ANALYSIS OF FACTORS INFLUENCING MATERIAL WASTE IN RCC CONSTRUCTION CONTRACTS AND THEIR MITIGATION MEASURES

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ABSTRACT

Construction waste becomes a global issue facing by practitioners and researchers around the world. Waste can affect the success of construction project significantly. More specifically, it has a major impact on construction cost, construction time, productivity and sustainability aspects. This paper aims to identify various factors causing construction waste in Chennai. Study was carried out through a structured questionnaire focusing on small scale contractors involved in construction projects. Data was analysed with Statistical Software Package SPSS. Reliability of data was found as 0.831 which showed that data collected was highly reliable. The calculation of Mean Rank of the construction waste causes found that the 10 key cause are errors, Ignorance of specifications, Poor planning, Inexperience designer, Effect of weather, Poor quality of materials, Lack of coordination among parties, Shortage of skilled workers, Poor site condition. Through identifying the causes it gives better understanding to the construction community for future construction projects which benefit not only in term of economy but also the environment.

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1. INTRODUCTION

Wastes defined as unwanted or discard materials. The wastes continually causing an environmental troubles and global warming problems to the world. There are many categories of wastes produce namely municipal solid waste, commercial waste, medical waste, biodegradable waste and construction waste. The municipal solid waste usually known as garbage and trash for any household. Other than that, commercial waste also

frequently occurred. The waste, mainly results from business and industrial sites. Medical waste also known as clinical. The waste is defined as waste commonly generate from hospital and clinics. The waste is generated in the diagnosis, treatment, or immunization of human beings or animals. The term biodegradable waste is any waste that is capable of undergoing anaerobic or aerobic decomposition. The waste are food processing, paper, textiles, wood, etc. The area of this research focusing on construction waste. The wastes produced at construction sites in physical form and non physical form. The physical waste are mainly from broken concrete, bricks, metals, packaging waste, etc. Whereas the non physical waste are cost overruns and time delays in construction projects.

In 21st century, researchers and practitioners around the world facing the challenges of construction waste. Various researches in develop countries indicate that contribution of construction waste in the urban area tend to increase. Researches in United States and Europe have revealed that considerable amount of waste lies in flow processes of construction. In addition, study conducted in Sri Lanka also reveals that the domestic construction industry workforce is ignorant of flow activities that create waste and their causes. Moreover, researchers from Nigeria described waste emanates during different stages of construction which can be during planning, estimating or construction stage. Other problems according to the Singapore researchers, during design, operational, procurement and material handling attributes that leads to site waste. Construction managers often fail to identify or address waste in the construction process. Thus, as a developing country, Chennai also has fallen into construction waste problems in line with the rapid development of construction sector. In tandem, with increasing demand of infrastructure projects, residential development projects, large amounts of construction waste are being produced in Chennai. These conditions may give a huge impact on project costs and time due to physical and non-physical waste for

Chennai construction industry. The objective of this on-going research is to identify various factors causing construction waste in Chennai.

1.1 Wastes In Construction

Waste is a familiar term in the industry world-wide. Waste in the construction industry is important not only from the perspective of efficiency, but also this concern has been growing in recent years about the adverse effect of the waste of building materials on the environment.

The construction industry has been found to be a major generator of waste. The construction sector is reported to be generating unacceptable levels of material waste. The construction industry has a major impact on the environment, both in terms of the resources it consumes and the waste it produces. The construction industry is responsible for producing a whole variety of different wastes, the amount and type of which depends on factors such as the stage of construction, type of construction, work and practices on site. Waste has been considered to be a major problem in the construction industry. Not only does waste have an impact on the efficiency of the construction industry but also on the overall state of the economy of the country. Construction activity generates an enormous amount of waste. The construction industry is one of the largest solid waste generators in Hong Kong Construction material waste has proved to have a negative effect on the national economy and the environment. Minimizing waste generates the greatest profit, the difference between price and cost.

