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Supply Chain Management in Flyover Projects in India

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Abstract: This paper explores the application of supply chain management (SCM) in the Indian construction industry. The authors studied the SCM practices followed in flyover projects and compared them with the seamless SCM model for construction proposed by a previous study. A case study approach was followed for the research work. Structured interviews were conducted to understand the SCM practices in flyover projects in India. The developed model advocates leading roles for client and strategic needs analysis and value management study that are missing in the studied projects. All of the projects studied faced cost and time overruns. The seamless SCM model may be extended to developing countries by incorporating requirements related to the long-term relationship between project agents and, if possible, by suggesting that clients should not select agents using only the minimal cost criteria. The extended model also proposes SCM training for all project agents before the start of the project. Strategic needs analysis and value management study should be an integral part of the construction project to improve project efficiency. Implementing the seamless SCM model calls for the early involvement (i.e., at the project design stage) of all project agents. Project sponsors can apply the findings of this study to manage time and cost overruns.

Keywords: Supply chain management, Construction project, Integration, Seamless project supply chain management model, Barriers for integration

INTRODUCTION

Construction projects are unique in nature and are characterised by one-time activity. Such projects are conducted by numerous agents and specialists. 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 (e.g., architects and structural designers), main contractors, sub-contractors, suppliers, or project management consultants/third-party consultants. Therefore, to manage the supply chain of construction projects, synchronisation of the activities of different agents and effective coordination between agents is vital. Effective management of the supply chain helps projects be completed successfully. The construction industry has recognised the importance of supply chain management (SCM) in improving the performance of projects, but the research in this area is still relatively immature (Briscoe and Dainty 2005; O'Brian et al., 2009; Saad, Jones and James, 2002).

The separation of the design and production processes in projects has been widely criticised over the last 50 years (e.g., Simon Report, 1944; Banwell, 1964; Latham, 1994; Egan, 1998). The case for the increased use of partnering in the construction supply network was made by both Latham (1994) and Egan (1998). One report (Egan, 1998) suggested that the construction supply chain has a critical role in driving innovation and sustaining incremental improvements in the

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sector's performance. To achieve ambitious performance targets, the report further recommended the adoption of methods that the manufacturing sector has successfully used, such as partnering, using integrated production teams and continually monitoring performance. The report also mentioned that although the industry is fragmented, longer-term relationships, such as those observed in the manufacturing sector, are possible because the main contractor may tend to use similar trade contractors on a repeating basis. Such methods are currently being showcased through the "Movement for Innovations" initiative, where substantial improvements are observed in terms of cost reduction, quality, work environment, relationships, productivity, margins, cash flow, planning for future workloads and image (Building Down Barriers, 1999; Hayward, 1999; Mylius, 1999; Whitelaw, 1999). These successes have provided a benchmark of best practices, particularly for upstream supply chain partnering between contracting companies and client organisations.

According to Vollman, Cordon and Raabe (1998), the construction SCM should be considered an integrated set of practices aimed at managing and coordinating the entire chain, from raw materials to end customers. Barker, Hong-Minh and Naim (2000) advocated for the construction industry to encourage collaboration and embrace SCM to effectively manage construction projects. We define the supply chain in the context of construction projects as a set of activities that range from the project need analysis to the successful commissioning or handing over of the project to the client. The set of activities that occur between these endpoints includes project design (i.e., architectural and structural design) and construction through main contractors and sub-contractors. The material suppliers and suppliers of other supporting services, such as electrical or mechanical works, are also part of the supply chain.

The Construction Industry Development Agency, CIDA (1994) and Department of Industry Science and Tourism, DIST (1998) reports on Australian industry suggest that projects in the Australian construction industry are continually plagued by time and cost overruns, quality deviations and poor health and safety conditions. The Australian Procurement and Construction Council (1997) and Department of Industry Science and Resources, DISR (1999) reports suggest a lack of coordination and communication between participants, strained contractual relationships, lack of a customer-supplier focus, price-based selection and ineffective use of technology. Love and Sohal (2002) revealed that inadequate management practices have contributed to unnecessary costs, wasted time, increased errors, and misunderstandings between design consultants and contractors. Ultimately, these management practices result in conflict, reworking, and in some instances, litigation. Though Bertelsen's study (1993) suggests that poor supply chain design in construction increases the project cost by ten percent, this is most likely a conservative estimate that also affects project duration.

The CIDA (1994) and DISR (1999) reports on the Australian construction industry suggest that the industry requires reform to improve quality, productivity and performance. The need for radical improvement is not restricted to Australia alone, as several other countries have received similar scrutiny, e.g., Finland (Kauppa-ja Teollisuusministerio [KTM], 1996; Silen, 1997), Hong Kong (Grove, 1998; Tang, 2001), Norway (Haugen, 1999), Singapore (Construct 21 Steering Committee, 1999) and the UK (Latham, 1994; Egan, 1998). The above reports all call for

improved collaboration, integration, communication and coordination among customers and suppliers throughout the project supply chain.

