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# Effect of Supplier Selection on Supply Chain Management in Construction Industry

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**ABSTRACT:** Supplier selection is the vital decision in construction supply chain. The supply chain of construction industry is primarily fragmented and needs through integration in the downstream. The extent of integration in downstream depends on the supplier selection practices of the supply chain. This study put forwards the argument that the supplier selection is the pre requisite for downstream integration in construction supply chain. This work we proposed to understand the mechanism of suppliers selection in Construction supply chain management. This study also investigate the various supplier selection criterion to integrate and analyse effect of suppliers/subcontractors in construction supply chain. A survey study of supplier selection issue in construction supply chain', we have tried to find out the factors on which suppliers are selected in construction industry in today's scenario. We think that the supplier selection is a prerequisite for integrating them in the supply chain. A client would prefer to select a supplier who is trusted and who can be capable to maintain good quality and consistent supply of materials throughout the life of the project and also the supplier should be open for long term relationship. In our study we collected the primary data relevant to our study through questionnaire. On the basis of the responses that were collected Relative Importance Index (RII) for each option for all the questions were calculated. Based on the RII values we have concluded about the various factors that play an important role in selection of suppliers in construction industry.

**KEYWORDS :** Supply chain management, Construction industry, construction industry, delay in construction, Logistic

## I. INTRODUCTION

Construction supply chain management (CSCM) is an emerging area to be studied. Though it is substantially different from Manufacturing supply chain, it is being inspired by it. In manufacturing supply chain management, emphasis is more on modelling volume production, whereas in CSCM is concerned with the coordination of discrete quantities of material (and associated speciality engineering services) delivered to specific construction projects. The organization and sourcing of material is becoming increasingly complex across the global construction industry. So, CSCM in terms of supplier selection is very important in today's world. Mounting emphasis on CSCM is due to both global sourcing of material and assemblies provided by advances in transportation technologies, as well as shortage of craft labour (reaching crisis proportion in many part of the world) that forces increasing amount of value added work to be conducted off -site deep in supply chain. At the same time construction clients are demanding faster, more responsive construction process and higher-quality facilities. These demands generally involve both more responsive production chain and closer coordination between the owner and the construction team. For all these reason, effective project execution means effective CSCM. Despite increasing interest in CSCM, there is very little material available both for practitioner and academics to educate them in CSCM. Just as global construction is distributed and diverse, the literature on supply chain is spread across various journals, conference proceedings, trade magazines and speciality books. A range of perspectives on supply chain management exists as research and execution draw from diverse area such as production and operation management, organizational arrangements and information technology. As such, there is not a single definition of CSCM, nor is there a single dominant paradigm. Nonetheless, there is mounting evidence of improvements in project performance through taking a supply chain perspective.

In this regard, we endeavour this study to integrate the suppliers/subcontractors in formation of supply chain. We argue that for the downstream integration in construction supply chain, integration of suppliers/subcontractors is the crucial link. Thus, this study has undertaken the research on supplier selection as the pre-requisite for downstream integration in construction supply chain. The result of the questionnaire survey has resulted into a list of factors that will ensure integration in downstream, keeping in mind supplier selection issues.

## II. LITERATURE REVIEW

### Role of Information in Construction Supply Chain Management

- Traditionally, project information exchange between designers and contractors has been mainly based on documents. These documents come in the form of architectural and engineering drawings, specifications, and bills of quantities and materials. This practice is far from being satisfactory, with about two-thirds of construction problems being caused by inadequate communication and exchange of information and data.
- Recognizing the importance of communication, construction supply chain management can be regarded as the process of strategic management of information flow, activities, tasks and processes, involving various networks of organizations and linkages, throughout a project life cycle.
- The key to supply chain management is the information flows associated with inter-organizational communications. As a result, a core issue is the effective management of information, both in the form of information flows that permit rapid inter-organizational transactions between supply chain partners and in the form of information accumulated, coded, and stored in an organization's database structures.
- Supply chain management crosses organizational boundaries, organizing information and process flows, sending signals to operations and evaluating results. Out of necessity, there is a heavy reliance on information management to coordinate the chain. As a result, information management becomes the heart of construction supply chain management.
- The construction industry has for many years suffered from difficult-to- access, out-of-date and incomplete information. Until the very recent past, it would have been inconceivable to electronically control and direct information flows in construction. Documents can now be produced and transmitted instantaneously by digital transmission at fractions of their previous costs.
- Project information is usually considered as the processed and presented data in a given situation, and is the data that enables effective action. Information produced by many sources, at many levels of abstraction and detail and retained by the creator of that information, contributes to fragmentation of the construction industry.

