
3. Shishodia, A.; Verma, P.; Dixit, V. Supplier evaluation for resilient project driven supply chain. *Comput. Ind. Eng.* 2019, 129, 465–478.
4. Siebelink, S.; Voordijk, J.T.; Adriaanse, A. Developing and testing a tool to evaluate BIM maturity: Sectoral analysis in the Dutch construction industry. *J. Constr. Eng. Manag.* 2018, 144, 05018007.
5. Thomé, A.M.T.; Scavarda, L.F.; Scavarda, A.J. Conducting systematic literature review in operations management. *Prod. Plan. Control.* 2016, 27, 408–420.
6. Dhabliya, D., & Others. (2021). An Integrated Optimization Model for Plant Diseases Prediction with Machine Learning Model. *Machine Learning Applications in Engineering Education and Management*, 1(2), 21–26.
7. Rabanal, N., & Dhabliya, D. (2022). Designing Architecture of Embedded System Design using HDL Method. *Acta Energetica*, (02), 52–58.
8. Juneja, V., Singh, S., Jain, V., Pandey, K. K., Dhabliya, D., Gupta, A., & Pandey, D. (2023). Optimization-Based Data Science for an IoT Service Applicable in Smart Cities. In *Handbook of Research on Data-Driven Mathematical Modeling in Smart Cities* (pp. 300–321). IGI Global.
9. Pandey, J. K., Veeraiah, V., Talukdar, S. B., Talukdar, V. B., Rathod, V. M., & Dhabliya, D. (2023). Smart City Approaches Using Machine Learning and the IoT. In *Handbook of Research on Data-Driven Mathematical Modeling in Smart Cities* (pp. 345–362). IGI Global.
10. Tiwari, R.; Shepherd, H.; Pandey, R.K. Supply chain management in construction: A literature survey. *Int. J. Manag. Res. Bus. Strateg.* 2014, 3, 7–28.
11. Croom, S.; Romano, P.; Giannakis, M. Supply chain management: An analytical framework for critical literature review. *Eur. J. Purch. Supply Manag.* 2000, 6, 67–83.
12. Durach, C.F.; Kembro, J.; Wieland, A. A new paradigm for systematic literature reviews in supply chain management. *J. Supply Chain Manag.* 2017, 53, 67–85.
13. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med.* 2009, 6, e1000097. [PubMed]
14. Su, H.-N.; Lee, P.-C. Mapping knowledge structure by keyword co-occurrence: A first look at journal papers in Technology Foresight. *Scientometrics* 2010, 85, 65–79.
15. Jin, R.; Zou, Y.; Gidado, K.; Ashton, P.; Painting, N. Scientometric analysis of BIM-based research in construction engineering and management. *Eng. Constr. Arch. Manag.* 2019, 26, 1750–1776.