Vrat (1998) observed that internationally, the interest in SCM has increased steadily since the 1980s; however, the concept in India is in a nascent stage. Economic deregulations and globalisation of the Indian industry have compelled Indian organisations to seek methodologies and processes that produce maximum efficiency both within and beyond their operations (Sahay, 1999). Further, Saxena and Sahay (2000) argued that the deregulation of the Indian economy over the last decade has attracted global players in every industrial sector and has unleashed a new competitive spirit in Indian organisations. Based on a study across all industrial segments, Sahay and Mohan (2003) recommended that Indian industry should align the supply chain strategy with business strategy, streamline processes for supply chain integration, form partnerships for minimising inventory and focus on infrastructure technology development to build an India-specific supply chain. The construction industry in India works in a very fragmented format. To apply the supply chain in construction, Ahmed, Azhar and Ahmad (2002) proposed integrating two construction processes: the procurement process and the construction service process. The flow of information and materials in the supply chain is not smooth, and in turn, this flow affects the overall project time and cost effectiveness. As discussed above, several independent organisations work together in construction projects, including clients, suppliers, architectural and structural engineering firms, main contractors, and sub-contractors. A project can be managed effectively if the activities of independent organisations are integrated by using SCM principles.

Government data[1] suggest that close to 60% of projects are plagued by time and cost overruns. On average, each project suffers from 20%–25% time and cost overruns, while in some sectors, overruns are over 50%. India has set a target of investing USD 1 trillion in infrastructure during the twelfth plan (2012–2017) period.

In the above context, the questions to be raised include the following:

1. Does the Indian construction industry follow SCM practices to integrate their activities?
2. If yes, what are the practices followed in the Indian construction sector to integrate the supply chain?
3. Are there any barriers to seamless project supply chain integration?

To study the above issues, the authors use the framework from the seamless SCM model proposed by Love, Irani and Edwards (2004). This paper attempts to answer the above questions in the context of flyover projects in India. The paper begins with the review of the literature of SCM in the construction sector, followed by the research framework, research objectives and research methodology. Next, we report the findings and analysis before discussing the findings. Lastly we summarise the paper with our conclusion and, present the implications and scope for future research.

LITERATURE REVIEW

Role and Challenges of SCM in Construction Projects

Love (2000) observed that many retail and manufacturing organisations were capitalising on SCM implementation for business process efficiency and effectiveness through intra- and inter-organisational relations. The construction industry was slow, or perhaps even reluctant, to employ SCM practices. He found that the major hurdle for not implementing SCM in construction projects is the temporary nature of client-designer-contractor-sub-contractor-supplier relations because of the unique nature of each product. Vrijhoef and Koskela (2000) found that the construction industry is the largest industrial sector in the world, accounting for approximately 10% of the global gross productive effort. The construction industry has great opportunity for improvement through SCM. O'Brien and Fischer (1993) also suggested that there is a potential for significant improvement in construction supply chain performance. However, they argued that the widespread use of labour-only subcontracting complicated the process because several tiers of sub-contractors exist within a single project setting. The involvement of multiple sub-contractors in a single project prevents the integration of the construction production process into a seamless project supply chain. A study by Greed (1997) showed that the pressure is continually on those at the next level down the hierarchy in the construction supply chain. Therefore, the relationships between main-contractors and sub-contractors tend to be strained (Hinze and Tracey, 1994). According to Koskela and Ballard (2006), involving downstream players in upstream decisions and integrated teams enables the main goals of transformation, flow and value generation to be pursued.

Barlow, Jashapara and Simpson (1997) observed that partnering is restricted to client-contractor linkages, as opposed to developing strategic alliances throughout the supply chain network. This is a result of the industry's traditional approach of vertically differentiating the construction process, which results in extremely fragmented project delivery structures. Project management is concerned with the coordination and integration of the project team to fulfil clients' needs (Walker, 2007).

The above-mentioned studies have identified challenges related to SCM in construction projects. These challenges are (1) the temporary nature of the relationship between agents, (2) several layers of subcontracting within a single project setting, (3) lack of knowledge of downstream project agents about upstream project decisions, and (4) a restricted partnership between the client and contractor.

Vrijhoef and Koskela (2000) identified the roles of SCM in construction to reduce total cost and time. Their focus was on the impacts of the supply chain on site activities, logistics, lead time and inventory. The study found that several SCM initiatives, such as partnering and incentive-based contracting, have been sporadically implemented to improve construction project performance. They further argued that such initiatives have often been used in combination with traditional practices for managing and controlling the project supply chain. As a result, performance improvements have been limited to the sub-process level. They suggested transferring activities from the site to earlier stages of the supply chain and integrating the management of the supply chain and site production.

Value Management and Strategic Needs Analysis

Ellis and Wood (2005) reported that value management focuses on continuously increasing the value provided to the client and is widely accepted as an important tool in the recent management of construction projects. Kelly, Male and Graham (2004) argued that it focuses on value rather than cost and seeks to achieve an optimal balance between time, cost and quality. It helps integrate the building processes that no other management structure in construction can provide (Kelly and Male, 1991). Ashworth and Hogg (2000) identified that value management is critical to the success of projects because it provides the basis for improving the value for the money in construction. At an international level, value management is considered to be an important field.

