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# Pre-Construction Measures to Prevent Delay in Construction of Residential Highrise Project

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***Abstract***: Indian cities are witnessing huge influx of migrating population from smaller towns and cities leading to population increase resulting in increase in property demand and land scarcity. As a result, High-rise residential project demand has been increasing in the Metropolitan Cities. The importance of construction industry in India has grown significantly but at the same time, construction projects in India have become infamous for delays and cost overruns. Construction delays are considered one of the most recurring problems in construction industry and has adverse effects on Project's success in terms of cost, time and quality. There are many research works conducted to identify various causes of delay in construction and their mitigation measure, yet the problem of delay continues to prevail. Indian metro cities like Delhi and Mumbai include higher number of Residential High-rise projects that have been witnessing delay of over 5 years. While most of the projects are executed conventionally with an emphasis on solving the problems as and when encountered, which eventually leads to delay, most of the delays can be prevented, provided due consideration are adopted in pre-construction stage to mitigate the risk of delays encountered during execution stage. The research aims at identifying the reasons of delay in pre-construction stage that are the root cause of various delays encountered during execution phase of Residential High-rise project. The research also intends to identify mitigation measures for the root causes of delay identified to prevent delays in construction project before the execution begin to prevent the risk of schedule overrun.

***Keywords: residential high-rise, construction delay, construction stages, delay prevention, Stakeholders, impact of delay***

## 1 INTRODUCTION

Indian construction Industry has grown tremendously in the last few decades. Construction is the second largest economic activity after agriculture, and has contributed around 6 to 9% of India's GDP over the past five years while registering 8 to 10% growth per annum (Hemanta Doloi, 2011). Various government flagship programs – including 100 Smart Cities Mission, Housing for All, Atal Mission for Urban Rejuvenation and Transformation (AMRUT), Make in India and Power for All are some of the growth drivers contributing to Indian construction industry. Hence, Residential project along with Infrastructure projects are expected to be the major contributors to the construction industry in India. While the importance of construction industry in India has grown significantly, Construction projects in India have become infamous for delays and cost overruns.

Delay means failure to complete a Project within given time and hence compromising the budget and quality of the deliverable. Construction delay is considered one of the most recurring problems in construction industry and has adverse effects on project's success in terms of cost, time and quality. It also has a negative effect on clients, contractors, and consultants in terms of growth in adversarial relationships, mistrust, litigation, arbitration, and cash-flow problems.

While most of the projects are executed conventionally with an emphasis on solving the problems as and when encounter, which eventually leads to delay, most of the delays can be mitigated before even happening. Construction delays can be prevented provided proper measures are taken in pre-construction phase of the project instead of eliminating it at the time of encounter. This will not only help in countering the risks associated with the project beforehand but also will help in keeping a check on schedule overrun, cost overrun and quality of the project. (Dashore, n.d.)

Delay in construction project has been a research topic for decades and so is the study of factors causing delays. But with delay analysis and remedies to solve it, it is important to make efforts to prevent them. Hence, the research conduct aims at proposing preventive measures for delays in construction project before the execution begin to prevent the risk of schedule overrun.

## 2 AIM

The aim of the research is to analyze reasons of construction delays in Highrise Residential construction project and propose pre-construction measures to prevent delay during execution phase.

## 3 OBJECTIVES

1. To identify various reasons of delays and their impact on Highrise Residential project.
2. To identify the root causes of the construction delays lying in Pre-construction stage.
3. To propose pre-construction measures to prevent delays in Highrise construction project.