2. LITREATURE REVIEW

In defining “Lean Production” principles , (Koskela 1992) defined waste as “any inefficiency that results in the use of equipment, materials, labor or capital in larger quantities than those considered as necessary in the production of a building.” (Formoso 1999), also defined waste as “any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client”. “Waste can be classified into unavoidable waste (or natural waste), in which the investment necessary to its reduction is higher than the economy produced, and avoidable waste, when the cost of waste is significantly higher than the cost to prevent it. The percentage of unavoidable waste in each process depends on the company and on the particular site, since it is related to the level of technological development" (Formoso1999).

According to Henry (2009), the construction sector represents one of the most dynamic and complex industrial developments the world over. The construction activities in the context of the Nigeria economy cannot be treated with a wave of hand. Obadan and Uga (1996) claimed that the construction industry contributes between 3 and 6% of the gross development product (GDP) in developing countries and records from the Federal Office of Statistics specifically ascertain that the contribution of construction industry to Nigeria's gross development product (GDP) has hovered around 2% for the past 15 years and this accounts for about 69% of the Nation's Gross Fixed Capital Formation (FOS, 1997). Empirical studies had also reinforced the fact that 1% increase in the stock of infrastructure generates 1% increase in the GDP across all countries. Ilesanmi (1986) posited that the cost of materials accounted for 50 to 60% of the total cost of construction of any project, while Skoyles (2000) came out with the most recent information that cost of material alone in the building construction project is 55 to 65%. To reduce cost of construction projects, an optimum material control on site should be therefore adopted. Construction waste is a growing problem in many countries. Stokoe et al. (1999) reported that construction and demolition (C&D) waste took up about 65% of Hong Kong's landfill space at its peak in 1994/1995. According to Ferguson et al. (1995), over 50% of the waste in a typical United Kingdom landfill could be construction waste. Craven et al. (1994) reported that construction activity generates 20 to 30% of all waste deposited in Australian landfills. In the United State, C&D waste represents about one-third of the volume of materials in landfills. Serpell and Labra (2003) reported that of the 3.5 million tons of C&D waste generated in Chile, only 10% is placed in authorized and controlled landfill sites. In the European Union, it is estimated that 0.5 to 1 ton per capital of C&D waste is generated annually. At the project and corporate levels, materials waste implies loss of profit and competitiveness for the contractor. Wastage may also lead to delays that cause costly idle time for other resources (Neo and Koh, 1995). At the national level, waste causes environment related problems (Tammemagi,1999). The cost and environmental implications of construction activities are now well known.

The construction industry in particular and the built environment in general has been found to be among the main consumers of resources and energy. Moreover, the construction sector is reported to be generating unacceptable levels of material and manpower waste. Generally, construction activities which produce wastage can be grouped into off-site and on-site operational activities. Off-site activities include prefabrication, project design (architectural, structural, mechanical and electrical design),
manufacturing and transporting of materials and components. On-site construction activities relate to construction of a physical facility which consists of the substructure and superstructure of the building. Some degrees of waste materials are inevitable in the construction process. All estimators allow wastage factors in pricing a bill of quantities. Over the years, experience has shown, however, that unless site management control is tight, wastage can frequently exceed, often by a large margin, than the figure allowed in the tender document. Enshassi (1996) buttressed the need for re-unification when he suggested that effective materials control demands concentrated and coordinated action of numerous people performing a variety of functions within the industry. He further suggested that waste seen on site is not necessarily caused by failure or inadequacy of individual functions involved in materials management system.

3. RESEARCH METHODOLOGY

The proposed approach in this paper considers waste as a future event which has an adverse effect on the production and supply cost for a company and for which possible outcomes can be predicted on the basis of probability. The proposed approach has two stages as below

1. Identification and classification of factors
2. Prioritization of factors

3.1 Factors Identification And Classification

A list of identified waste causing factors with their categories and classification is presented below: Identification, categorization and Classification of waste causing factors. Categorization of construction waste is a study into the composition and amount of construction waste generation that enhances understanding of the sources and causes of waste generation. Construction waste can be categorized into five broad areas of material waste, time waste, labour waste, process waste and equipment waste.

