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# A Study on Supply Chain Management in Construction Projects

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**Abstract:** *The construction industry in general is characterized with high fragmentation, low productivity, cost and time overruns, and conflicts compared with other manufacturing industries. Supply chain management as an innovative management mode provides a new solution for resolving these problems from systems perspective.*

*The main objective of this study is to find critical factors affecting supply chain management in construction industries. Focusing on the questionnaire survey, factors are collected and using fuzzy logic based assessment ranking is to be done. Selection of supplier is a complicated decision involving many criteria is taken into consideration. Analysis and Ranking is done using SPSS software and risk severity is to be carried out using fuzzy logic toolbox of MATLAB software rank. Questionnaire survey of supply chain management is carried out in several construction industries randomly selected among Kerala's construction industries. It is said that the ultimate goal of any effective supply chain management system is to reduce inventory.*

## I. INTRODUCTION

Supply chain management (SCM) has been widely regarded as an effective and efficient management measure and strategy to improve the performance of the construction industry, which has suffered from high fragmentation, large waste, poor productivity, cost and time overruns, and conflicts and disputes for many years. It has become a major subject of management research and manufacturing theory recently. Currently supply chain management is in its developing stage. The construction sector players including engineers, contractors, suppliers and clients. Every product that reaches an end user represents a cumulative effort of multiple organizations. These organizations refer collectively as a supply chain.

Supply chain management deals with the flow of goods and services and includes all processes that transform raw materials into final products. The major characteristic of the construction supply chain is that each client represents a unique customer with unique requirements. The construction supply chain have to adjust to that in order to become more effective and more efficient. Construction Project Management is defined as the direction, regulation and supervision of a project from early development to completion. The ultimate goal of construction project management is the full satisfaction of client's demands both in terms of functionality and budget.

## II. METHODOLOGY

"Supply Chain Management System" SCMS is an important step adopted to improve the quality in their productivity, early supply of materials, reduce inventory etc. Several literature reviews and factors related to the supply chain systems were studied. Each studies concentrate on different factors. Using the available details from the literatures, a questionnaire is prepared using likert scale method. The questionnaire provides the details regarding the critical factors affecting the supply chain system. From the questionnaire survey information's can be gathered and factors can be identified. Ranking can be done using SPSS software & analysis using fuzzy logic toolbox of MATLAB software. This study details the results of the questionnaire survey of supply chain management that are to be conducted in several construction industries randomly selected in kerala. A questionnaire is simply a tool for collecting and recording information about a particular issue of interest. It addresses a large number of issues and questions of concern in a relatively efficient way with the possibility of a high response rate. The success of a questionnaire is based upon the skills and insights with which the lists of questions are formulated along with the type of questions used.

## III. ANALYSIS

The collected data were analysed and ranked using the SPSS software and the risk severity were analysed through fuzzy logic toolbox of MATLAB software.

### A. Data Collection

For conducting the survey, 150 printed copies of questionnaires were distributed to various companies. Among them 94 responses were obtained from various people like Engineers, Contractors, Suppliers and Clients. These responses are used to identify the most critical factors of Supply Chain Management. The response rate data are explained in following tables and charts.

**B. Demographical Analysis**

1) *Designation of the Respondents:* From different companies a total of 29 Engineers, 21 Contractors, 25 Suppliers and 19 Clients had answered to the questionnaire. Figure 4.1 represents the designation of respondents.

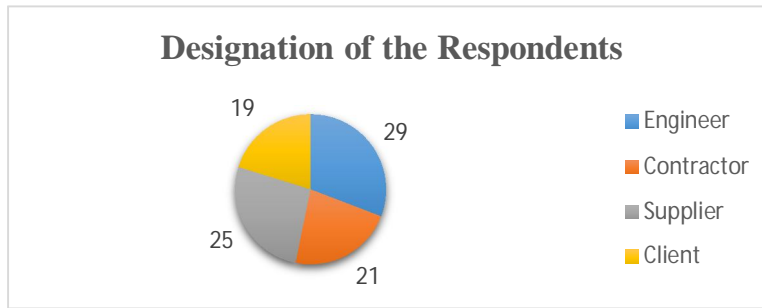


Figure 3.1 Designation of the Respondents

Among 94 people, 14 people from small industries, 42 from medium and 38 people from large industries were answered to the questionnaire survey.