Strategic needs analysis (SNA) is a process that involves the client and all other stakeholders who have an interest in the project and can make a contribution to improving the type, nature and quality of the proposed project (Smith, Love and Wyatt, 2000). Smith, Kenley and Wyatt (1998) suggested that SNA starts with the premise that the delivered solution will be the one that can best satisfy the clients' strategic needs. In this SNA approach, the client is advised at the strategic or pre-design stage. Early stages of projects call for critical decisions that affect the economy, efficiency, timing, functional content, appearance and real value of the project (Barett, Hudson and Stanley, 1999; Smith and Love, 2001). Smith and Jackson (2000) suggested that the approach analyses and reviews client objectives, proposes alternatives and confronts participants with decision making.

Partnering between Supply Chain Members

The Construction Industry Institute (CII) defines partnering as "a long-term commitment by two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organisation boundaries. The relationship is based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost-effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services". Bygballe, Jahre and Sward (2010) identified three key dimensions of partnering: relationship duration, relationship partners and relationship development. Harris and McCaffer (2001) considered partnering to be a strategic arrangement whereby a contractor is engaged in a series of projects with the same client to lower costs and improve efficiency. According to Reed (1999) and Himes (1995), partnering between members of the construction supply chain helps in problem solving and improves the knowledge of the processes. Al-Mahbashi (2007) identified that the requirement of an organisation to be competitive led to the emergence of alliances, partnering and other forms of collaborative work in construction. Barlow and Jashapara (1998) highlighted the importance of collaborative links between firms for simulated organisation learning. The study of Barlow, Jashapara and Simpson (1997) emphasised that mutual objectives, trust and understanding of each other's commitment are critical to partnering success.

Though the application of SCM philosophies is emergent within the construction industry, organisations are beginning to comprehend the intrinsic value (Akintoye, McIntosh and Fitzgerald, 2000; Vrijhoef and Koskela, 2000; Love, 2000; Dainty, Briscoe and Millett, 2001). Pearson's (1999) study suggested that SCM has replaced partnering in the UK construction industry. However, only a few UK clients (British Airport Authorities [BAA], the Ministry of Defence and Tesco) and contractors (Balfour, Beatty and Tarmac) use SCM as an integrative part of their business strategy for managing their projects. Further, the study notes that clients and contractors have reduced their supplier base, established and nurtured relationships with suppliers, organised training programmes to encourage a cooperative approach to problem solving, and developed systems for rating a supplier's performance on quality, speed and prices. The study also stated that these firms involve suppliers at an early stage in the project to acquire their knowledge regarding design and procurement issues. The research of Castro-Lacowture and Skibniewski (2003) displayed the effective conflict resolution ability of E-work Models. The E-work model assumes that all project participants, e.g., the designer, contractor, sub-contractor, and fabricator, belong to the same company and share the cost minimisation function.

Research Gap

The focus of most of the existing research into construction SCM has been on specific aspects of the supply chain, such as client-contractor relations (Akintoye, McIntosh and Fitzgerald, 2000), contractor, sub-contractor and supplier interface (Vrijhoef and Koskela, 2000), or rework (Love, Mandal and Li, 1999). Studies in the construction sector are also undertaken on aspects such as environmental performance (Ofori, 2000), design management (Khalfan et al., 2001), service quality (Hoxley, 2001), and purchasing behaviour (Dubios and Gadde, 2000). Barker, Hong-Minh and Naim (2000) argued that there is a clear gap in research that takes a holistic approach to SCM as applied to construction projects. Until now, in the construction industry, initiatives belonging to the domain of SCM have been minimal, covering a subset of issues (e.g., transportation costs) in a limited part of the construction supply chain (e.g., the construction site). Asplund and Danielson (1991) stated that in most cases, the issues are considered from a main contractor's point of view. Agapiou et al. (1998), Akintoye, McIntosh and Fitzgerald (2000) and Love (2000) argued that construction project SCM is not forthcoming in the literature.

We can observe from the above discussion that most studies on SCM in the construction sector have been undertaken in developed countries for specific aspects of SCM. Our research is an attempt to study the use of SCM in the context of the Indian (i.e., a developing country) construction industry. Further, this research on supply chain perspective has been attempted with a holistic view for infrastructure projects.

The next section discusses the research framework, research objectives and research methodology.

RESEARCH FRAMEWORK, RESEARCH OBJECTIVES AND RESEARCH METHODOLOGY

Research Framework

In our research, we used the Love, Irani and Edwards (2004) model to develop the research framework. The authors of the model reported that an effective implementation of the SCM model in practice requires a leader who can coordinate and integrate activities and resources throughout the procurement process. They propose a seamless project supply chain model, as shown in Figure 1, for construction projects; using this method, the project facilitator acts as a conduit through which two-way communications would flow between project teams and the client.

