

# Analysing the Sources of Uncertainties along the Construction Supply Chain

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**Abstract**— Construction industry is well known for cost overrun and time overrun in its projects. Supply chain management is essential in Indian construction industry due to its competitive nature. Construction supply chain faces lot of challenges due to uncertainty that arise in almost every project. Thus, it is essential to analyze the uncertainties that may arise in the supply chain of the project. Supply chain in construction industry is project specific and has various uncertainties. This paper analyses possible uncertainties that are bound to occur in a construction supply chain. The uncertainties along a construction supply chain are grouped under four criterias namely control, supply process and demand, based on the uncertainty circle. They were analyzed through questionnaire survey, to determine the major factors and the most impacting criteria in the supply chain.

**Index Terms** — Construction Supply Chain, Uncertainties, Uncertainty circle, Construction management, Supply chain management.

## 1 INTRODUCTION

The construction sector is a major employment driver, being the second largest employer in the country, next only to agriculture. This is because of the chain of backward and forward linkages that the sector has with other sectors of the economy. About 250 ancillary industries such as cement, steel, brick, timber and building material are dependent on the construction industry. A unit increase in this sector has a multiplier effect and the capacity to generate income as high as five times.

Even though construction industry plays a major role in the economy of the country, it has various flaws in itself, requiring proper managerial aspect to enhance the industry. One such aspect that is being researched in this paper is, **Supply Chain Management** in construction industry.

Supply chain management is the integration of key business processes from end user; through to original suppliers that provide products, services and information that add value for customers and other stakeholders. It is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer.

Construction Supply Chain Management is defined as the strategic management of information flows, activities, tasks, and processes, involving various networks of independent organizations and linkages (upstream and downstream) which produce value that is delivered to the owner in the form of a finished product [13]. Construction supply chain involves stakeholders who are individual service providers such as sub

contractors, designers, engineering consultants, transporters and manufacturers of materials and equipments [16].

According to R. Virjhoef (2000) [11], even in normal situations a lot of problems exist in construction supply chain, most of which are not identified or are ignored. Also, most of the problems are caused in another stage of the construction supply chain than where the problem actually surfaces. Thus, indicating that construction supply chain possesses a lot of uncertainties.

Uncertainty affecting supply chain operations has long been recognized by researchers as a major obstacle to the delivery of customer value in supply chains [6]. More over construction supply chain has a wide range of uncertainties that need to be identified and analyzed in order to prevent them.

This paper analyses the uncertainties that have been identified according to Jonathan Gosling (2013) [6]. Based on the generalized framework, the uncertainties are analyzed to identify the major impacting factors in Indian Construction industries, based on the opinion from private players.

## 2 RESEARCH METHODOLOGY

This paper analyses the generalized framework (Fig: 1) to identify the major impacting factors in Indian construction industry. There are 41 sources of uncertainties listed here, which are in turn grouped in five different criteria, of which four criteria are based on uncertainty circle. Thus the research involves,

1. Understanding the framework and developing a questionnaire.
2. Questionnaire survey.
3. Analyzing the questionnaire survey to obtain the major impacting factors that influence Indian construction industry, according to respondent's opinion.