**C. Analysis Of Results**

The main objective of conducting this project is to identify the factors that affect Supply Chain Management. The factors were identified from the literature review, these were analysed and ranked according to their significant influence towards construction projects in Supply Chain Management system.

**IV. RESULTS AND DISCUSSION**

**A. Factors For Engineers**

1) Factors Affecting the Efficiency of SCMS for Engineers

Table 4.1 Factors Affecting the Efficiency of SCMS for Engineers

| SL No. | Factors             | Mean   | Rank |
|--------|---------------------|--------|------|
| 1      | Production Planning | 4.5862 | 3    |
| 2      | Transportation      | 4.0345 | 5    |
| 3      | Inventory           | 4.7586 | 1    |
| 4      | Lead Time           | 4.4483 | 4    |
| 5      | Purchasing          | 4.7241 | 2    |

The major factors that affect the efficiency of SCM are Inventory, Transportation, Lead Time, Purchasing and Production Planning. Engineers were asked to scale the functions which were expected to influence their relationship with their suppliers.

2) Factors that are Barrier to Supply Chain Organization for Engineers

Table 4.2 Factors that are Barrier to Supply Chain Organization for Engineers

| SL No. | Factors   | Mean   | Rank |
|--------|---|--------|------|
| 1      | Late and incorrect payments                                     | 4.5862 | 1    |
| 2      | Retention / holding   | 4.3103 | 5    |
| 3      | Bidding process   | 4.4483 | 3    |
| 4      | Impractical program discussion                                  | 4.4138 | 4    |
| 5      | Traditional contracts do not promote good working relationships | 3.1724 | 8    |
| 6      | Estimators are too demanding on small organizations             | 4.2069 | 6    |
| 7      | Companies do not understand other business within supply chain  | 3.9310 | 7    |
| 8      | Quality less products purchasing and production                 | 4.5517 | 2    |

Late and incorrect payment, quality less products purchasing and production, estimators are too demanding on small organizations, companies do not understand other business within supply chain, and traditional contracts do not promote good working relationships are the main barriers to Engineers.

3) Factors Considering Supply Chain Participation for Engineers

Table 4.3 Factors Considering Supply Chain Participation for Engineers

| SL NO. | FACTORS                                  | MEAN   | RANK |
|--------|--|--------|------|
| 1      | Improved customer service                | 5.0000 | 1    |
| 2      | Overall supply chain reduction           | 4.6552 | 3    |
| 3      | Increased profitability                  | 4.6207 | 5    |
| 4      | Reducing paperwork                       | 4.3793 | 7    |
| 5      | Increased market competitiveness         | 4.3103 | 8    |
| 6      | Cost reductions within your organization | 4.5172 | 6    |
| 7      | Benefits to the client                   | 4.6552 | 4    |
| 8      | Benefits to your supplier                | 4.2759 | 9    |
| 9      | Improved quality assurance               | 4.9655 | 2    |

Contractors should analyse their partners’ demand logically during the project which is essential for a successful collaboration between a contractor and its partners leading to a well-established and developed SCM organization. Mainly Increased profitability, Increased market competitiveness, improved customer service, Benefits to the suppliers, improved quality assurance are the main factors.

B. Factors For Contractors

1) Factors Affecting the Efficiency of SCMS for Contractors

Table 4.4 Factors Affecting the Efficiency of SCMS for Contractors

| SL No. | Factors             | Mean   | Rank |
|--------|---------------------|--------|------|
| 1      | Production Planning | 4.4286 | 4    |
| 2      | Transportation      | 3.7143 | 5    |
| 3      | Inventory           | 4.7143 | 1    |
| 4      | Lead Time           | 4.5238 | 3    |
| 5      | Purchasing          | 4.6190 | 2    |

2) Factors that are Barrier to Supply Chain Organization for Contractors

Table 4.5 Factors that are Barrier to Supply Chain Organization for Contractors

| SL No. | Factors   | Mean   | Rank |
|--------|---|--------|------|
| 1      | Late and incorrect payments                                     | 4.7143 | 1    |
| 2      | Retention / holding   | 4.4762 | 3    |
| 3      | Bidding process   | 4.4286 | 4    |
| 4      | Impractical program discussion                                  | 4.1905 | 6    |
| 5      | Traditional contracts do not promote good working relationships | 3.1429 | 8    |
| 6      | Estimators are too demanding on small organizations             | 4.2381 | 5    |
| 7      | Companies do not understand other business within supply chain  | 4.1905 | 7    |
| 8      | Quality less products purchasing and production                 | 4.5238 | 2    |