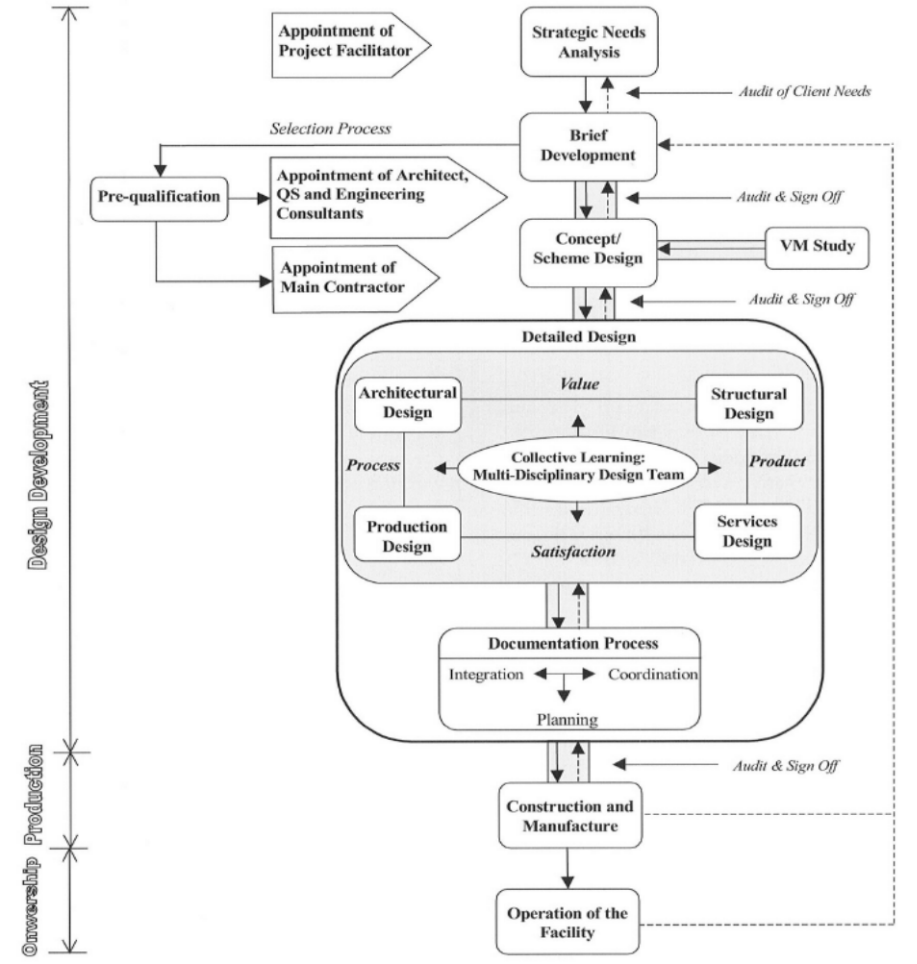

Figure 1. A Seamless Project Supply Chain Management Model
(Source: Love, Irani and Edwards, 2004)

The model shows that any construction project starts with the strategic needs analysis as the first step. According to this model, a project facilitator, i.e., project manager, should be appointed by the client at the initial stage of the project. His responsibilities would include identifying the project's strategic needs, and initiating and managing the design and development process. Value management is also considered an important aspect of project processes and should be undertaken prior to the project's detailed design and documentation stage; value management helps minimise the impact of any change orders or design rework that may be initiated by the client at a later stage. Green (1996) observed that some of the best projects have demonstrated the benefits of using value management.

The authors of the model further proposed that structural and other designers, contractors, sub-contractors, suppliers and project management consultants should all work together from the design stage itself. Input at the design stage from other agents, including contractors, sub-contractors and suppliers, would help the designer understand the needs at the site better. At the same time, contractor involvement at the design stage would help the contractors understand what is expected of them and how to execute the work effectively. Throughout the construction process, the project manager would assume an active coordinator's role to ensure smooth project implementation.

This research evaluated the practices followed in Indian projects and compared them with Love's proposed model (Love, Irani and Edwards, 2004). The following elements of the model were used for our study:

1. Strategic Needs Analysis,
2. Value Management Study,
3. Role of Project Management Consultants (PMCs)/Third-Party Consultants (TPCs),
4. Appointment of a Structural Consultant,
5. Selection of the Main Contractor, Sub-Contractor and Supplier, and
6. Role of the Client.

Research Objectives

1. To study and compare the current SCM practices in a flyover project in the Indian construction industry with a "seamless project SCM model for construction" proposed by Love, Irani and Edwards (2004).
2. To identify barriers in implementing the above-mentioned seamless supply chain model for flyover projects in the Indian construction industry and suggest modifications or improvements to the model.

Research Methodology

This research study employed a case study research design. Yin (1994) suggested that the multiple case study approach shows numerous sources of evidence through replication rather than through sampling logic. Hence, generalisation of the results from case studies, irrespective of single or multiple case study designs, stems from theory rather than on populations.

Of the 10 flyover projects in the implementation stage that we considered, four projects were selected. The selected four flyover projects were from four different zones of one metro city of the Gujarat State in India. They were typical in nature because all four projects were implemented by government authorities, which served as the client. The projects undertaken on the public private partnership (PPP) model may differ in terms of implementation. Semi-structured interviews were conducted to understand the SCM practices in the flyover projects. Prior to conducting the interview, a pilot study was conducted with four respondents to understand the SCM phenomenon in the construction industry. The feedback was considered to improve the quality of the semi-structured interviews. The respondents were from selected four flyover projects. They comprised project management consultants (PMC), structural consultants, clients, contractors, sub-contractors and suppliers. In total, we contacted 42 respondents who had work experience ranging from five to 30 years.