3.1.1. Causes Of Construction Waste Generation On Sites

Waste, being the extravagant or ineffectual use of resources, is to some extent inevitable. However, the cause, nature and amount of waste can be controlled right from design, through manufacture, to the construction processes. Previous research on waste causes reveals that it may occur at any stage of the process from inception, through design, construction and operation of the built facility and it may occur due to one or a combination of many factors (Gavilan and Bernold, 1994). The sources of construction waste were organized under the following seven categories.

3.2.1 QRA Sheet

QRA Sheet is designed, in particular, to assess individual risks subjectively. It has a list of identified and categorized risks on the left hand side column of the sheet. It shall ask for probability and consequence of each risk in a subjective way. For probability assignment, a probability scale Identified and classified risk Probability:

For example in each case:

A). Design

F1

F2

F3

B). Handling

F1

F2

F3

F4

Risks falling in very low and low zones of P-C matrix shall be eliminated, as these risks shall have negligible effect on objectives of construction business in terms of cost. Risks falling in “Significant” and “high zones” of P-C Matrix shall have potential Consequences on construction business objectives in terms of cost. These risks shall actually have substantial influence on objective of a company.

4. METHOD OF DATA ANALYSIS

4.1 Preliminary Survey

A preliminary quantitative study was carried out to investigate the perception of industry’s players regarding construction waste issue. From the identified factors, a structured questionnaire was developed and distributed in Chennai region. The questionnaire distribution was done randomly using two approaches, namely via postal mail as well as direct visitations to the respective firms. From the total of 80 questionnaires were distributed, only 58 (73%) of the respondents duly filled and returned the questionnaires. Data was analyzed with Statistical Software Package SPSS. Descriptive Analysis, Reliability Study, Standard Deviation Ranking were used in this research. The purpose of respondent’s demography is to review the capabilities of the respondents in understanding the issues of construction waste.

In term of experience in the construction industry, this survey found that as much as 39% of respondents had working experience of 6 to 10 years, followed by 32% respondents who possessed working experience of between 11 to 15 years. The minority group of respondents in terms of work experiences was those less than 5 years’ experience, is 29%.

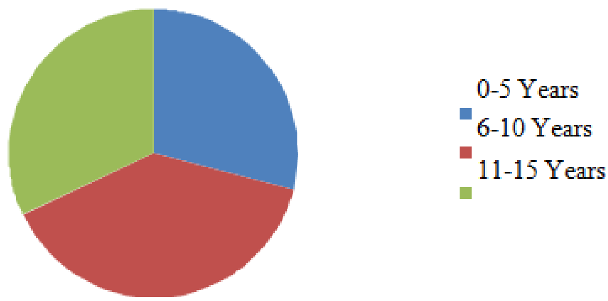

Fig. 1. Respondent's experience in construction.

Fig. 2 of the pie chart indicates that 71% of the respondents are in between 6 to 15 years working experience in Chennai construction industry. The profile information of the respondents experience reflects their understanding about issues concerning identifying factors causing of construction waste.

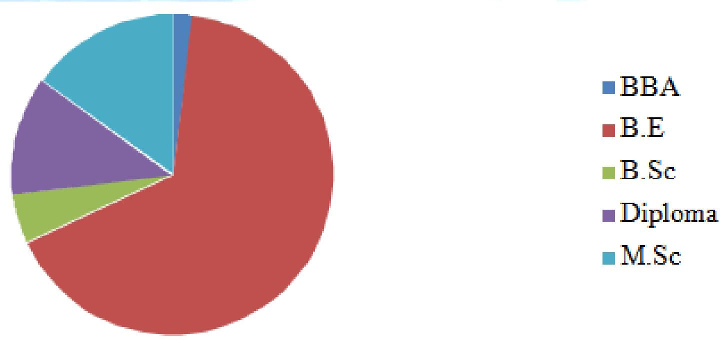

Fig. 2. Respondents' Qualification.