## 4 LITERATURE REVIEW

### *4.1 Causes of Delay*

(Desai Megha, 2019) identified 59 causes of delay through questionnaire survey and importance index technique. The research concluded that Original contract duration is too short, Shortage of labors, Delay in material delivery, Low productivity level of labors, Delay in progress payments by owner as the primary causes of delay. (Bhangale, 2017) diagnosed three most significant factors that adversely impact construction project delivery time performance are: quality of management during construction; quality of management during design, and design coordination. Main causes of delay were related to designer, user changes, weather, site conditions, late deliveries, economic conditions. (Subhav Singh, 2018) concluded that shortage of materials on site; unforeseen ground conditions; poor procurement planning; problems to access the site; rework; weather conditions; inadequate modern equipment; skilled workforce; and equipment failure were ranked by the contractors and consultants as the main causes of project delays in India. (DOLOI, et al., 2012) developed a theoretical structural equation model that suggest, client's influence was found to be one of the key contributing factors resulting in schedule overrun, lack of commitment and contractor's inefficiency in the project. Lack of efficient construction planning plays the second key role in adverse time performance. While the effect of lack of commitment on contractor's inefficiency is highly significant. The results also highlight the importance of the role of clients and technical expertise in planning in achieving satisfactory time performance on Indian projects.

### *4.2 Impacts of Delay*

(Veera Vijay. Divi, 2017) In any construction project time, quality and cost are the three main factors, in which time plays a key role. Eventually there are several impacts on the project quality, cost and may also lead to disputes. These impacts may also lead to loss of productivity, project acceleration, negotiation, arbitration, litigation and also termination of the project. Hence these can also be referred as secondary impacts of the delays. (Saurabh Thorat, 2017) in his study discusses various impacts of delay like Time overrun, Cost overrun, Reduction of profit, Poor quality of completed project, Abandonment of project, Dispute and Arbitration.

### *4.3 Delay Mitigation*

(Ashish Chandu Pawar, 2016) made recommendations to reduce down construction delays occurred in Residential Project by these various methods are given below sound Implementation Planning, better Formulation and Appraisal of Projects advance action, clearances, assurance of funds resources, better contract management, penalties and incentives and monitoring. (Subramanyan, et al., 2012) suggested some considerations to prevent the delays caused to the project based on the expert interview which are proper methodology of award of work should be arrived at instead of selecting the lowest tender, project-specific risk factors must be handled on a fair basis by providing a suitable built-in mechanism in the contract, architect/consultant-specific risk can be handled by early freezing of design details and development of synchronized drawings to minimize disputes, related delays, and extra item claims, the tender pre-qualification system should have a mechanism to encourage contractors to train their men, to handle external-environment-specific factors, the parties should know what are the major risks are that cannot be transferred and identify suitable mechanisms to cover such risk and a proper contract administration to mitigate overall risk to a greater extent in the Indian construction industry.

## 5 RESIDENTIAL HIGH-RISE

Residential Highrise in itself includes two multifaceted facilities with complex structural design along with complex service load. NBC Part 4 defines Highrise as, all buildings 15 m or above in height (Bureau of Indian Standards, 2016), while as per Model Building code buildings higher than 15m of height without stilts and above 17.5m of height with stilts shall be considered as high rise building ( Ministry of Urban Development, Government of India, 2016). In India, a building greater than 75ft (23 m), generally 7 to 10 stories, is considered as high-rise. Also, a building is considered to be high-rise when it extends higher than the maximum reach available to fire fighters (Kavilkar & Patil, 2014). The exact height above which a particular building is deemed a high-rise is specified by fire and building codes for the country, region, state, or city where the building is located (Craighead, 2009). Residential Highrise shall fall in Group A-4 classification as per National Building code, which includes apartment housing with three or more dwelling units with independent cooking facility, which requires special service provisions like fire safety, waste management and lift in addition to usual service requirement like water supply, electricity and sewerage system (Bureau of Indian Standards, 2016).

### *5.1 Structural Complexity*

The largescale volume of the building and massive service requirement can be achieved only through complex structural design for the building with enough strength to bear the heavy dead load, wind load, earthquake load and live load the building is subjected to.

#### *5.1.1 Basement*

Construction of Highrise is challenging as its construction means going deeper than those needed for typical and conventional foundations, construction of basement which is difficult as it is supposed to be carried out below deep ground in adverse condition such as existence of ground water, muddiness or limited working space. Such cases became more serious in areas of soil with high water table and clayey soil (Phaniraj K, 2014).