## III. LITERATURE SURVEY

Prefabricated buildings can be traced back to 1940, which refers to buildings built with elements produced in the component production factory and then delivered and assembled at the construction site [1]. Prefabricated buildings have advantages of high construction efficiency, being cost-saving, and environmentally friendly. Owing to the sustainable development strategy, the Chinese government has issued relevant policies to promote the reform of the construction industry, and local governments at all levels have shown active support. As a result, a large number of prefabricated building element suppliers have come into the market accordingly. Nowadays, making an optimal choice among the numerous suppliers to maintain a safe and stable construction, to save the cost to the greatest extent, and to cooperate with future construction projects for a long time has become an urgent issue in China's construction industry. Construction with prefabricated components is considered an efficient method to improve productivity and construction efficiency [2]. However, without proper management and planning from the beginning of the construction element supplier selection, the investment risks are likely to occur, which is not conducive to the sustainable development of construction enterprises [3]. The current research on the selection of prefabricated construction suppliers is still at an early stage [4]. By investigating the relevant literature in recent years, most of the research on supplier selection focuses on manufacturing, logistics, and agricultural economy. The selection of building components suppliers is relatively rare [5]. The comprehensive evaluation of assembly building suppliers can be analyzed jointly from the method and multi-dimensional factors. The use of multi-dimensional system indicators in the analysis method will make the results more scientific. There are many methods for the use of establishing a comprehensive evaluation system, including the sensitivity analysis method of grey system theory [6], cluster analysis method [7], analytic hierarchy process [8,9], fuzzy comprehensive evaluation method [10], rough set analytic hierarchy process [11], and factor analysis method [12], etc. Although the above methods introduce the uncertainty of factors in the analysis, there is no random and objective evaluation of the influencing factors of supplier selection. To overcome the shortcomings, the structural equation model was used in this paper. The advantage of the structural equation model is that it combines the statistical results with the hypothetical relationship to verify and estimate the logical relationship between factors, which overcomes the shortcomings of the above methods.

Chang [13] used an SEM model to analyze the safety risk mechanism of prefabricated building construction, conducted analyses from the aspects of personnel, management, and mechanical technology, and quantified the index system to



determine the biggest risk factor in a project. Li [14] used SEM to quantitatively evaluate the impact of investment risk of prefabricated buildings and made suggestions on avoiding the most influential factors. Hong et al. [15] have characterized and quantified the factors of construction equipment shutdown based on SEM and strengthened the management of key risks. Wei [16] studied the management mode and supply chain of congregate apartments, analyzed the problems existing in the development of the supply chain ecosystem, and provided corresponding suggestions. Huang [17] established a performance evaluation model in the supplier research of prefabricated building elements, which provided ideas for the sustainable development strategy of prefabricated buildings. Cheng studied the difference of concrete rates for prefabricated elements and reduced the subsequent cost of construction projects in terms of the economy [18]. Zhao took the fabricated buildings constructed with the regular mode in Hefei as an example, analyzed the strategic objectives of traditional cast-in-place buildings, and found it has a serious pollution problem, which makes them unsuitable for sustainable development. In contrast, he expounded the comprehensive economic benefits of the prefabricated buildings and put forward a comprehensive benefit evaluation model, which theoretically supported the sustainability of prefabricated buildings [19]. According to the review of previous investigations, it is found that the research on the development of prefabricated buildings is mostly based on the existing political factors, economic factors, management factors, etc., and therefore can only take care of the existing problems.