The qualification attained by the respondents as shown in Fig. 3. The chart shows 66% of the respondents obtain Bachelor of Engineering (BE). The second largest of respondents' education level is Masters of Science (MSc), 15%. The Diploma holder comprises of 12% and then followed by BSc, 5%. The smallest percentage is Bachelor of Business Administration (BBA), only 2% of the total respondents. This indicates that majority of the respondents obtain bachelor degree, 73%. Therefore, it can be deduced that all of the respondents were well educated.

4.2 Reliability Analysis

The reliability test was conducted on the data to measure its stability and consistency. In this test Cronbach's alpha (reliability coefficient) was determine in order to indicate the reliability of the data. The closer Cronbach's alpha value to 1 the higher the internal consistency reliability of the data. In this study, reliability test on the data was carried out and it was found that the alpha value is 0.831. This indicates that data collected was highly reliable.

RESULTS AND DISCUSSIONS

Statistical analysis is done using SPSS which is a comprehensive and flexible statistical analysis and data management solution. SPSS can take data from almost any type of file and use them to generate tabulated reports, charts, and plots of distributions and trends, descriptive statistics, and conduct complex statistical analyses. SPSS is available from several platforms; Windows, Macintosh, and the UNIX systems. SPSS (Statistical Package for the Social Sciences) is a computer program used for survey authoring and deployment, data mining, text analytics, statistical analysis. Statistics included in the base software such as in descriptive statistics methods of cross tabulation, frequencies, exploring, and descriptive ratio statistics can be included. In the bi variant statistics, such as means, tests, correlation, non parametric tests can be performed.