#### *5.1.2 Formwork*

High rise needs complex formwork system to ensure construction at higher altitudes. There can be various options like jump formwork, slip formwork, etc. for external structure while it is more cost effective to use system formwork for the construction of typical floors, due to the repetitive structural form. The cost of formwork is highly related to the number of re-use or re-cycling. It is a general assumption that a set of formworks can be re-used for at least six to eight times and 100 times for timber and steel form respectively (Arthur W T Leung, 2003).

#### *5.1.3 Special Concrete mix*

Construction of high-rise also involves use of concrete with high workability which needs to be transported from the batching area to the site and then pumped up to the desired height to enable construction.

*5.1.4 Equipment*

Selection of right equipment and placing them at strategic location in plan is critical to ensure speedy construction and delivery of men and material. Selection of optimal equipment and vertical transportation system for construction requires ongoing analysis and constant modification due to dynamic nature of project during construction.

*5.2 Efficient Project planning*

To complete the project and reduce the loss of productivity, the high-rise construction manager should have an excellent and thorough knowledge of delays that may occur and should plan and utilize an efficient management system to address those delays (Asa, et al., 2019).

*5.2.1 Slab Cycle*

In the construction of a high-rise building, one of the planning objectives is to ensure the early completion of the structural frames to generate floor areas for the execution of finishing works, building services installation and internal fitting out. The completion of the structural frames is therefore critical in the overall programme (Arthur W T Leung, 2003). Usually 7 days slab cycle is targeted for Residential floor (Amitabh Kumar, 2011).

*5.2.2 Critical Path*

Critical path of any project must be considered to optimize project schedule. For Residential Highrise, slab cycle forms a crucial part, as it's after the civil work completion of the floor that the finish work and services can be commenced. Hence special consideration is required to maintain consistency in sequential execution of slabs.

*5.3 Financial Planning*

Mostly in Residential High-rise financial planning relies on income from pre-booking of residential units. Though relying on apartment sell is risky, shifting reliance on bank loan can be relatively less risky but results in increased cost of construction due to the interest imposed (Piyush Shivhare (29th June, 2020) Telephonic Interview).

*5.3.1 Multiple Approval*

Residential Highrise are complex project that grow vertically needs several special approvals and NOCs from various departments (like Fire Safety, Airport authority, etc.) in addition to the conventional approvals. Accomplishing all the approvals for the concerned project is usually a prolonged process.

*5.3.2 Multiple dwelling units*

Residential Highrise buildings are designed to incorporate a number of typical dwelling units distributed floor wise usually. Services planned for single dwelling unit are applicable to all the similar units, leading to scaling up of a small error manifold. Also, dwelling units before delivery are expected to be finished exclusively as per their buyer's will, which requires designing and a whole new set of drawings for execution, affecting the financial planning of the project.

*5.3.3 Multiple consultants*

To ensure accessibility to the top floor of the Highrise building, safety and security and comfortable living of the residents, Residential Highrise Buildings involve a complex network of services, complicated structural design and bulk finish. Hence, the execution of such multifaceted building requires involvement of various specialized consultants concerning to Fire Safety, MEP, Safety and Security, structural consultant, architectural consultant, project management consultant, etc. The facilities and complexity in the building grows exponentially in accordance with the social status and cost upgradation.

*5.3.4 Long Term Project*

The long duration of the projects and their multi-stage processes starting from the preparing and beginning of the project to implementation and final delivery of it; lead to several conditions, possibilities, uncertainties and the possibility of falling into the risk of extending the duration of the project or incurred financial or other losses, which adversely affect the operation of the project and the economics of construction (Khalid, 2019).

*5.3.5 Corrupt Practices*

Corruption is particularly relevant for megaprojects because of their intrinsic characteristics like large investment commitment, vast complexity (especially in organizational terms), and long-lasting impact on the economy, the environment, and society; that are mutually interdependent since they influence each other (Locatelli, et al., 2016).