Different from previous studies, this work regards time as a factor of sustainable development and takes care of the problems in the follow-up long-term cooperation and building operation stage. On the analysis of selecting the prefabricated building element suppliers, the affecting factors covered the aspects from quality, technology, economy, and management to long-term cooperation. In summary, when selecting a prefabricated building element supplier, various aspects need to be taken into consideration. First, a risk assessment (RIA) is needed, which helps to analyze the source of fabrication risks and economic risks in the construction process of prefabricated buildings, as well as the common mistakes in the long-term follow-up cooperation [20]. Zhang et al. effectively combined the risk problem with the mathematical model [21]. Nevertheless, many investigations focusing on supplier selection management are mainly based on decision theory combined with actual engineering experience and only give decision evaluations for the short term, which makes it hard for construction enterprises to find long-term cooperative suppliers. Therefore, for the selection of element suppliers, the key is to highlight the risk source for the whole process, starting from production and installation to the later operation stage, and establish a comprehensive evaluation index system for construction enterprises to comprehensively evaluate the suppliers. In the process of production, construction, and long-term operation of the prefabricated elements, this study explores the potential relationship between various indexes in the evaluation system of element supplier selection, establishes the relevance model, and constantly modifies it in the process of verification. The relevance degrees between different factors were highlighted, which fed back the evaluation system. In response to the problems found in the research process.

#### IV. RESEARCH METHODOLOGY

The methodology is qualitative, which explores the "insider's view" of the process, and provides independent analysis of suppliers and subcontractors selection process in construction projects. The objective is to gain access to the participant's experiential insights on supplier selection process. The data presented in this research is primarily qualitative. The principal objective is to use the participant's experiences to find the criteria on which they select the suppliers. Specific research questions were developed for use in conducting the qualitative analysis through survey. These questions were designed to address the measures used to seek the basis on which suppliers are selected for construction projects. The Supplier selection study in Construction supply chain management is relatively unexplored in Indian context. Much enlightened business had started with this concept with the help of experts and consulting firms. However, expectedly Indian enterprises had not taken this approach thus far. This study would be a significant approach towards integrating vendors in the Construction supply chain management and improves its deliverables.

Before selecting a supplier, a firm must decide whether to use single sourcing or multiple suppliers. Single sourcing guarantees the supplier sufficient business when the supplier has to make a significant buyer specific investment. The buyer specific investment may take the form of plant and equipment designed to produce a part that is specific to the buyer or may take the form of expertise that need to be developed. Single sourcing is also used in the automotive industry for parts that are seats that must arrive in the sequence of production. Coordinating sequencing is impossible for multiple sources. As a result auto companies have a single seat source for each plant but multiple source across their manufacturing network. Having multiple sources ensure a degree of competition and also the possibility of a backup, should a source fail to deliver. A good test of whether a firm has the right number of suppliers is to analyze what impact deleting or adding a supplier will have. Unless each supplier has a somewhat different role, it is very likely that

the supplier base is too large. In contrast, unless adding a supplier with a unique and valuable capability clearly adds to total cost, the supply base may be too small. The selection of suppliers is done using a variety of mechanism, including offline competitive bids, reverse auctions or direct negotiation. No matter what mechanism is used supplier selection should be based on the total cost of using a supplier and not just the purchase price. Next we discuss some auctions mechanisms that are often used in practice and highlight some of their properties.

When outsourcing to third party, firms have historically obtained competitive bids and in recent years used reverse auctions in the internet. Competitive bids are a form of auctions in which the bids are not revealed to the other bidders. In the following discussions we treat them as auctions. In many supply chain settings, a buyer looks to outsource a supply chain function such as production or transportation. Potential suppliers are first qualified and then allowed to bid on how much they would charge to perform the function. The qualification process is important because there are multiple attributes of performance that the buyer cares about. When conducting an auction based primarily on unit price, it is thus important for the buyer to specify performance expectations along all directions other than price. In reality, a buyer may be better off with a multi attribute auction, but in most cases buyer end up with specifications on various attributes and a price-only auction. The qualification process is used to identify suppliers that meet performance expectations along the non price attributes. From the buyers' perspective, the proposal of auction is to get bidders to reveal their underlying cost structure so that the buyer can select the supplier with the lowest costs. Commonly used mechanism for these auctions are as follows-

- Sealed-bid first-price auctions require each potential supplier to submit a sealed bid for the contract for a specified time. These bids are then open and the contract is assigned to the lowest bidder.
- In English auction, the auctioneer start with a price and supplier can make bids as long as each successive bid is lower than the previous bid. The supplier with the last(lowest) bid receives the contract. The difference in this case is that all suppliers get to see the current lowest bid as the auction unfold.
- In Dutch auction, the customer starts with a low price and then raises it slowly until one of the suppliers agrees to the contract at that price.
- In second-price (vickrey) auctions, each potential supplier submits a bid. The contract is assigned to the lowest bidder but at the price quoted by the second-lowest bidder.