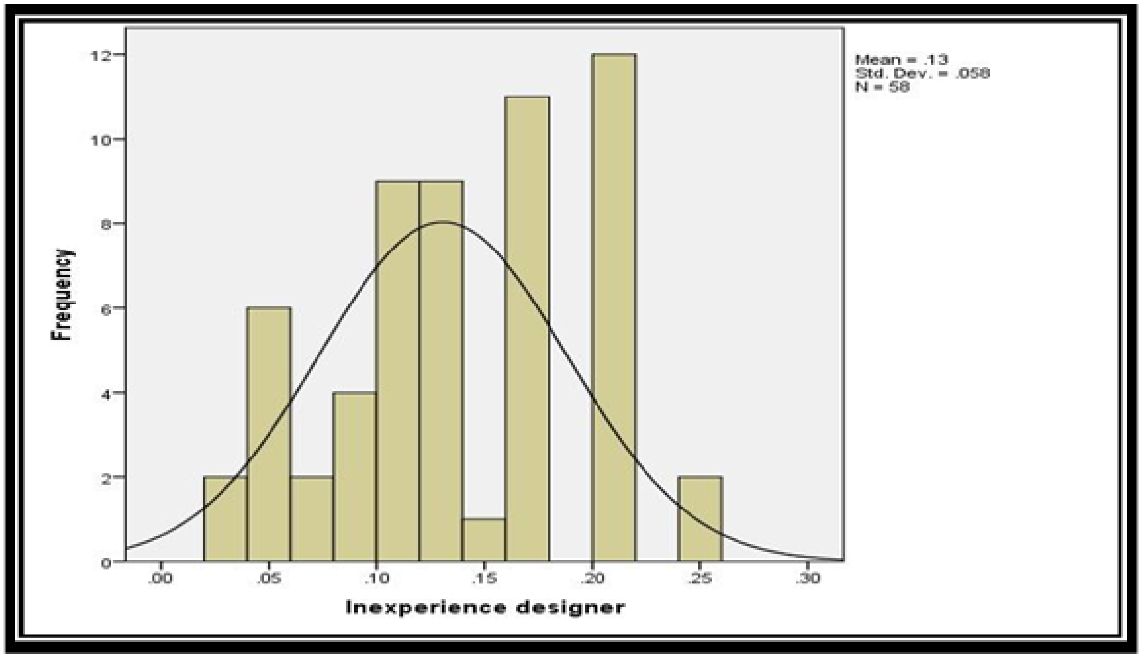

Figure.4.3 Bar chart for Inexperince Designer

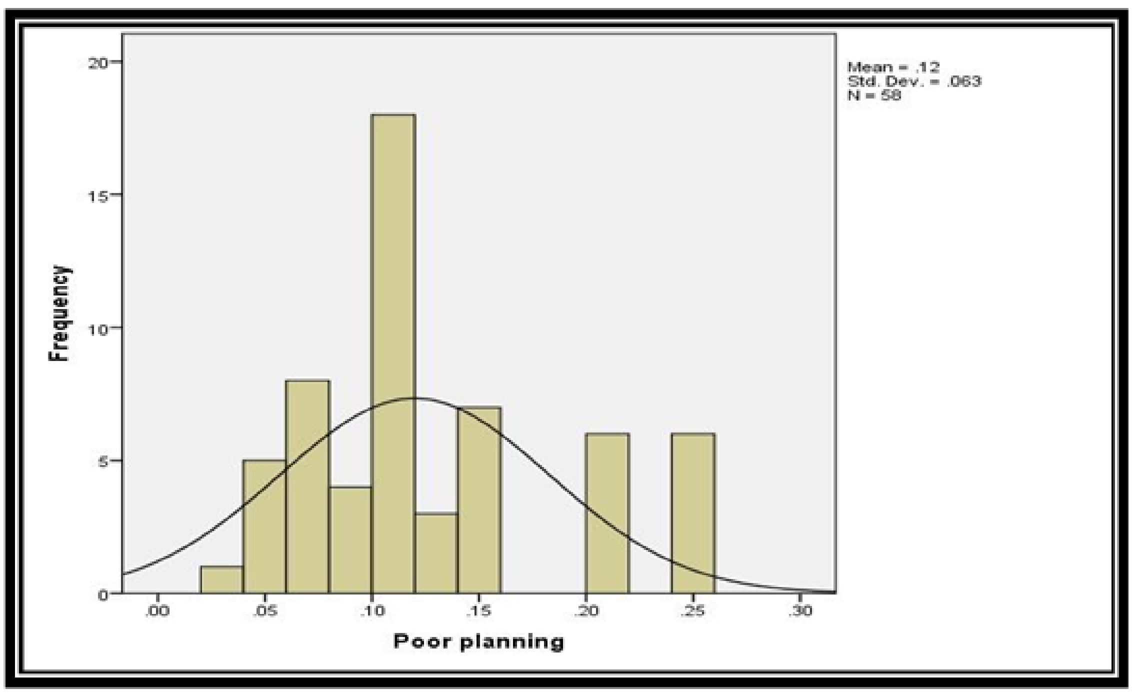

Figure.4.2 Bar chart for Poor Planning

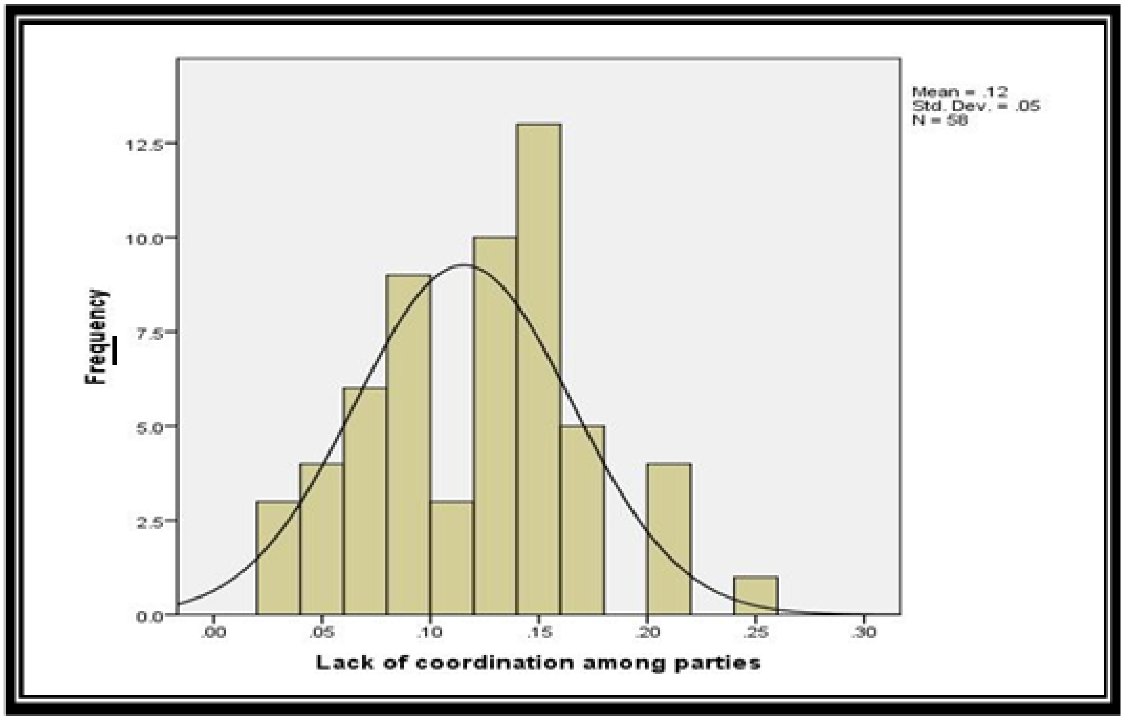

Figure.4.6 Bar chart for Lackof Co ordination among Parties

The graphs generated using SPSS are shown above while, Mean is presented in y-axis and risks in x-axis. Manual ranking of risks purely based on frequency is not possible as both factors i.e., probability and consequence have to be considered, hence SPSS is used high probability and high consequence risks show up as high mean and high standard deviation risks. Higher mean and probability risks are arranged in ascending order as below:

1. Accidents
2. Poor supervision
3. Resources problem
4. Design errors
5. Ignorance of specifications
6. Poor planning
7. Inexperience designer
8. Effect of weather
9. Poor quality of materials

10. Lack of coordination among parties

After identification, classification and prioritization of factors the process to be carried out are as follows.

1. These top ten factors idenified are sent back to the experts in the site to propose mitigation strategies.
2. These mitigation strategies are formulated based on the ideas received from the experts and future proposal measures are done.

5.1. Accidents

MITIGATION STRATEGIES

The employer shall determine if the walking/working surfaces on which its employees are to work have the strength and structural integrity to support employees safely.

- Employees shall be allowed to work on those surfaces only when the surfaces have the requisite strength and structural integrity.
- Each employee on a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest system.
- Each employee who is constructing a leading edge 6 feet (1.8 m) or more above lower levels shall be protected from falling by guardrail systems, safety net systems, or personal fall arrest systems.
- Exception when the employer can demonstrate that it is infeasible or creates a greater hazard to use these systems, the employer shall develop and implement a fall protection plan which meets the requirements.
- Each employee on a walking/working surface 6 feet (1.8 m) or more above a lower level where leading edges are under construction, but who is not engaged in the leading edge work, shall be protected from falling by a guardrail system, safety net system, or personal fall arrest system.
- Each employee on the face of formwork or reinforcing steel shall be protected

from falling 6 feet (1.8 m) or more to lower levels by personal fall arrest systems, safety net systems, or positioning device systems.