3) Factors Considering Supply Chain Participation for Contractors

Table 4.6 Factors Considering Supply Chain Participation for Contractors

| SL NO. | FACTORS                                  | MEAN   | RANK |
|--------|--|--------|------|
| 1      | Improved customer service                | 5.0000 | 1    |
| 2      | Overall supply chain reduction           | 4.5238 | 5    |
| 3      | Increased profitability                  | 4.4762 | 6    |
| 4      | Reducing paperwork                       | 4.4286 | 8    |
| 5      | Increased market competitiveness         | 4.1905 | 9    |
| 6      | Cost reductions within your organization | 4.6667 | 3    |
| 7      | Benefits to the client                   | 4.6667 | 4    |
| 8      | Benefits to your supplier                | 4.3810 | 7    |
| 9      | Improved quality assurance               | 5.0000 | 2    |

C. Factors For Suppliers

1) Factors which Develop Successful Supply Chain Relationship with clients

Table 4.7 Factors which Develop Successful Supply Chain Relationship with clients

| SL NO. | FACTORS   | MEAN   | RANK |
|--------|---|--------|------|
| 1      | Valid delivery date                             | 4.4400 | 7    |
| 2      | Accurate order fulfilment                       | 4.4400 | 8    |
| 3      | Level of complaints/ returns                    | 4.2000 | 11   |
| 4      | Delivery at specified time                      | 5.0000 | 1    |
| 5      | Flexibility/willingness to change or compromise | 4.3600 | 9    |
| 6      | Fast order cycle time                           | 4.3600 | 10   |
| 7      | Handling of complaints                          | 4.8400 | 3    |
| 8      | Added value/additional benefits                 | 4.0400 | 13   |
| 9      | Quality of materials                            | 4.7200 | 6    |
| 10     | Quality of service                              | 4.8000 | 4    |
| 11     | Trust   | 4.8800 | 2    |
| 12     | Simplifying the whole construction process      | 4.2800 | 12   |
| 13     | Cost and financial stability                    | 4.7600 | 5    |

It was analysed that suppliers were aware of importance of clients for developing a successful supply chain relationship. The questionnaire were provided to reveal the degree of importance of which factors were more important for them. Factors were listed as valid delivery date, delivery at specified time, quality of materials, simplifying the construction process, handling of complaints.

2) Factors Considered While Taking Decision with Clients

Table 4.8 Factors Considered While Taking Decision with Clients

| SL NO. | FACTORS   | MEAN   | RANK |
|--------|---|--------|------|
| 1      | Being consulted in deciding the production Schedule       | 4.6400 | 3    |
| 2      | Being consulted in deciding which new products to develop | 4.5600 | 5    |
| 3      | Being consulted regarding new technological Innovations   | 4.7600 | 1    |

|   |   |        |   |
|---|---|--------|---|
| 4 | Delivery risk factors                             | 4.2000 | 7 |
| 5 | Market competitors                                | 4.4800 | 6 |
| 6 | Production factors (Quality, Quantity, standards) | 4.6400 | 4 |
| 7 | Financial status                                  | 4.6800 | 2 |

Delivery risk factors, being consulted in deciding which new product to develop, Market competitors, being consulted in deciding the production schedule, being consulted in deciding which new product to develop are the selected main five factors.

### 3) Factors Considered When Sharing Information with Clients

Table 4.9 Factors Considered When Sharing Information with Clients

| SL NO. | FACTORS   | MEAN   | RANK |
|--------|---|--------|------|
| 1      | Competitive advantage is sought by production planning or inventory decisions                   | 4.3200 | 2    |
| 2      | Competitive advantage is sought by sharing information with suppliers or customers              | 4.2800 | 3    |
| 3      | Competitive advantage is sought by performing some of your suppliers or customers work for them | 4.4400 | 1    |
| 4      | Proportion of overall production process subcontracted to outside firms                         | 4.2400 | 4    |

Competitive advantage is sought by sharing information with suppliers or customers, Competitive advantage is sought by production planning or inventory decision, Proportion of overall production process subcontracted to outside firms, Competitive advantage is sought by performing some of the supplier or customers work for them thus all factors are considered and ranked accordingly.