When identifying the auction to use, the firm want to minimize the price it pays. The firm also care about ending up with the supplier with the lowest underlying costs because it makes it more likely that the supplier will actually be able to supply at the price it has committed to. A relative issue is whether supplier has any incentive to make false bid that are not consistent with their cost structure. Such bids may increase what the firm pays and also lead to contract being awarded to a firm that does not have the lowest cost. An important issue with the sealed-bid first-price auction is what is known as the winner's curse. Once selected base on sealed bids, the winner could have realized that it should have raised its bids slightly and still own, because other suppliers bid at a higher level. In this sense winning the bid lead the winner to realize that it left money on the table. Thus, bidders adjust their initial sealed bids upward, taking this phenomenon into account. The issue does not arise in any open auction, when the bidder sees the current best bid when planning for their next bid. This issue also does not arise in the second price-auction because the winner gets the price quoted by second-lowest bidder and thus has no incentive to hide its true cost.

- The following factors influence the performance of an auction:-
- Is the suppliers cost structure private (not affected by factors that are common to other bidders?)
- Are suppliers symmetric or not, that is, ex ante, are they expected to have similar cost structures?
- Do suppliers have all information they need to estimate their cost structure?
- Does the buyer specify a maximum price it is willing to pay for the supply chain?

Let us start with a cost structure, for suppliers. In most instances it is reasonable to assume that the part of the suppliers cost arises from how it has structured its processes and part of its cost arises from market factors such as raw material and labour cost that are common across suppliers. In other words, the suppliers cost structure is likely to be independent and correlated to some extent. The independence and correlation is likely to be higher with suppliers having similar processes located in similar markets. If suppliers are symmetric with cost that are interdependent and correlated the expected price that a firm has to pay using an English auction is no more than that in a second price auction, which is no more than in a sealed- bid first- price auction. In other words under these condition the English auction is likely to fetch the lowest price for the firm. If suppliers are asymmetric, it is possible that a second price auction may do better than a English auction.

If the buyer firm has some information that has a direct bearing on supplier's cost and the suppliers are aware that suppliers has this information but do not know the information itself, it is in the best interest of the firm to reveal this information. Under all auctions mechanisms (with symmetric bidders), the buyer pays less with all information revealed than with less information revealed. Thus, it is the best interest of the buyer to specify its needs clearly and revealed all information related to the supply chain task of which it is aware. Not revealing this information lead the bidders to shed their bids to guard against the winner's curse, resulting in an increase in the price paid by the buyer. Thus, it is in the buyer's interest not only to reveal all public information before bidding but also to convince potential suppliers that all information has been revealed. The very significant factor that must be accounted for when designing an auction is the possibility of collusions among bidders. Second price auction are particularly vulnerable to collusion among bidders. Consider an agreement among bidders under which the bidder with the lowest cost agrees to bid its true cost, with all other bidder bidding a high number (say, the cost of the most expensive bidder or the reserve price of the buyer). In second price auction, the lowest bidder gets to perform the supply chain function but the buyer has to pay a higher price than the cost of the second lowest supplier. This collusion strategy is equilibrium because none of the other bidders has anything to gain by deviating from the collusion agreement. Observe that this collusion strategy can be avoided with any first price auction, either sealed bid or English. In either case a collusion agreement with very high price will not hold, because, many bidders will have the temptation to join the bidding if they have a lower cost. Ultimately, any first price auction will bring more than the lowest cost bidder in to the auction.