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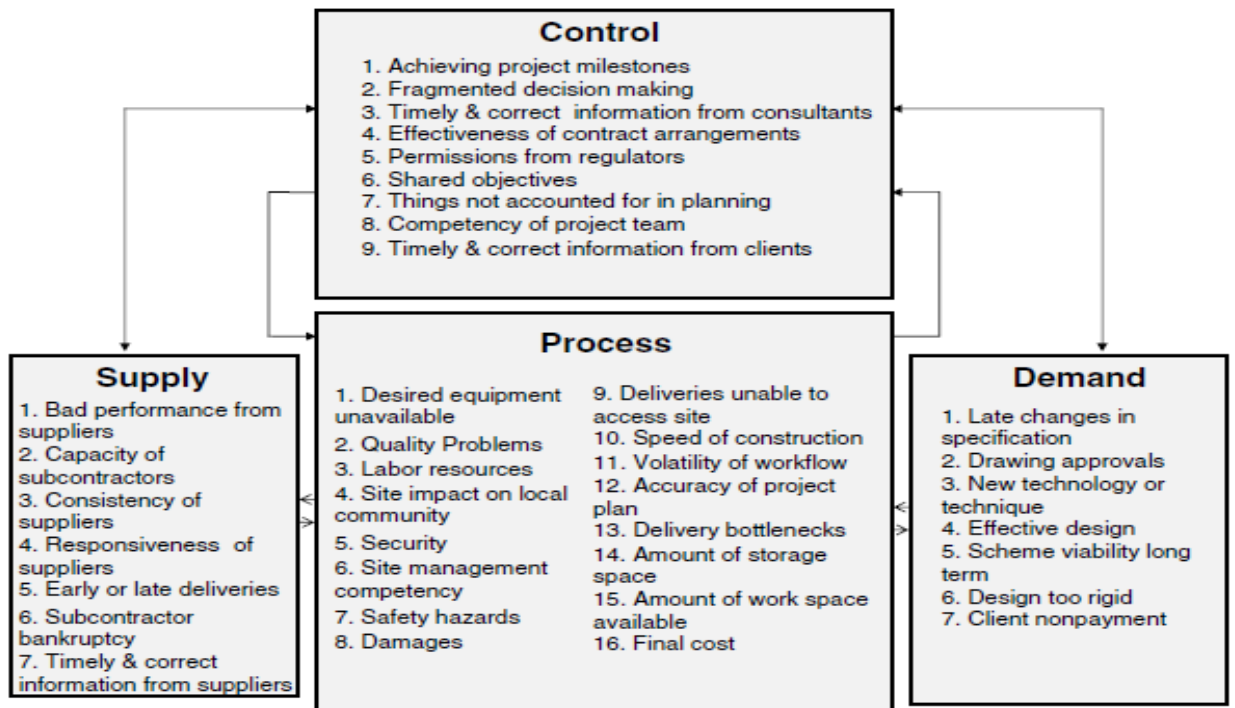


Fig.1.Sources of uncertainties categorized using uncertainty circle (Source: Jonantham Gosling (2013) [6])

### 2.1 Uncertainty Circle

The framework that has been adopted in this paper is based on uncertainty circle. Uncertainty can be defined as a state that ranges from just short of certainty to a near complete lack of knowledge about a result. Supply chain uncertainty can be defined as “situations in the supply chain in which the decision maker does not know definitely what to decide as he/she is indistinct about the objectives; lacks information about or understanding of the supply chain system or its environment; lacks information processing capabilities; is unable to accurately predict the impact of possible actions on supply chain behavior; or, lacks effective control actions.”

The supply chain uncertainty framework is classified in four general categories: process, supply, demand, and control.

### 2.2 Questionnaire Survey

A Questionnaire survey was conducted which involved 41 questions based on the framework. There were a total of 60 respondents from various sections in the construction supply chain, such as contractors, planning engineers, site engineers etc. Each question was rated on a five point likert scale, indicating the impact of a particular uncertainty factor in the construction industry that affects the Construction Supply Chain.

## 3 ANALYSIS

The questionnaire was prepared considering the sources of uncertainties listed in the framework. Table 1 lists the factors that were considered. The respondents were asked to rate the factors on a five point likert scale. The relative importance index (RII) for each factor under each category was plotted in a bar graph.

Relative Importance Index is one of the supplementing methods to analyze the outcomes of likert scale responses and regression methods.

An ordinal measurement scale of 1 to n with maximum value being 9 will be used in the likert scale to attain the responses from the respondents. The relative importance of each factor is determined from the responses using the forth coming formula.

$$\text{Relative Importance Index} = \frac{\sum_{i=1}^n W_i X_i}{\sum_{i=1}^n X_i} * 100$$

Where,

$W_i$ = the rating given to each factor by the respondents ranging from 1 to n.

$X_i$ = the percentage of respondents scoring

$i$ = the order number of respondents

Therefore, higher the value of RII, higher will be the rank of the factors that were analysed.