### D. Factors For Clients

#### 1) Factors in Relationship between Clients & Organization

Table 4.10 Factors in Relationship between Clients & Organization

| SL NO. | FACTORS                                    | MEAN   | RANK |
|--------|--|--------|------|
| 1      | Reliability of supply                      | 4.6316 | 5    |
| 2      | Top management support                     | 4.5789 | 8    |
| 3      | Trust                                      | 4.8947 | 1    |
| 4      | Mutual interest                            | 4.7895 | 2    |
| 5      | Manpower development                       | 4.3158 | 11   |
| 6      | Closer links between demand/ supply        | 4.4737 | 9    |
| 7      | Free flow of information                   | 4.6842 | 3    |
| 8      | Integrated information systems             | 4.2632 | 12   |
| 9      | More frequent meetings                     | 4.3684 | 10   |
| 10     | Joint business planning                    | 4.1053 | 13   |
| 11     | Simplifying the whole construction process | 4.6842 | 4    |
| 12     | Creating standardization of processes      | 4.6316 | 6    |
| 13     | Simplifying the bidding process            | 4.6316 | 7    |

Trust, mutual interest, free flow of information, simplifying the whole construction process, Reliability of supply are the first five ranked factors obtained.

2) Factors Considered while Taking Decision with Suppliers

Table 4.11 Factors Considered while Taking Decision with Suppliers

| SL NO. | FACTORS   | MEAN   | RANK |
|--------|---|--------|------|
| 1      | Being consulted in deciding the production Schedule       | 4.5789 | 3    |
| 2      | Being consulted in deciding which new products to develop | 4.5789 | 4    |
| 3      | Being consulted regarding new technological Innovations   | 4.5263 | 5    |
| 4      | Financial status  | 4.6316 | 2    |
| 5      | Market competitors  | 4.4737 | 6    |
| 6      | Quality standards   | 4.7895 | 1    |
| 7      | Inbound transportation                                    | 4.4211 | 7    |

Quality standards, Financial status, Being consulted in deciding the production Schedule, Being consulted in deciding which new products to develop, Being consulted regarding new technological Innovations are the major five ranked factors considered while taking decision with suppliers.

3) Factors Considered When Sharing Information with Suppliers

Table 4.12 Factors Considered When Sharing Information with Suppliers

| SL NO. | FACTORS   | MEAN   | RANK |
|--------|---|--------|------|
| 1      | Competitive advantage is sought by sharing information with suppliers   | 4.6316 | 1    |
| 2      | Competitive advantage is sought by production planning                  | 4.3684 | 2    |
| 3      | Competitive advantage is sought by taking inventory decisions           | 4.4211 | 3    |
| 4      | Proportion of overall production process subcontracted to outside firms | 3.6316 | 4    |

Competitive advantage is sought by sharing information with suppliers, Competitive advantage is sought by production planning, Competitive advantage is sought by taking inventory decisions, Proportion of overall production process subcontracted to outside firms are the critical factors when sharing information with suppliers.

*E. Analysis Using Fuzzy*

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth.