Collusion results in suppliers suppressing their desire to provide the supply chain function and raising their bids from what would be appropriate given their cost. This is often the case in multiunit auction, in which the buyer want supplier to bid on a certain quantity of supply chain function. In multiunit Dutch auctions, the buyer starts by announcing a higher price and then lowers it slowly until a supplier is willing to provide one unit of the goods or services. The price is lowered slowly until the supplier has committed to all unit of goods and services desired by the buyer. In this auction each unit is supplied at different price. In a multiunit English auction, the buyer start a higher price and the bidder announce the quantity they are willing to supply. If the total quantity the supplier willing to supply exceeds the desired quantity, the buyer lower the price until the quantity for which suppliers bid equal to the desired quantity. All suppliers are then get to supply at this price. This auction is also referred to as uniform price auction. Suppliers in either auction can raise the final price by colluding and forming a bidding ring that assign only one bidder to enter the bidding process for the entire ring. After the initial auction the ring will have a separate auction to divide up the quantity they have been assigned among themselves.

#### Guideline for Constructing Questionnaire

- The following points were kept in mind while designing the questionnaire;
- The problem to be studied is to always keep in view, as it provides the starting point for developing questionnaire. The problems to be dealt with during the course of research must be clear.
- Appropriate form of question depends on the nature of information sought, nature of respondents and kind of analysis intended. A researcher must decide whether to go for open or close ended questions. Questions must be simple and in logical flow and well structured in tabular plan. The units of enumeration should also be defined precisely so that they can ensure accurate and full information.
- Rough draft of the questionnaire should be prepared, giving due thought to appropriate sequence of putting questions. Questionnaire previously drafted should also be referred.
- One must re-examine, and in case of need must revise the rough draft for a better one. Technical defects must be minutely scrutinized and removed.
- Pilot study should be undertaken for pre-testing the questionnaire. The questionnaire must be edited in light of the results of the pilot study.
- Questionnaire must contain simple but straight forward directions for the respondents so that they may not feel any difficulty in answering the questions.

#### Questionnaire Development

A questionnaire was developed for the collection of data on pertinent aspects of the case samples that were studied. It also addressed the quantitative characteristics of the research. The purpose of the questionnaire was to establish the relevance of the research criteria. The questionnaire requested a description of the selection procedure, selection criteria, impact of technical expertise on project, minimum skills required in supplier. It also requested information about ideal phase for involvement of suppliers, relationship with suppliers, role of client is supplier selection, impact of early participation of supplier.

- The purpose of this research is to find the criteria based on which suppliers are selected in present day construction industry.
- The method of data collection was selected to be a questionnaire as it is the fastest and cheapest means of collecting data.
- The questionnaire was made of all closed ended questions, where the respondent has to give his view on each of the option for a question from the choice of strongly agree, agree, undecided, disagree and strongly disagree.
- All the questions were presented in tabular form, and care was take to maintain logical consistency between the questions.
- The language used was simple and formation of questions were technically sound.
- The respondent had to fill up about their Name of the organization, experience, educational qualification and designation. Name of the respondent was optional, as some respondent may hesitate to show their identity.
- The means of data collection was by sending the questionnaire through e- mail and then follow up for response.
- Once sufficient number of responses were collected analysis of the replies were done using the Relative importance index.
- The option for a question with the highest relative importance index was selected as the preferred option for the question.
- Through preferred options for all the questions we will come to know about the current criteria for the selection of suppliers in construction industry.

As per in our Gmail account. As this method is very user friendly, fast to comprehend and easy to analyse the result. Whether questionnaire made of word document and send in as attachment, are always difficult for the user to answer and comprehend. It is also difficult for us to analyze those results. The responder's e-mail id was accumulated through friends, alumni, family members and old colleagues all over the world. The number of mail send was more than four hundred and the response was thirty five. We also followed it up with regular update of our gmail account and by calling some of the respondent. The process took almost twenty days.