As per (CHIOCHA, 2009), (Locatelli, et al., 2016) Certain specific characteristics causes Highrise residential projects more subject to corruption like size that makes it easier to hide bribes and inflated claims in large projects, uniqueness which makes it easier to inflate, as there is no comparison available, number of contractual links providing an opportunity to pay a bribe in exchange for the contract award, project complexity making it vulnerable to mismanagement or poor design that can be used to hide bribes and inflate claims, work is concealed making the quality check of the components costly or difficult, in several cultures bribery and deceptive practices are often accepted as the norm, a wide range of professions are involved in construction leading to varying standards of skill, integrity and oversight. No single organization has overall responsibility, tendering process may prove to be competitive causing corruption of tender, complicated tendering process may also lead to corruption due to the failure of contractors and consultants in supplying required pre-qualification documents and in many instances for frequently required government approvals, contractors, consultants and individuals end up bribing municipal inspectors to either expedite the processing of approvals or overlook problems on job sites.

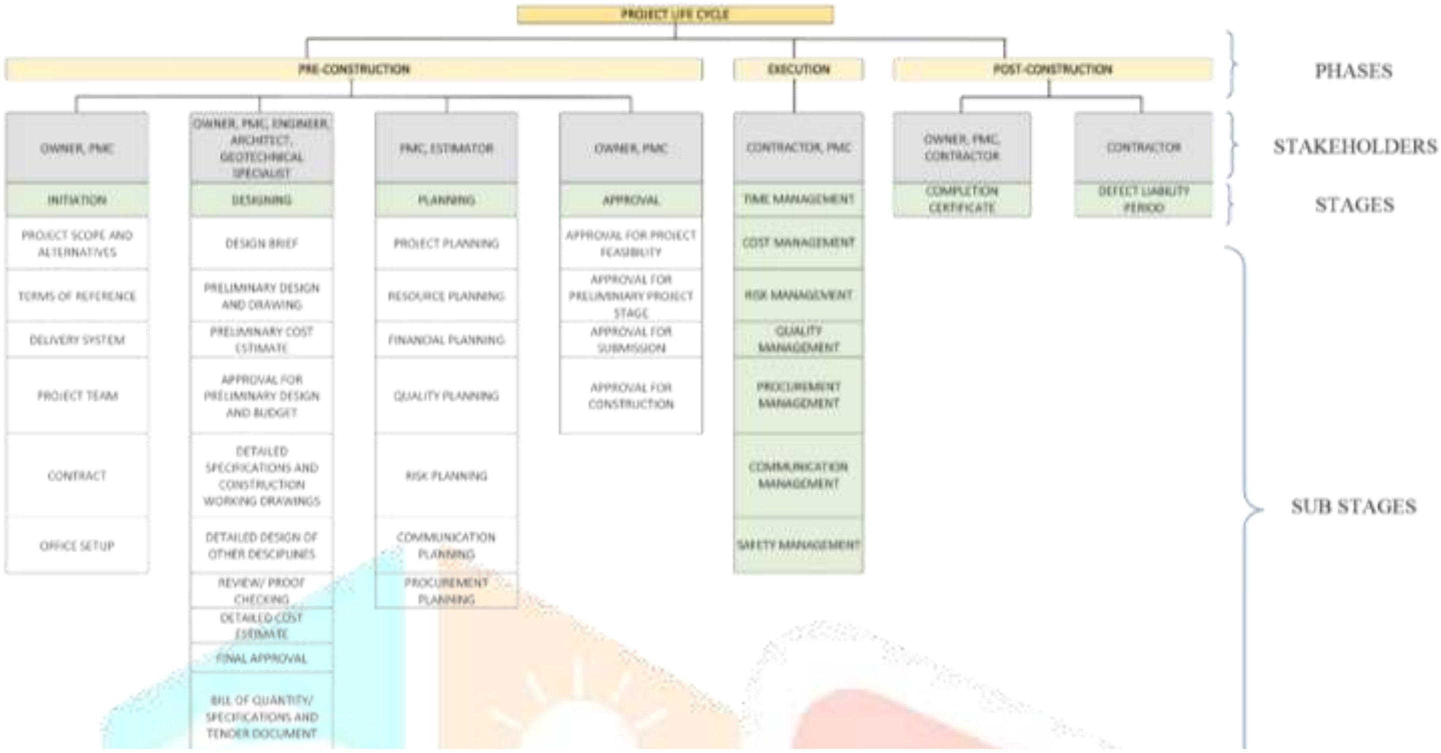


Figure 1 Project Life Cycle

## 6 STAGES OF CONSTRUCTION

Life cycle of a construction project can be broadly segmented into Pre construction phase, Execution phase and Post construction phase. Inclusive of various procedures, approvals and responsibilities of the Stakeholders involved, the three stages sum up a Project's Life Cycle (figure 1).