There are basically three steps for analysing data in Fuzzy logic tool,

- 1) Fuzzification
- 2) Fuzzy Inference
- 3) Defuzzification

a) Fuzzy Output

Table 4.13 Fuzzy output factors for Engineers

| SL NO. | FACTORS   | RANK | FUZZY OUTPUT SEVERITY |
|--------|---|------|-----------------------|
| 1      | Production Planning   | 8    | MODERATE              |
| 2      | Transportation  | 20   | MINIMAL               |
| 3      | Inventory   | 3    | CRITICAL              |
| 4      | Lead Time   | 13   | MINIMAL               |
| 5      | Purchasing  | 4    | CRITICAL              |
| 6      | Late and incorrect payments                                     | 9    | MODERATE              |
| 7      | Retention / holding   | 16   | MINIMAL               |
| 8      | Bidding process   | 12   | MINIMAL               |
| 9      | Impractical program discussion                                  | 14   | MINIMAL               |
| 10     | Traditional contracts do not promote good working relationships | 22   | MINIMAL               |
| 11     | Estimators are too demanding on small organizations             | 19   | MINIMAL               |
| 12     | Companies do not understand other business within supply chain  | 21   | MINIMAL               |
| 13     | Quality less products purchasing and production                 | 10   | MODERATE              |
| 14     | Improved customer service                                       | 1    | CRITICAL              |
| 15     | Overall supply chain reduction                                  | 5    | CRITICAL              |
| 16     | Increased profitability   | 7    | MODERATE              |
| 17     | Reducing paperwork  | 15   | MINIMAL               |
| 18     | Increased market competitiveness                                | 17   | MINIMAL               |
| 19     | Cost reductions within your organization                        | 11   | MODERATE              |
| 20     | Benefits to the client  | 6    | MODERATE              |
| 21     | Benefits to your supplier                                       | 18   | MINIMAL               |
| 22     | Improved quality assurance                                      | 2    | CRITICAL              |

Table 4.14 Fuzzy output factors for Contractors

| SL NO. | FACTORS   | RANK | FUZZY OUTPUT SEVERITY |
|--------|---|------|-----------------------|
| 1      | Production Planning   | 15   | MINIMAL               |
| 2      | Transportation  | 21   | MINIMAL               |
| 3      | Inventory   | 3    | CRITICAL              |
| 4      | Lead Time   | 10   | MODERATE              |
| 5      | Purchasing  | 7    | MODERATE              |
| 6      | Late and incorrect payments                                     | 4    | CRITICAL              |
| 7      | Retention / holding   | 11   | MODERATE              |
| 8      | Bidding process   | 13   | MINIMAL               |
| 9      | Impractical program discussion                                  | 18   | MINIMAL               |
| 10     | Traditional contracts do not promote good working relationships | 22   | MINIMAL               |
| 11     | Estimators are too demanding on small organizations             | 17   | MINIMAL               |
| 12     | Companies do not understand other business within supply chain  | 19   | MINIMAL               |
| 13     | Quality less products purchasing and production                 | 9    | MODERATE              |
| 14     | Improved customer service                                       | 1    | CRITICAL              |
| 15     | Overall supply chain reduction                                  | 8    | MODERATE              |
| 16     | Increased profitability   | 12   | MINIMAL               |
| 17     | Reducing paperwork  | 14   | MINIMAL               |
| 18     | Increased market competitiveness                                | 20   | MINIMAL               |
| 19     | Cost reductions within your organization                        | 5    | CRITICAL              |
| 20     | Benefits to the client  | 6    | MODERATE              |
| 21     | Benefits to your supplier                                       | 16   | MINIMAL               |
| 22     | Improved quality assurance                                      | 2    | CRITICAL              |

Table 4.15 Fuzzy output factors for Suppliers

| SL NO. | FACTORS   | RANK | FUZZY OUTPUT SEVERITY |
|--------|---|------|-----------------------|
| 1      | Valid delivery date   | 13   | MINIMAL               |
| 2      | Accurate order fulfilment   | 14   | MINIMAL               |
| 3      | Level of complaints/ returns  | 22   | MINIMAL               |
| 4      | Delivery at specified time  | 1    | CRITICAL              |
| 5      | Flexibility/willingness to change or compromise   | 16   | MINIMAL               |
| 6      | Fast order cycle time   | 17   | MINIMAL               |
| 7      | Handling of complaints  | 3    | CRITICAL              |
| 8      | Added value/additional benefits   | 24   | MINIMAL               |
| 9      | Quality of materials  | 7    | MODERATE              |
| 10     | Quality of service  | 4    | CRITICAL              |
| 11     | Trust   | 2    | CRITICAL              |
| 12     | Simplifying the whole construction process  | 19   | MINIMAL               |
| 13     | Cost and financial stability  | 5    | CRITICAL              |
| 14     | Being consulted in deciding the production Schedule   | 10   | MODERATE              |
| 15     | Being consulted in deciding which new products to develop                                       | 11   | MODERATE              |
| 16     | Being consulted regarding new technological Innovations   | 6    | MODERATE              |
| 17     | Delivery risk factors   | 23   | MINIMAL               |
| 18     | Market competitors  | 12   | MINIMAL               |
| 19     | Production factors (Quality, Quantity, standards)   | 9    | MODERATE              |
| 20     | Financial status  | 8    | MODERATE              |
| 21     | Competitive advantage is sought by production planning or inventory decisions                   | 18   | MINIMAL               |
| 22     | Competitive advantage is sought by sharing information with suppliers or customers              | 20   | MINIMAL               |
| 23     | Competitive advantage is sought by performing some of your suppliers or customers work for them | 15   | MINIMAL               |
| 24     | Proportion of overall production process subcontracted to outside firms                         | 21   | MINIMAL               |