### Questionnaire

- The questionnaire was compiled on the basis of the following factors:
- Selection procedure for vendors
- Selection criteria considered for the selection of sub-contractor and suppliers
- Phase in which involvement of the suppliers and sub-contractors would significantly influence the project effectiveness
- Impact of technical expertise on project work
- Testing capability of the supplier
- Relationship with the supplier
- Method to encourage subcontractor towards waste elimination process
- Supplier's geographical reach
- How resourceful the supplier is
- Transparency and openness of supplier
- Expectations from suppliers to ensure quality and timely work
- Extent to which the client briefing affected decision regarding supplier and sub-contractor selection
- Attitude of client towards supplier selection
- Minimum skill requirement of subcontractors to execute the work
- Method which would ensure proper coordination on project work
- Cooperation of suppliers in situations to cope up with frequent design changes
- Impact on material availability due to frequent design changes
- The incentives provided by the client for on time delivery of the project
- Methods of preventing complacency on part of suppliers and sub contractors
- Impact due to early participation of supplier and subcontractors in projects

## V. RESULTS AND DISCUSSIONS

After preparing the questionnaire, responses to the questions were collected by sending the questionnaire through e-mail. The respondents were working professionals with engineering background. To analyze the responses given by the respondents and to get the criteria on which suppliers are selected in construction industry. Relative Importance Index method was used.

Relative Importance Index (RII) is the process where weight is given to each type of response as per the judgment of the user. In this case;

- Strongly Disagree = 1
- Disagree = 2
- Undecided = 3
- Agree = 4
- Strongly Agree = 5

Once the weights are decided then the total numbers of responses for each option of each question are found out. Then RII for each option is calculated using the equation;

$$RII = (W1*n1 + W2*n2 + \dots) / A*N$$

Where W = Weight of the option as decided by user,

n = Number of responses under each option,

A = Highest weight given and

N = Total number of respondents.

The option with the highest RII for a question is the preferred option for that question.

## Factors affecting Supplier Selection

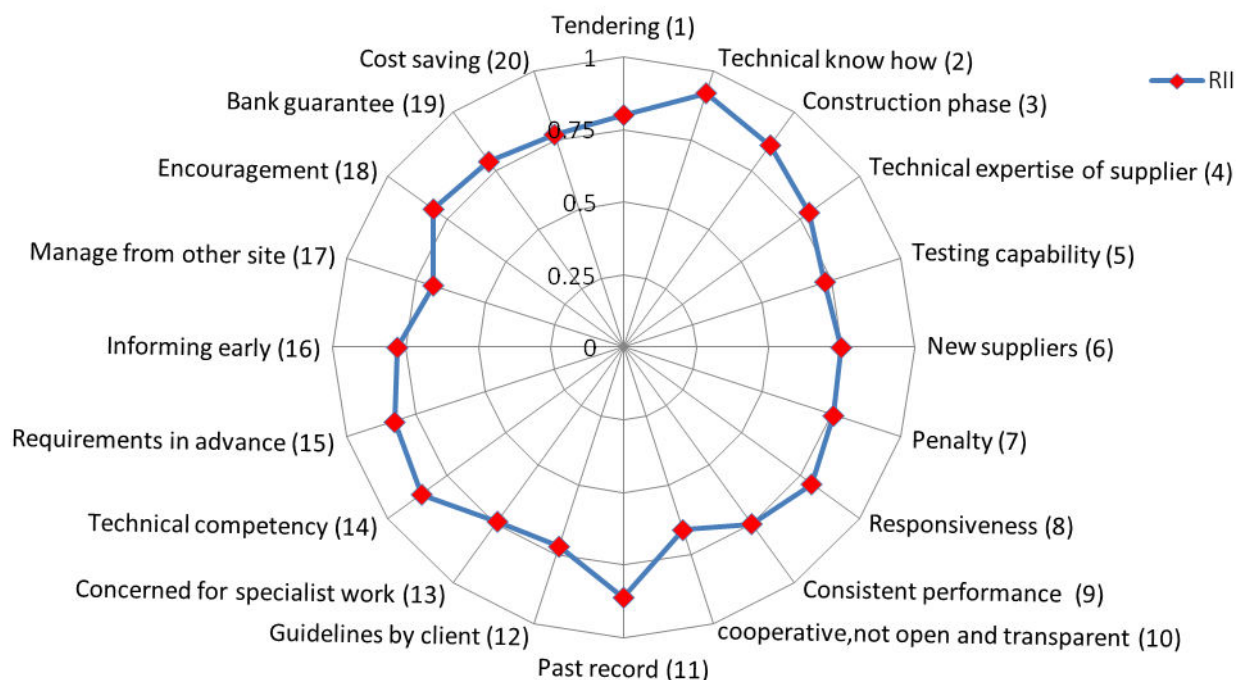


Figure 1 : Factor affects for supplier selection

After successfully implementation proposed approach we applied RII approach on collected data, and evaluated the ranks of all factors as given below,