An explanation of the seamless project supply chain model proposed by Love, Irani and Edwards (2004) was given. Content analysis was performed to compare and analyse the SCM practices across the projects. The respondents were required to compare the practices followed in their project with the practices recommended by the authors of the proposed seamless supply chain model. We identified gaps in the current SCM practices followed by the studied firms compared with the practices suggested by the Love, Irani and Edwards (2004) seamless SCM model for construction. A profile of the projects studied is given below in Table 1.

Table 1. Profile of Projects Studied

	Case Study Project 1	**Case Study Project 2**	**Case Study Project 3**	**Case Study Project 4**
Client	Government	Government	Government	Government
PMC / Third party consultant	Third party consultant	Third party consultant	Third party consultant	PMC
Number of respondents contacted	10	11	9	12
Project start date	August 2009	July 2009	Dec 2007	Jan 2009
Tentative end date of project	July 2010	August 2010	July 2010	Aug 2010
Actual end date of project	April 2011	February 2011	December 2010	July 2011
Project cost	Rs. 8 Crores	Rs. 10 Crores	Rs. 23 Crores	Rs. 7 Crores

The listed projects were all delayed and could not be completed as planned with regards to time and cost.

FINDINGS AND ANALYSIS

Our findings and analysis, including a comparison of the SCM practices followed in Indian flyover projects with the Love, Irani and Edwards (2004) model of seamless project SCM, is given below. Table 2 shows the comparative analysis.

Table 2. Comparative Analysis: Seamless SCM in Case Study Projects

Love, Irani and Edwards Model Requirements	**Case Study Project 1**	**Case Study Project 2**	**Case Study Project 3**	**Case Study Project 4**
1. Strategic Needs Analysis	Not done; Based on PCU project was undertaken	Not done; Based on PCU project was undertaken	Not done; Based on PCU project was undertaken	Not done; Based on PCU project was undertaken
2. Values Management Analysis	Not done; Based on PCU project was undertaken	Not done; Based on PCU project was undertaken	Not done; Based on PCU project was undertaken	Value management studies for project functionality, construction feasibility and method of construction was carried out, it helped in 40% reduction in time and 5% reduction in cost
3. Appointment of PMC/Third Party Consultant	Managed by client's engineers; Third party consultant appointed after the designs were completed	Managed by client's engineers; Third party consultant appointed after the designs were completed	Managed by client's engineers; Third party consultant appointed after the designs were completed	PMC appointed at the start of design stage
4. Involvement of Structural Consultant at Design Stage	Appointed after design stage	Appointed after design stage	Appointed after design stage	Structural consultant and PMC by same firm, some degree of integration in supply chain

(*continue on next page*)

Table 2: (*continued*)

Love, Irani and Edwards Model Requirements	**Case Study Project 1**	**Case Study Project 2**	**Case Study Project 3**	**Case Study Project 4**
5. Involvement of Contractors, Sub-Contractors and Suppliers at Design Stage	Not involved at design stage	Not involved at design stage	Not involved at design stage	Not involved at design stage
6. SCM between Clients, Contractors, Sub-Contractors and Suppliers at Design Stage	Contractual relationship between them which is limited to respective projects, Selection criteria of agents are work experience and least cost	Contractual relationship between them which is limited to respective projects, Selection criteria of agents are work experience and least cost	Contractual relationship between them which is limited to respective projects, Selection criteria of agents are work experience and least cost	Contractual relationship between them which is limited to respective projects, Selection criteria of agents are work experience and least cost

Strategic Needs Analysis and Value Management Study

Passenger Count Unit (PCU) and traffic intensity at the peak hours were already known in all projects; therefore, the respondents claimed that a proper strategic needs analysis was not conducted for any of the projects. However, all of the respondents agreed that the procedure of identifying the clients' strategic needs and developing a plan is logical and helpful for the effective implementation of projects. The model proposed by Love, Irani and Edwards (2004) suggests that a proper strategic needs analysis in terms of a project feasibility report helps in the effective implementation of projects.

Additionally, a value management study was not conducted in the first three case studies before the start of the projects. The project management teams from these three projects had either non-existent or very limited knowledge regarding value management study. Upon vaguely understanding the concept, they claimed that they already had the right practices in place, so there was no need for a value management study. The model suggests that value management study analysis concerning the use of various construction materials, equipment and methods from the viewpoint of cost and project time is very critical.

A value management study was completed in only one of the studied projects: Case Study Project 4. In this project, the same consulting firm was involved in project management and structural design. The consultant agreed and claimed that they conducted a value management study for the project's functionality, construction feasibility and construction method. They claimed that

the value management study helped reduce the construction time by approximately 40% and the costs by approximately 5%.

Our research found that most of the agents in the Indian construction industry do not understand the importance of value management analysis and consider it to be an activity that increases the cost.

Project Management Consultants/Third-Party Consultants

Of the four projects studied, the first three projects were managed by the client's engineers. However, in these three projects, third-party consultants were appointed to ensure that the project progressed with the desired quality and specifications. Third-party consultants were appointed after the detailed designs were completed and approved by the relevant authorities. Therefore, the integration of other project activities with design activity was missing. In the fourth project, the Project Management Consultancy (PMC) was appointed at the start of the design stage. The PMC had an in-house structural design team that completed the design of the project. In this case, the project manager was also the head of the design team. Involving the project managers in the design process helped them understand the expected quality of the structure and plan the construction sequence in a more efficient way. It also reduced the uncertainties related to the execution stage. Thus, involving PMC/third-party consultants in the design stage helps project-related decisions be made more quickly and the project be completed in the stipulated time.