Table 2 lists the top 10 major impacting factor having higher RII.

TABLE 1  
 FACTORS AND THEIR CATEGORIES

SL. NO.	SOURCES OF UNCERTAINTIES
<b>Control</b>	
1	Achieving project milestones
2	Fragmented decision making
3	Timely and correct information from clients
4	Effectiveness of contract agreements
5	Permission from regulators
6	Shared objectives
7	Things not accounted fro in planning
8	Competency of project teams
<b>Supply</b>	
1	Bad performance from suppliers
2	Capacity of subcontractors
3	Consistency of suppliers
4	Responsiveness of suppliers
5	Early or late deliveries
6	Subcontractor bankruptcy
7	Timely and correct information from suppliers
<b>Process</b>	
1	Unavailability of desired equipment
2	Quality problems
3	Labour resources
4	Site impact on local community
5	Security
6	Site management capacity
7	Safety hazards
8	Damages
9	Deliveries unable to access site
10	Speed of construction
11	Volatility of work
12	Accuracy of project plan
13	Delivery bottle necks
14	Amount of storage space
15	Amount of work space available
16	Final cost
<b>Demand</b>	
1	Late changes in specifications
2	Drawing approvals
3	New technology or technique
4	Effective design
5	Scheme viability long term
6	Design too rigid
7	Client non-payment
<b>External</b>	
1	Bad weather
2	Economic market conditions
3	Geology / site conditions