1. Selection procedure
2. Selection criteria
3. Phase in which involvement





4. Technical expertise
5. Testing capability
6. Relationship with supplier
7. Waste elimination process
8. Suppliers' geographical reach
9. Resourcefulness
10. Transparency and openness
11. Quality and timely work
12. Client briefing\
13. Attitude of client
14. Minimum skill requirement
15. Proper coordination
16. Frequent design changes
17. Material availability
18. The incentives
19. Complacency of suppliers
20. Early participation of suppliers

## VI. CONCLUSION

This study was carried out to find the criterion that governs the selection of suppliers and subcontractors in the construction industry. After the analysis of the feed backs of the questionnaire, we found the following major factors in the study.

- As per the study people feels that tendering is the best way of selecting suppliers and subcontractors, as it provides good quality resources at competitive price.
- Technical knowhow of a supplier and subcontractor plays a major role in selection process.
- Good performance in past projects is what clients' looks for as minimum requirement for selection of supplier and subcontractor.
- While selecting supplier construction industry looks for consistent performance in terms of quality and on time delivery.
- As per the study client expect their suppliers to be responsive.
- As per the study the supplier should have a good testing capability to finish project as per established QA & QC.
- For good quality and timely work the past record and continuous monitoring and controlling are the two things that matters the most.
- As per the study people feels that the technical expertise of suppliers and subcontractors help in finishing the project on schedule and budget.
- As per the study people always look for new suppliers as a way for continuous improvement.
- As per the study construction phase is the preferred phase to introduce suppliers and subcontractors into the project.
- As per the study imposing penalty is the best way for preventing wastage at site.
- As per the study providing incentive is a good way of encouragement for on time delivery.
- As per the study bank guarantee is a good way to prevent compliance on part of suppliers.
- As per the study clients were more concern about the specialist work and provided guidelines for selection of suppliers and subcontractors.
- As per the study in case of shortage of material on site people prefer to manage materials from other sites.
- As per the study in case of frequent design changes the supplier and subcontractors are informed well in advance.
- As per the study for proper coordination between various independent parties working at a site, the requirements are put forward well in advance.
- As per the study early integration of supplier and subcontractor results in saving of cost on labour, material and methods.

Based on the review of literature on formation of supply chain in construction industry, we found that construction industry is too fragmented and too adversarial to adopt supply chain management practices. We believe that a Supply chain initiative in construction industry is the way forward to reduce delays and cost and time overrun. In this regard,

we endeavour this study to integrate the suppliers/subcontractors in formation of supply chain. We argue that for the downstream integration in construction supply chain, integration of suppliers/subcontractors is the crucial link. Thus, this study has undertaken the research on supplier selection as the pre-requisite for downstream integration in construction supply chain. The result of the questionnaire survey has resulted into a list of factors that will ensure integration in downstream, keeping in mind supplier selection issues.