The PMC and third-party consultants were appointed based on both their work experience and the cheapest cost quoted in the tender. All of the flyover projects studied are government projects. It is expected that government projects, i.e., public works, be completed with minimal cost. The main goal in appointing a PMC/third-party consultant is to deliver the projects in the stipulated time and with the specified quality and budget. To achieve this goal without hurdles, SCM concepts should be used in projects.

Structural Consultant

Structural consultants were appointed when the decision to make the flyover was finalised and/or approved by government authorities. They were selected through the tendering procedure, wherein the main criteria for selection were work experience and the cheapest cost.

The structural consultant's role included soil testing, surveying and levelling and generating estimates, detailed designs and drawings. The guidelines set by the Roads and Buildings Department of the Government of India were followed for structural designs. The drawings were checked and reviewed by engineers of the Road and Building Department. No other agents related to the project were involved in the structural or other designs because the practice followed in India is to appoint the contractor only after the design and drawings are ready.

In the first three case study projects, the structural consultants were not involved at the strategic needs analysis stage. No design changes were permitted for any of the projects because there was no coordination between the structural consultant and the execution team at the design stage. Therefore, the agents working in the downstream process were compelled to follow the drawings.

Additionally, in some instances, the design was not changed to suit the contractors' working methods.

In one project, i.e., Case Study Project 4, structural design and project management consultancy were performed by the same consultant. Therefore, in this project, the project management team was involved in the design process. Their involvement helped the PMC obtain better clarity during the project execution stage because the personnel who carried out the structural design could be easily reached for any data needed. Additionally, the PMC's suggestions were availed by the structural design team at the design stage. However, other agents working in the downstream process were not involved in the design process.

Main Contractor, Sub Contractor and Supplier

Main contractors were appointed by the clients once the designs were ready. Therefore, it was difficult to modify the design to suit the working method of the contractor. The criteria for selecting the main contractors were work experience, labour and machinery strength and the cheapest cost quote. The selection was done through the tendering procedure. Because the main contractors are accustomed to the present work system, the idea of being involved at the design stage initially seemed absurd to them. However, after discussion on SCM, they agreed that their involvement at the design stage would help them understand the project needs better.

The sub-contractor and suppliers were also not involved at the design stage. Involving the main contractor and the sub-contractor at the design stage would help in developing and planning workable production strategies, schedules, and working methods. The suppliers could help by proposing the appropriate material and equipment.

It was found from the study that the relationships shared by the main contractors and the sub-contractors and by the main contractor and suppliers were temporary. The main contractors preferred to work with the same sub-contractor and suppliers; however, this was not possible because the selection is made based on bidding. Main contractors agreed that working with the same suppliers and sub-contractors on a continuous basis would be helpful to understanding their strengths and weaknesses better. Working with the same suppliers and sub-contractors help plan the work accordingly. It is also observed that a good relationship with other agents helps promote team work among the different agents; good relationships would eventually lead to a better work environment and faster completion of work at the budgeted cost.

The main contractors also agreed that they took the sub-contractors' advice regarding the need and time required to plan further work. Sub-contractors' work was usually reviewed every day by the contractors. The contractors, however, usually review suppliers once per year. Daily and weekly reviews with site engineers were carried out. Fortnightly, monthly and quarterly reviews were also carried out by all contractors. Because the main contractors from the studied projects were medium-sized firms, they did not have a proper information system in place. All contractors agreed that having an information system in place that linked supplier and sub-contractor information would help provide a better information flow. Thus, it would lead to real-time project review

with all agents. However, the contractors are of the opinion that the cost of using an information system is very high compared with the period for which it would be used, as the projects are unique and have a definite start and end point. Using an information system would be very helpful if all of the agents involved in a particular project continued working together for more projects in the future.

In the studied projects, the tentative material delivery schedule was given to the suppliers, but most of the time, orders were placed two or three days in advance. Suppliers were rarely asked for suggestions or information regarding what type of materials would be suitable. The maximum time overrun allowed for the materials to reach the site was approximately one to two days. The contractor would look for alternate sources for the same material so that in the case of non-availability of a material from one supplier, the material could be procured from another supplier. A proper information system would be helpful in managing timely material deliveries from suppliers and supplier relationships through real-time information.

Client

The clients also agreed that linking the information systems of all of the agents would help provide a better information flow. It is observed that because all of the studied projects were from the government department, the contracts were awarded as per the government rules, i.e., the cheapest cost subject to an agent meeting other qualifying criteria. Thus, it may not be possible to award contracts to agents who have a proper information system to implement SCM. Moreover, because the project is a time-bound activity, the construction team for one project would break up once the project is completed.

All clients unanimously agreed that coordination through the proper flow of information was a very important factor for the successful completion of any project. According to the clients, implementing the seamless SCM model would not be feasible in government projects because government departments must follow a set of rules when awarding a contract. However, they agreed that coordination through an information system would benefit both the project and the involved agents.