## 7 RESEARCH METHODOLOGY

Data for preparation of questionnaire was done through secondary data collected through literature study. Various research papers were referred and 49 causes of delays that are most frequently mentioned were identified. For first objective primary data collection online questionnaire survey was prepared with the help of data collected. The survey aimed at identifying the severity and frequency of occurrence of various reasons of delay identified that affect the Project's overall schedule at various stages. Using the data from survey Importance Index for causes of delay was calculated and they were ranked from highest to lowest, to identify the most significant causes of delay. Identified causes of delay were further analyzed to identify their root cause that is the second objective. To achieve third objective, on the basis of interview and literature review, pre-construction measures to prevent delay in construction were proposed.

### *7.1 Preparation of questionnaire*

There is very less research done specific to delays in residential high rise hence several research papers( (Desai Megha, 2019), (Bhangale, 2017), (Umesh Pawar, 2017), (Subhav Singh, 2018), (Saurabh Thorat, 2017), (Ansari Hassaan, 2017), (Raj, 2017), (Ashish Chandu Pawar, 2016), (DOLOI, et al., 2012)) quoting causes of delay in either residential project or high rise were referred to identify the most frequently mentioned 49 causes of delay. Following are the causes identified

Table 1 Identified Causes of Delay

| S.NO. | GROUP | CAUSES OF DELAY |
|---|---|---|
| 1 | PMC related Delay Factors | Improper project planning |
| 2 | | Poor site management |
| 3 | | Poor time estimate |
| 4 | | Poor communication with other parties |
| 1 | Client related Delay Factors | Slow decision making |
| 2 | | Delay in payment/ hindered cashflow |
| 3 | | Scope change |
| 4 | | delayed approvals |
| 5 | | Poor communication and co-ordination between other parties. |

| | | |
|---|---|---|
| 6 | | Unavailability of incentives for contractor for completing work beforehand |
| 7 | | Delayed site handover |
| 1 | Contractor related Delay Factors | Improper project planning |
| 2 | | Low financial capability |
| 3 | | Improper construction methods |
| 4 | | Insufficient experience |
| 5 | | Poor site management |
| 6 | | Rework due to mistakes |
| 7 | | Poor communication with other parties |
| 1 | Consultant related Delay Factors | Delay in preparation and approval of drawings |
| 2 | | Less coordination with client/ parties |
| 3 | | Waiting time for approval of test and inspection |
| 4 | | Reluctance for proposed change |
| 5 | | Inadequate experience of consultant |
| 6 | | Revisions in design documents/ design error |
| 7 | | Unclear and inadequate details in drawings |
| 1 | Material related Delay Factors | Shortage of material |
| 2 | | Improper storage of material/ Damage of materials |
| 3 | | Price Fluctuation of material |
| 4 | | Late procurement of material |
| 5 | | Changes in material types and specifications during construction |
| 1 | Labour and Equipment related Delay Factors | Shortage of skilled manpower and labor |
| 2 | | Low productivity of labor |
| 3 | | Labor disputes and strikes |
| 4 | | Equipment Unavailability |
| 5 | | Low productivity of equipment |
| 6 | | Equipment Failure |
| 1 | Contract related Delay Factors | Major disputes and negotiations |
| 2 | | Original planned contract duration is unrealistic |
| 3 | | Ineffective delay penalties |
| 1 | Approval related Delay Factors | Delay in obtaining permissions from Government authority |
| 2 | | Delay in performing final inspection and certification by a third party |
| 1 | External related Delay Factors | Weather condition |
| 2 | | Accidents and injuries on site |
| 3 | | Change in government policies |
| 4 | | Non-availability of utilities on site |
| 1 | Other Delay Factors | Poor organizational structures for client or consultant |
| 2 | | Multiple stakeholders |
| 3 | | Corrupt Practices |
| 4 | | Lack of Responsibility |