## REFERENCES

1. Nistico, N.; Gkagka, E.E.; Gantes, C.J. Roof Isolation with Tuned Mass-based Systems and Application to a Prefabricated Building. *Arab. J. Sci. Eng.* 2015, 40, 431–442.
2. Ng, A.; Loosemore, M. Risk allocation in the private provision of public infrastructure. *Int. J. Proj. Manag.* 2007, 25, 66–76.
3. Kaliszewski, J. The Project of Building a Concrete Prefabrication Plant Using the Innovative Production Technologies. Ph.D. Thesis, Warsaw University of Technology, Warsaw, Poland, 2019. Available online: <https://repo.pw.edu.pl/info/master/WUT3ac3ecc92bf54ef0a55f6bf6ee9f4acc/> (accessed on 13 January 2021).
4. Qi, B.K.; Zhu, Y.; Fan, W.Y. Life cycle risk identification method for assembled building. *J. Shenyang Constr. Univ. Soc. Sci. Ed.* 2016, 3, 7.
5. Bai, C.; Sarkis, J. Integrating sustainability into supplier selection with grey system and rough set methodologies. *Int. J. Prod. Econ.* 2010, 124, 252–264. [CrossRef]
6. Govindan, K.; Aditi; Darbari, J.D.; Kaul, A.; Jha, P.C. Structural model for analysis of key performance indicators for sustainable manufacturer-supplier collaboration: A grey-decision-making trial and evaluation laboratory-based approach. *Bus. Strateg. Environ.* 2021, 30, 1702–1722.
7. Fischinger, M.; Kramar, M.; Isakovic, T. Seismic safety of prefabricated reinforced-concrete halls-analytical study. *Gradevinar* 2009, 61, 1039–1045. Available online: <https://hrcak.srce.hr/43827> (accessed on 17 January 2021).
8. Huang, Z.; Zhao, W.; Zhang, Y.; Yao, X.; Jia, Q.; Wang, H.; Le, T.; Song, D.; Gao, Y. Comprehensive Safety Evaluation of Emergency Training for Building Ruins Scenario Based on Analytic Hierarchy Process-Grey Fuzzy Evaluation. *IEEE Access* 2020, 8, 147776–147789.
9. Seo, H.; Myeong, S. The Priority of Factors of Building Government as a Platform with Analytic Hierarchy Process Analysis. *Sustainability* 2020, 12, 5615. [CrossRef]
10. Pinto, A. QRAM a Qualitative Occupational Safety Risk Assessment Model for the construction industry that incorporate uncertainties by the use of fuzzy sets. *Saf. Sci.* 2014, 63, 57–76.
11. Deng, W.B.; Wang, H.J.; Yuan, Y. Research on Evaluation of Prefabricated Building Component Suppliers Based on Dominance-Based Rough Set Approach. In *Proceedings of the 6th International Symposium on Project Management (ISPM)*, Chongqing, China, 21–23 July 2018; Huang, D., Yu, H., Xu, H., Zhang, H., Eds.; Curran Associates, Inc.: Red Hook, NY, USA, 2018; pp. 131–136.
12. Bai, S.Z.; Wang, D.H.; Zhang, S.T. Dynamic Selection of Supplier in Chain Catering Industry. In *Proceedings of the 2010 International Conference on Logistics Systems and Intelligent Management (ICLSIM)*, Harbin, China, 9–10 January 2010.
13. Chang, C.G.; Zhao, T. GT-SEM-Based Safety Risk Mechanism of Prefabricated Construction. In *Proceedings of the 2020 12th International Conference on Communication Software and Networks (ICCSN)*, Chongqing, China, 12–15 June 2020; pp. 280–284.
14. Li, X.J. Research on investment risk influence factors of prefabricated building projects. *J. Civ. Eng. Manag.* 2020, 26, 599–613.
15. Hong, J.K.; Shen, G.Q.P.; Li, Z.D.; Zhang, B.Y.; Zhang, W.Q. Barriers to promoting prefabricated construction in China: A cost-benefit analysis. *J. Clean Prod.* 2018, 172, 649–660.
16. Wei, L.; Xin, L. Analysis on the Countermeasures of Residence Industrialization with Supply Chain Theory. In *Proceedings of the 2017 International Conference on Smart Grid and Electrical Automation (ICSGEA)*, Changsha, China, 27–28 May 2017; pp. 645–647.
17. Wang, Y.W.; Wang, Y.Q.; Shen, Q.P. A Performance Assessment Model for Green Residential Supply Chain Based on Life Cycle Theory. In *Proceedings of the 2009 International Conference on Construction and Real Estate Management*, Beijing, China, 5–6 November 2009; China Architecture & Building Press: Beijing, China, 2009.
18. Cheng, Q.Z. Investment control of prefabricated building. *Urban. Archit.* 2017, 5, 210–211.
19. Weishu, Z.; Beibei, Z.; Yang, Y. Empirical study of comprehensive benefits for prefabricated buildings: A case study of Hefei city. *Int. J. Electr. Eng. Educ.* 2020, 0020720920928465.
20. Yang, S.H.; Yashiro, T.; Nishimoto, K. Industrial ecology in off-site building component industry: Case study on bathroom units sectors. In *Proceedings of the Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing*, Tokyo, Japan, 11–15 December 2001; Institute of Electrical and Electronics Engineers: New York, NY, USA, 2002; pp. 886–891.



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