Barriers to implement seamless supply chain integration

Agents involved across the entire construction supply chain process (e.g., client, consultant, contractor, sub-contractor and supplier) should give equal importance to each other to develop a seamless project supply chain. The subordinate position of the sub-contractors and suppliers within the hierarchy of relationships leads to inter-organisational conflict. The pressure is continually on those at the next level down the hierarchy, which prevents the integration of those involved in the production process into a seamless supply chain.

For a seamless supply chain to exist, the flow of information among the agents and the alignment of the involved agents' systems and procedures in the project is very important. Because the main contractors involved in the surveyed projects were small or medium-sized enterprises, they themselves were not equipped with proper information technology systems. This is a barrier to integrating all of the agents in a supply chain in India. Not even the clients (in the

case of government departments) are equipped with an information technology system. Very little or no effort has been made to align the systems of different agents to avoid time- and communication-related problems.

The quality of information shared by the consultants with the main contractors and by the main contractors with the sub-contractors is also a matter of concern. The absence of a communication channel, late or inaccurate design information, main contractors' general neglect and sub-contractors' needs for accurate and prompt project-related data all have an impact on work quality. In a few cases, as a result of delay in certain permissions from government departments, the work suffered. Although it is the client's responsibility to obtain the necessary permissions from various regulatory authorities for executing the project, contractors are pressured to complete the work on time without obtaining the necessary permissions.

It was observed that clients, consultants and main contractors were more concerned with completing the projects in the shortest possible time. However, these agents failed to understand that better coordination and integration of their activities would help the project be completed with minimal hindrances. The respondents revealed that the lack of trust between agents as a result of past bitter experiences is a fundamental barrier to sharing each other's needs.

Our study found that downstream agents (e.g., contractor, sub-contractor, supplier) have been excluded from early involvement in projects because price was the major and primary criterion for selection the downstream agents. The practices followed by Indian government projects do not involve such agents in the early phase (e.g., strategic needs analysis, structural design and value management) of a project. As a result, the staff of the main contractor focuses on cost issues rather than identifying the added value that a supplier or sub-contractor might provide. The same is done by the client when selecting the main contractor. An argument presented by the clients is that as a public department, they must focus on the cheapest cost when the contractor meets a few basic selection criteria. The clients would be accused of partiality towards the chosen contractor if other parameters that were not as quantifiable as cost was taken into consideration. Moreover, involving these agents at an earlier stage of the project would mean an increase in that particular agent's responsibilities, which would increase the project's initial cost. It is suggested that the client should be made to understand that this additional cost would far outweigh the costs associated with changes, rework and delays in the project schedule.

DISCUSSION

Our research shows that the involvement of all agents in a construction project, e.g., contractor, sub-contractor, supplier, structural consultant and PMC/third-party consultant, is lacking at the project design stage, which leads to several problems at the execution stage. The practice in the Indian construction industry is to involve these agents once the design is finalised. It is not possible to include all agents at the design stage because they are selected through a tendering process, with the cheapest cost as one of the criteria. It is suggested that the client can invite all qualified bidders to participate in design discussions and that later, whoever qualifies, per the client's norm, may be given the contract.

The study revealed that the role of project facilitators is inadequate. In our study, this refers to third-party consultants, the client's engineers and the PMC. The project facilitator can actively play the role of a leader to ensure smooth and proper coordination between various agents. The client's active role as project leader will help in the timely execution of the project with the budgeted cost and required quality.

In government projects, the practice of offering or awarding a contract to the lowest cost bidder may be re-evaluated so that the overall quality of work and execution of the contract can be improved. Our results also show that construction industry agents lack knowledge of the SCM practices identified by the study of Love and Sohal (2002). This may be the reason for the slow implementation of SCM in the construction industry, as cited by Love (2000). We suggest that agents should be trained on the application of SCM in the construction industry to reap the benefits in projects.

This study also showed that partnering in the construction supply network is limited to the main contractor and sub-contractor, main contractor and supplier and sub-contractor and supplier levels. This relationship is on a project-to-project basis only, although they prefer to work with each other on a permanent basis because sub-contractors and suppliers are awarded a contract only through bidding processes and lowest cost criteria. Indirectly, this hampers the efficiency in project execution. Our study supports the arguments for partnering and networking in the construction supply chain made by Latham (1994), Egan (1998), Vollman, Cordon and Raabe (1998) and Harris and McCaffer (2001). We further suggest that the missing link is the involvement of all of the agents at the start of the project, i.e., the strategic needs analysis and design suggested by Love, Irani and Edwards (2004) in the seamless project supply chain model should be addressed by the industry.

All of the studied projects faced time and cost overruns that could have been controlled by using SCM concepts in construction projects. Two of the specific reasons that were identified for time overrun in the studied projects are (1) improper soil testing that led to pile foundation redesign and (2) encountering underground utilities while digging the foundation, which led to pile shifting. This could have been avoided if all of the project agents were involved from the project conception stage. Although Case Study Project 4 had some integration in their supply chain, it was not deliberate. Further, it had a missing link in downstream supply chains regarding integration with contractors, sub-contractors and suppliers. Therefore, the project could not obtain the benefit of limited supply chain integration. In our study, we noted that because of the poor performance of one agent, problems were created for other agents working downstream in the construction process. Thus, this study further confirms the findings of Greed (1997) that pressure is continually applied on those at the next level down in the process hierarchy. Proper coordination among agents helps them foresee some of the hurdles that hinder project completion. A lack of coordination among agents also leads to an increase in the overall cost of the project and delays the project completion time.