*7.2 Online Survey*

An online survey was conducted and the respondents were asked to rate the causes of delay during construction with respect to their severity and frequency of occurrence. The rating was based on Likert scale in which the rating scale was as follows:
1 - Very less; 2 – Less; 3 – Moderate; 4 – High; 5 - Very high

*7.3 Respondent Profile*

The survey was sent to professionals (Project manager, Construction Manager, Engineer, Architect, Supervisors) associated with case study project. The survey was sent to around 16 respondents out of which only 10 responses were received. The responses received were reliable and authentic, hence the analysis was conducted.

Table 2 Respondent's Profile

| Respondent | Profession | Experience |
|---|---|---|
| R1 | Project Manager | >20 |
| R2 | Architect | 10-20 |
| R3 | Architect | 5-10 |
| R4 | Engineer | <5 |
| R5 | Engineer | 5-10 |
| R6 | Project Manager | >20 |
| R7 | Engineer | >20 |
| R8 | Architect | <5 |
| R9 | Engineer | <5 |
| R10 | Engineer | >20 |

Kish (1965) showed that the sample size can be calculated as following equation for 94% confidence level (Phaniraj K, 2014)
n = n'/ [1+ (n'/N)]
N = total number of populations
n= sample size from finite population
n' = sample size from infinite population = $S^2/V^2$;
where,
S is the variance of the population elements and V is a standard error of sampling population. (Usually S= 0.5 and V = 0.06)
So, for 16 respondents:
n= n'/ [1+(n'/N)]
n'= $S^2/V^2 = (0.5)^2/ (0.06)^2 = 69.44$
N = 16
n= 69.44/ [1+(69.44 / 16)] = 13
This means that the number of responses for the survey should be at least 13 in order to achieve 94% confidence level. But the actual number of responses received is 10, Moser and Kalton (1971) showed that a response rate of less than 30% is likely to produce results subject to non-response bias. Based on this, obtained response rates of 76.92% is reasonable and will reflect good results and outputs (Phaniraj K, 2014).

*7.4 Data Analysis*

*7.4.1 Importance Index Calculation*

Importance Index Technique was used to analyze the data collected from the survey. This technique uses the product of the severity index and frequency index to identify the importance index and then causes were ranked from highest Importance index to Lowest importance index.

Frequency index: A formula is used to rank causes of delay based on their frequency of occurrence as indicated by the participants.

Frequency Index: **(F.I.) (%) = ∑ a (n/N) * 100/5**

Where, ‘a’ is the constant expressing weighting given to each response (ranges from 1 for rarely up to 5 for always), n is the frequency of the responses, and N is total number of responses.

Severity index: A formula is used to rank causes of delay based on severity as indicated by the participants.

Severity Index: **(S.I.) (%) = ∑ a (n/N) * 100/5**

where ‘a’ is the constant expressing weighting given to each response (ranges from I for little up to 5 for severe), n is the frequency of the responses, and N is total number of responses.

Importance index: The importance index of each cause is calculated as a function of both frequency and severity indices, as follows:

Importance Index:

**(IMP.I.) (%) = [F.I. (%) * S.I. (%)]/100**

Importance index calculation and ranking was done for all the causes of delay identified from highest to lowest.