Table 4.16 Fuzzy output factors for Clients

| SL NO. | FACTORS   | RANK | FUZZY OUTPUT SEVERITY |
|--------|---|------|-----------------------|
| 1      | Reliability of supply   | 6    | MODERATE              |
| 2      | Top management support  | 11   | MODERATE              |
| 3      | Trust   | 1    | CRITICAL              |
| 4      | Mutual interest   | 2    | CRITICAL              |
| 5      | Manpower development  | 21   | MINIMAL               |
| 6      | Closer links between demand/ supply                                     | 15   | MINIMAL               |
| 7      | Free flow of information  | 4    | CRITICAL              |
| 8      | Integrated information systems  | 22   | MINIMAL               |
| 9      | More frequent meetings  | 19   | MINIMAL               |
| 10     | Joint business planning   | 23   | MINIMAL               |
| 11     | Simplifying the whole construction process                              | 5    | CRITICAL              |
| 12     | Creating standardization of processes                                   | 7    | MODERATE              |
| 13     | Simplifying the bidding process   | 8    | MODERATE              |
| 14     | Being consulted in deciding the production Schedule                     | 12   | MINIMAL               |
| 15     | Being consulted in deciding which new products to develop               | 13   | MINIMAL               |
| 16     | Being consulted regarding new technological Innovations                 | 14   | MINIMAL               |
| 17     | Financial status  | 9    | MODERATE              |
| 18     | Market competitors  | 16   | MINIMAL               |
| 19     | Quality standards   | 3    | CRITICAL              |
| 20     | Inbound transportation  | 17   | MINIMAL               |
| 21     | Competitive advantage is sought by sharing information with suppliers   | 10   | MODERATE              |
| 22     | Competitive advantage is sought by production planning                  | 20   | MINIMAL               |
| 23     | Competitive advantage is sought by taking inventory decisions           | 18   | MINIMAL               |
| 24     | Proportion of overall production process subcontracted to outside firms | 24   | MINIMAL               |

## V. CONCLUSION

Studies and discussions were done on supply chain management at various fields based on the journals collected. Supply chain management is a challenging task in the construction industry and are complex in their structure. Different factors affecting supply chain in construction fields are identified and the conceptual remedial measures for each study are suggested according to its convenience. The details regarding the topic is collected by questionnaire survey with the help of internal and external personalities involved in the system. By conducting questionnaire survey more knowledge regarding the SCMS was obtained. Even if major steps are taken to improve the efficiency and productivity of construction industry, for the last decades on the performance of construction industry in terms of the budget, quality of service, quality of materials and time of delivery, there is still room for the improvements of supply chain management tools.

The overall performance of Engineers, Contractors, Suppliers and Clients were ranked. Improved customer service, Improved quality assurance, Inventory and Purchasing are the main five ranked factors. According to the survey of Contractors the highest ranked factors are Improved customer service, Improved quality assurance, Inventory, Late and incorrect payments and Cost reductions within their organization. In case of Clients it is obtained as Trust, Mutual interest, Free flow of information, Simplifying the whole construction process and quality standards. Finally fuzzy logic based assessment helps to understand about the MATLAB software and risk severity were obtained. According to the fuzzy output severity Inventory, Purchasing, Improved customer service, overall supply chain reduction and Improved quality assurance are the critical factors that affect SCMS for Engineers.

### RECOMMENDATIONS

As a recommendation for the critical risk severity problem following are as follows

- A. Inventory control
- B. Better purchasing management
- C. Improvisation in customer service for better customer satisfaction.
- D. Quality control management
- E. Total quality management
- F. Timely payments
- G. Cost control techniques
- H. Trust between actors
- I. Information sharing between actors
- J. Simplifying construction activity

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