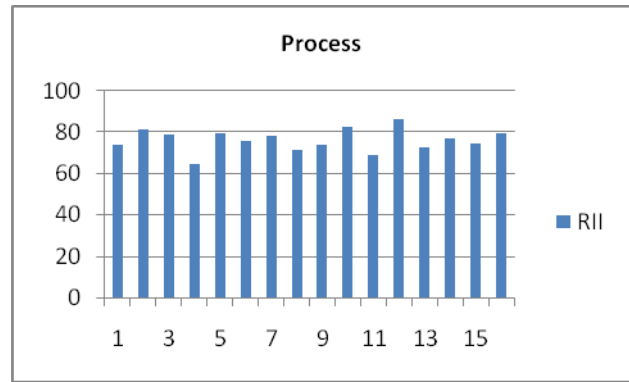


Fig.2 RII for process

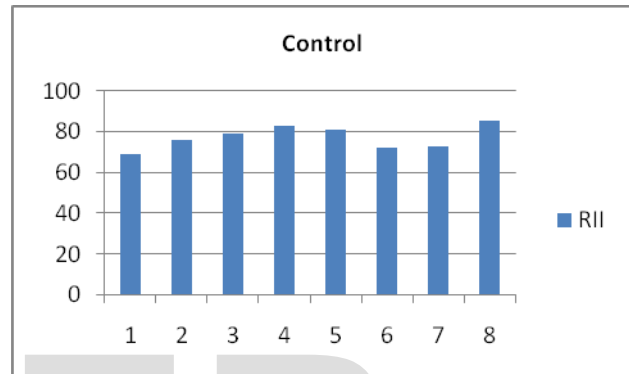


Fig.3 RII for control

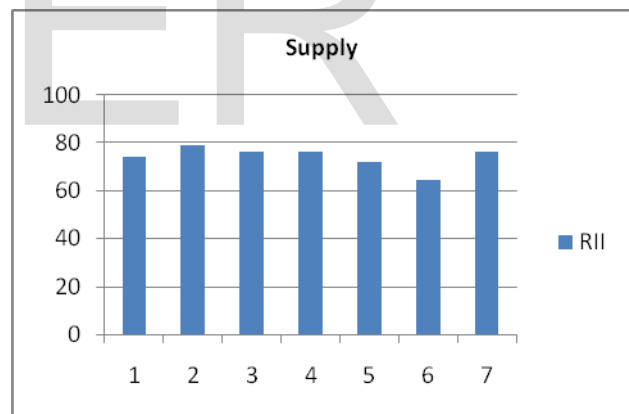


Fig.4 RII for supply

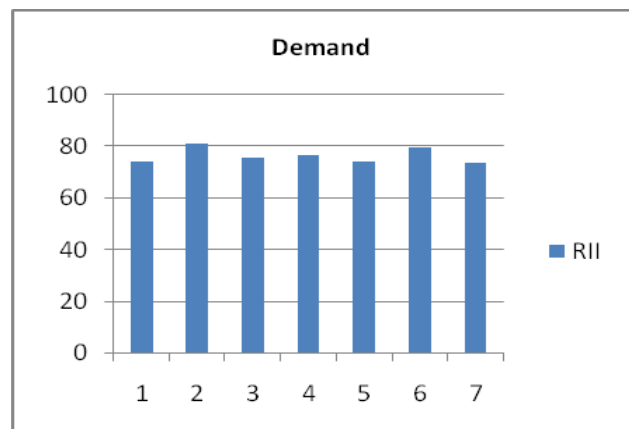


Fig.5 RII for demand

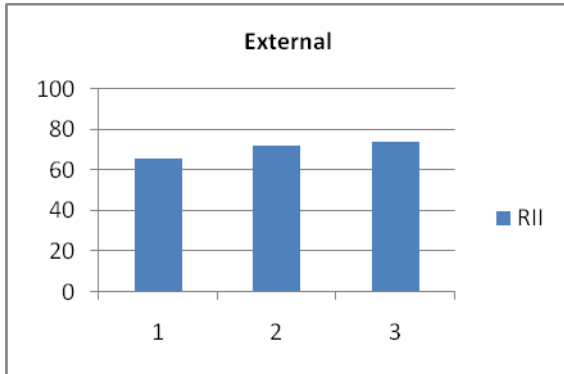


Fig.6. RII for external

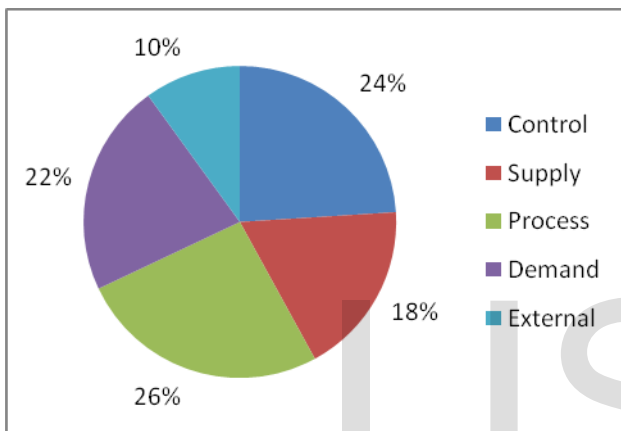


Fig.7. Overall percentage contribution of each category

TABLE 2  
 TOP 10 FACTORS AND THEIR CATEGORIES

Sl. No.	Factors	Uncertainty Source
1	Accuracy of project plan	Process
2	Competency of project team	Control
3	Effectiveness of contract agreements	Control
4	Speed of construction	Process
5	Quality problems	Process
6	Permission from regulators	Control
7	Drawing approvals	Demand
8	Security	Process
9	Final cost	Process
10	Design too rigid	Demand

## 6 DISCUSSION

### 6.1 Control

The factors that come under control are related to administrative issues. The factors discussed under this category are, achieving project milestones, fragmented decision making, timely and correct information from clients, effectiveness of contract agreements, permission from regulators, shared objective, things not accounted for in planning, competency of

project team.

The major factors under this category from the analysis (Fig: 3) are: Competency of project team, Effectiveness of contract agreement, and Permission from regulators.

Competency of the project team is a major factor, as it leads to the success of the project. The project team involved in a project is the ones who take critical decisions, implementing decision in the required way etc., indicating the need for an efficient team. Thus, in this study it indicates that, the respondents have faced issues or uncertainties due to lack of a competent team.