Table 3 Survey Analysis

| S.No | Causes of Delay | Group | F.I. | S.I. | IMP.I | Rank |
|---|---|---|---|---|---|---|
| A22 | Reluctance for proposed change | Consultant | 72 | 74 | 53.28 | 1 |
| A32 | Low productivity of labor | Labour and Equipment | 68 | 74 | 50.32 | 2 |
| A3 | Poor time estimate | PMC | 72 | 68 | 48.96 | 3 |
| A17 | Rework due to mistakes | Contractor | 66 | 74 | 48.84 | 4 |
| A37 | Major disputes and negotiations | Contract | 66 | 74 | 48.84 | 4 |
| A21 | Waiting time for approval of test and inspection | Consultant | 68 | 70 | 47.60 | 5 |
| **S.No** | **Causes of Delay** | **Group** | **F.I.** | **S.I.** | **IMP.I** | **Rank** |
| A31 | Shortage of skilled manpower and labor | Labour and Equipment | 66 | 72 | 47.52 | 6 |
| A27 | Improper storage of material/ Damage of materials | Material | 62 | 76 | 47.12 | 7 |
| A12 | Improper project planning | Contractor | 66 | 70 | 46.20 | 8 |
| A16 | Poor site management | Contractor | 66 | 70 | 46.20 | 8 |
| A39 | Ineffective delay penalties | Contract | 66 | 70 | 46.20 | 8 |
| A40 | Delay in obtaining permissions from municipality | Approval | 66 | 70 | 46.20 | 8 |
| A13 | Low financial capability | Contractor | 64 | 72 | 46.08 | 9 |
| A38 | Original planned contract duration is unrealistic | Contract | 64 | 72 | 46.08 | 9 |
| A2 | Poor site management | PMC | 66 | 68 | 44.88 | 10 |
| A24 | Revisions in design documents/ design error | Consultant | 64 | 70 | 44.80 | 11 |
| A4 | Poor communication with other parties | PMC | 64 | 68 | 43.52 | 12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| A9 | Poor communication and co-ordination between other parties. | Client | 62 | 70 | 43.40 | 13 |
| A15 | Insufficient experience | Contractor | 62 | 68 | 42.16 | 14 |
| A19 | Delay in preparation and approval of drawings | Consultant | 60 | 70 | 42.00 | 15 |
| A8 | delayed approvals | Client | 62 | 66 | 40.92 | 16 |
| A47 | Multiple stakeholders | Other | 60 | 68 | 40.80 | 17 |
| A25 | Unclear and inadequate details in drawings | Consultant | 58 | 68 | 39.44 | 18 |
| A29 | Late procurement of material | Material | 58 | 68 | 39.44 | 18 |
| A6 | Delay in payment/ hindered cashflow | Client | 60 | 62 | 37.20 | 19 |
| A1 | Improper project planning | PMC | 58 | 64 | 37.12 | 20 |
| A20 | Less coordination with client/ parties | Consultant | 56 | 66 | 36.96 | 21 |
| A18 | Poor communication with other parties | Contractor | 56 | 62 | 34.72 | 22 |
| A46 | Poor organizational structures for client or consultant | Other | 54 | 64 | 34.56 | 23 |
| A5 | Slow decision making | Client | 60 | 56 | 33.60 | 24 |
| A26 | Shortage of material | Material | 52 | 64 | 33.28 | 25 |
| A49 | Lack of Responsibility | Other | 54 | 60 | 32.40 | 26 |
| A23 | Inadequate experience of consultant | Consultant | 54 | 58 | 31.32 | 27 |
| A36 | Equipment Failure | Labour and Equipment | 52 | 60 | 31.20 | 27 |
| A41 | Delay in performing final inspection and certification by a third party | Approval | 52 | 60 | 31.20 | 27 |
| **S.No** | **Causes of Delay** | **Group** | **F.I.** | **S.I.** | **IMP.I** | **Rank** |
| A14 | Improper construction methods | Contractor | 52 | 58 | 30.16 | 28 |
| A28 | Price Fluctuation of material | Material | 50 | 60 | 30.00 | 29 |
| A34 | Equipment Unavailability | Labour and Equipment | 50 | 60 | 30.00 | 29 |
| A42 | Weather condition | External Reasons | 50 | 58 | 29.00 | 30 |
| A30 | Changes in material types and specifications during construction | Material | 50 | 56 | 28.00 | 31 |
| A7 | Scope change | Client | 48 | 56 | 26.88 | 32 |
| A33 | Labor disputes and strikes | Labour and Equipment | 42 | 62 | 26.04 | 33 |
| A10 | Unavailability of incentives for contractor for completing work beforehand | Client | 48 | 46 | 22.08 | 34 |
| A35 | Low productivity of equipment | Labour and Equipment | 44 | 48 | 21.12 | 35 |
| A48 | Corrupt Practices | Other | 44 | 48 | 21.12 | 35 |
| A44 | Change in government policies | External Reasons | 42 | 50 | 21.00 | 36 |
| A11 | Delayed site handover | Client | 42 | 50 | 21.00 | 36 |