Our research also confirms the findings of Pearson (1999) that the main contractors, who have nurtured the relationship with sub-contractors and suppliers, prefer to work with the same agents on a permanent basis to achieve efficiency and effectiveness in construction projects. We agree with Wong and Fung's (1998)

findings that the main contractor must develop a structure for an efficient communication system for effective relationship management within their project team because the main contractor is at the hub of the design and production processes. In the Indian construction industry, competitiveness is not an issue among agents; therefore, there are minimal efforts to re-examine ways to manage the supply chain, as advocated by Al-Mahbashi (2007).

This research suggests that the Indian industry embrace the model proposed by Love, Irani and Edwards (2004) to improve construction projects' efficiency. It is further suggested that to partly introduce seamless SCM, project sponsors can award work to a Vertically Integrated Construction Company (VICC). The client's representative or client's engineer can act as project facilitator between the client and VICC to implement seamless SCM.

VICC refers to firms having in-house expertise to undertake all of the activities of a construction project, ranging from needs analysis to commissioning or project hand over. Integrating various project activities will be easier and faster for VICC as various divisions of VICC undertakes different roles in managing the project. Coordinating internally with other divisions will help manage the supply chain effectively.

CONCLUSION, IMPLICATIONS AND SCOPE FOR FUTURE RESEARCH

Conclusion

A typical construction supply chain network has the main contractor at the centre of the hub, with links to the client, main supply agencies (i.e., sub-contractor and suppliers), and design services and any specialist management services. The above agencies all operate independently, which makes the coordination task of the contractor difficult.

The agents involved in the Indian construction industry have either no or limited knowledge about the SCM concept and its application in the construction industry. It is further found that the studied firms did not follow two important stages, i.e., strategic needs analysis and value management study, as identified by Love, Irani and Edwards (2004) in their seamless SCM model. The concept of value management study is either not or vaguely known to agents working in the Indian construction industry. Downstream agents in the industry, including contractors, sub-contractors and suppliers, are not consulted at the design stage. They act as independent agencies and work in isolation. Sub-contractors and suppliers have limited collaboration with contractors, e.g., only during the project execution stage. It is observed from the study that the clients' proactive role as a leader in the supply chain is missing; this is a major barrier in the implementation of seamless SCM. The process of awarding work based only on lowest cost and work experience also creates hurdles in the implementation of seamless SCM in the Indian construction industry. Further, it is not possible to have a long-term relationship between agents because agents often work together for only a single project. Therefore, the agents are not motivated to implement an Information Technology (IT) system for integrating their supply chains.

All of the respondents agreed that working in coordination with other agents in the project would result in faster decision making so that the project can

be completed on time and within the budgeted cost. They also agreed that proper coordination would help stimulate teamwork and a collective learning environment. This study reveals that the Indian construction industry does not function like the true seamless project SCM model proposed by Love, Irani and Edwards (2004).

We suggest some modifications and improvements to the seamless project SCM model for construction proposed by Love, Irani and Edwards (2004) for its practice in developing countries like India. Because collaboration and a relationship between the agents involved in construction projects is limited to a single project, clients and clients' managers can plan to create long-term partnerships for specific categories or types (e.g., flyover, roads, factory buildings, airports) of projects. Least cost criteria may be avoided for awarding project work to agents. Clients may plan SCM training for all agents involved in project work before the start of the project.

Implications

Strategic needs analysis and value management study should be made an integral part of the construction project. Such studies help make the work easier and faster at the later stages. Implementing seamless project SCM calls for the involvement of all agents working on the projects starting at the beginning of the project.

An integrated information system helps achieve transparent and mutually beneficial processes for all parties in the project supply chain. Thus, it is very important that information systems be made an integral part of the construction industry. To achieve an integrated system that would make the construction process transparent, the client should take the lead and play an active role. Experienced public and private clients would be ideal for taking leadership in the processes. This study shows that public departments are not properly equipped, which makes this change more difficult to achieve in public departments.

Future Scope of Research

Only four projects were considered in this research. More such case studies can be examined to gain better insight about adoption of SCM in the Indian construction industry.

Because public sector projects were used as the case studies, the agents chosen for the work were those that quoted the lowest price for the given specifications. Their capability in terms of managing the project professionally was limited. Most of the contractors chosen for the case study projects had a very poor infrastructure to facilitate the integration of the supply chain and make information flow smoothly. Therefore, private projects should be studied. How a private sector client can affect the dynamics of the supply chain of the project can be studied to note the differences in public and private sector practices in the Indian construction industry.

Infrastructure projects other than flyovers can be studied to compare the SCM practices suggested by the model. Future research can be undertaken on issues relating to the selection of project team members if a public sector client were to adopt the proposed SCM model.

NOTE

1. Project Implementation Status Report of Central Sector Projects costing USD 3.5 million and above (April to June 2008), Ministry of Statistics and Programme Implementation.

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