### 6.2 Supply

Supply category has the following factors: bad performance from suppliers, capacity of sub contractors, and consistency of suppliers, responsiveness of suppliers, early or late deliveries, subcontractor bankruptcy, timely and correct information from suppliers.

The top factors in this category (Fig: 4) are: Capacity of sub contractors, responsiveness of suppliers, consistency of suppliers and timely and correct information from suppliers.

Capacities of sub contractors, consistency of suppliers are essential for the success of a project. Continuous material flow, labor flow is the key necessity of a project which is the responsibilities of suppliers and subcontractors. Timely information from suppliers is also a major factor, as the project team must be aware of the material arrival, and any delay in material delivery. In case of material delay being informed at an earlier stage by the supplier, it might be possible for the project team to perform a parallel activity that does not require that particular material. This can possibly reduce an overall delay in the project to a certain extent.

### 6.3 Process

Factors under the process criteria are: unavailability of desired equipment, quality problems, labour resources, site impact on local community, security, site management competency, safety hazards, damages, deliveries unable to access site, speed of construction, volatility of work, accuracy of project plan, delivery bottlenecks, amount of storage space available and final cost.

The major impacting factors in this category (Fig: 2) are: Accuracy of project plan, Speed of construction and Quality problems.

Accuracy of project plan is the most impacting factor and is the overall top factor. Most or all projects face this uncertainty. Plans get revised a lot of time during the construction process because of various reasons, such as, sudden change identified in geological condition, changes done by clients etc.

### 6.4 Demand

Demand factors are: late changes in specifications, drawing approvals, new technology or technique, effective design, scheme viability long term, design too rigid, client non-payment.

Top factors under this category (Fig: 5) were found to be: Drawing approvals and Design too rigid.

Delay in the approval of drawings also lead to subsequent delay in the project.

## 6.5 External

Factors under external category (Fig: 6) are: bad weather, economic market condition and geology / site conditions. The factors that do not fit in to any of the four categories were listed in the external category.

Bad weather being a natural uncertainty is one that cannot be taken care of. Economic market conditions have fluctuations in material price. This factor possibly affects the contractor involved in the project. Thus, accordingly there must be a clause in the contract agreement to prevent any loss incurred by the contractor. Uncertainty in geology/site conditions are often faced in a construction project. In projects carried out in larger area, changes in the site conditions are bound to happen.

## 7 CONCLUSION

The major impacting factors according to the respondents were identified as: **accuracy of project plan, competency of project team, effectiveness of contract agreements, speed of construction, quality problems, permission from regulators, drawing approvals, security, final cost and design too rigid.** According to Fig: 7 process category had the most impacting factors and contributed to 26%, next is control with 24%, demand with 22%, supply with 18% and external with 10%. The percentages are bound to vary based on the respondents due to experience of the responds in their particular project. Thus, these percentages can vary according to the type of construction project, as each project has unique uncertainties.

According to the analysis done on identification of impacting factors in this work, the process is given the highest importance as most of the issues surface at the construction process i.e., the process category. Any issues that occur in previous stages are bound to surface in the process stage. According to R.Virjhoef (2000) [11], most of the waste and problems occur in other stages and not in the stage where it is actually encountered. It must be noted that all the four categories: Control, Process, Supply and Demand are inter-related. Hence, if an issue occurs at the process stage, there is possibility to have its root in previous stages such as control or in supply. For instance, Quality problems are one of the major impacting factors that come under process category. This uncertainty might occur due to incompetency of suppliers with respect to quality of materials or due to the incompetency of the project team when it comes to quality of construction on the whole. Thus, a major problem indicated by the respondents has its root in other factors that has less importance.

This is one of the major problems in construction supply chain wherein people tend to have a myopic control [11].

Hence, this study indicates the major impacting factors in construction projects in India, also the lack of a wider perspective when it comes to construction supply chain management.

In order to prevent the drawbacks, it is necessary to have a wider knowledge about construction supply chain, monitoring the supply chain throughout the project, sharing information throughout the supply chain. Sharing of information can be done by harnessing latest information technology, such as, creating a common platform for all supply chain participants, in order to eliminate most of the uncertainties.

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