- Each employee on ramps, runways, and other walkways shall be protected from falling 6 feet (1.8 m) or more to lower levels by guardrail systems.
- Each employee at the edge of an excavation 6 feet (1.8 m) or more in depth shall be protected from falling by guardrail systems, fences, or barricades when the excavations are not readily seen because of plant growth or other visual barrier;
- Each employee working on, at, above, or near wall openings (including those with chutes attached) where the outside bottom edge of the wall opening is 6 feet (1.8 m) or more above lower levels and the inside bottom edge of the wall opening is less than 39 inches (1.0 m) above the walking/working surface, shall be protected from falling by the use of a guardrail system, a safety net system, or a personal fall arrest system.
- When an employee is exposed to falling objects, the employer shall have each employee wear a hard hat and shall implement one of the following measures such as Erecting toe boards, screens, or guardrail systems to prevent objects from falling from higher levels.

5.2 Poor Supervision

Supervision is an extremely vital part of a workplace that intends to maximize its success potential. It naturally follows, then, that poor supervision in a workplace is among the primary obstacles to achieving potential successes by a business. After all, employees, no matter their task, must have the proper instruction and training to ensure that they are doing their jobs correctly, and with minimal risk of error or injury

- Ensuring bottom level supervision by employing medium level supervisors.
- Ensuring top level supervision by employing top level supervisors.
- Establishing an integrated workmanship supervision system in all levels.
- Provision of security cameras and integrated GPS tags for the employees to enable proper supervision.

5.3 Resources Problem

Generally happens due to deficit in cash flow therefore proper cash flow should be ensured so that resource problem does not occur in any part of construction.

- Purchasing and storing of raw material resources equipment prior to the beginning of construction activities so that construction is not interpreted due to shortage of any of the resources.
- Proper maintenance of resources in the site must be ensured so that the existing resource does not become unusable for construction.
- Procurement of resources prior to the escalation of process in market must be done.
- Proper estimation and optimization of the resources must be done in order to procure the resources when needed.

5.4 Design Errors

From the evaluation above a simple definition of design error is "a deviation from the plans and specifications." It is not the intention of this definition to include any cost or schedule growth or insinuate its root causes or legal responsibility. It is the responsibility of the owner, designer and contractor to establish the criteria in order to make a reasonable determination for responsibility. The survey shows a common theme, that of a mistake or error in the design. The survey also indicates several reasons why design errors exist and who cause them. This provides evidence that there is not a concise definition within the construction industry.

From die survey firms have introduced different steps in order to reduce the number of design errors. Within the realm of Total Quality Management concepts, firms have developed Quality Control plans as a check and balance system to reduce the number of design errors and reduce contractor rework. The reduction in errors and rework is possible through better coordination within die different disciplines. These plans establish criteria to review all the documents within the package. All the coordination and reviewing can only be totally served through effective communication. Owners' responses were fundamentally driven toward the designer obtaining and adhering to a Quality Control plan. A Quality Control plan would consist of various reviews and the incorporation of more field investigations. One owner response requested a return to actively pursuing A & E liability towards design errors. This is necessary for the design firms that do not accept the responsibility, governed by law, to ensure documents that are complete and useable and virtually free of error.

- Proper design is essential for a healthy construction. Therefore proper designing must be done and must be verified and approved by senior level authorities before execution. If execution is done using improper design then it leads to catastrophic results. In many cases the only mitigation strategy is to demolish the existing construction and reconstructing using proper design.
- Proper verification of the design must be done by comparing with standard design codes such as IS code and ASTM.

5.5 Ignorance Of Specification

- Specification must be cross verified by high level authorities before execution.
- Specification must be checked with standard codes such as IS codes and ASTM.
- Proper training must be given to the engineer about specification and they must be made aware about the various specification standards.
- Proper contract clauses must be given in documents to counter any discrepancies in the specification and ensuring the claiming of legal liability.

5.6 Poor Planning

- Proper planning and scheduling must be done prior to the beginning of construction. Old plans and scheduling must be changed according to the updated plans and schedules.
- Any deviation of the activities from the original plans must be adjusted according in order to compensate for the lag or delay that has occurred.
- Proper planning and scheduling technique must be taught to the employee and the right usage of planning and scheduling software must be taught to them.
- If the existing employee are not capital capable enough to do proper planning and scheduling then it can be given to other company by outsourcing.

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