| | | | | | | |
|---|---|---|---|---|---|---|
| A45 | Non-availability of utilities on site | External Reasons | 42 | 50 | 21.00 | 36 |
| A43 | Accidents and injuries on site | External Reasons | 28 | 42 | 11.76 | 37 |

The causes corresponding to the highest ten importance index value were identified. These causes corresponding to top 10 Importance Index value were the final outcome of the second objective of the research.

*7.4.2 Cronbach's Coefficient Alpha test*

This method is used to measure their liability of the questionnaire between each group and the mean of the whole groups of the questionnaire. Alpha typically varies between 0 and 1. The closer the Alpha is to1, the greater the internal consistency of items in the instrument being assumed (Ashish Chandu Pawar, 2016).

$$\boldsymbol{\alpha} = \frac{k}{k-1}\left[1 - \frac{\sum_{i=1}^{k} \sigma_y^2}{\sigma_x^2}\right]$$

Where,
K = number of items
$\sigma_y^2$ = Variance of Component
$\sigma_x^2$ = Variance of the observed total cumulative score

Table 4 Cronbach's Coefficient for Frequency

| FREQUENCY | |
|---|---|
| No. Of Question | 49.00 |
| Sum of Item Variance | 55.82 |
| Variance of Total Scores | 694.16 |
| Cronbach's $\alpha_f$ | 0.94 |

Table 5 Cronbach's Coefficient for Severity

| SEVERITY | |
|---|---|
| No. Of Question | 49.00 |
| Sum of Item Variance | 66.45 |
| Variance of Total Scores | 1091.85 |
| Cronbach's $\alpha_s$ | 0.96 |

Since there were two inputs in the questionnaire i.e. frequency and severity, hence the Cronbach's coefficient alpha test was conducted for both separately. Value of Cronbach's α for frequency and severity were calculated to be 0.94 and 0.96 respectively. Value of Cronbach α was found to be near to 1, hence the data is reliable.

*7.5 Analysis of Results*

*7.5.1 Reluctance for Proposed Change by the Consultant*

Reluctance for proposed changes by the Consultant (IMP.I. = 53.28) is the most important factor which affects the schedule of a high-rise residential project. Reluctance by the consultants is due to the rework and resources required to undertake the changes. Consultants provide services to multiple projects simultaneously and hence avoid rework to ensure completion of work within the given time and budget. Lack of dedication and lack of knowledge are another reason for avoiding changes that require advanced understanding.

*7.5.2 Poor Time Estimate by PMC and Original planned contract duration is unrealistic*

Poor Time Estimate by PMC is at 3rd rank with IMP.I. value of 48.96 and Original planned duration is unrealistic is at 9th rank with IMP.I. value 46.08. Work scheduling is the responsibility of PMC during pre-construction stage. High rise Residential project due to its complexity and enormous scale involves multiple activities and stakeholders varying with timeline. Calculating and establishing efficient sequencing and schedule of the activity and stakeholder's role is the most crucial task in itself. It is the estimated time of the project that guides the contract, financial planning and phasing of the project. Poor Time estimate leads to overall time overrun, contract disputes, bad reputation, monetary loss, resources mismanagement and quality compromising of the project. Lack of experience and adequate knowledge of PMC, poor productivity calculation or client's pressure can cause poor time estimation of the project.

*7.5.3 Low Productivity of Labour and Shortage of skilled manpower and labour*

Low productivity of labour with IMP.I. of 50.32 is at 2nd rank and Shortage of skilled manpower and labour with IMP.I. of 47.52 at 7th rank. Around 30–40% of the total project cost is spent on labour. More often actual labour productivity at the site is found to be significantly less than what was assumed while submitting the tender.

Labour management affects labour productivity on site significantly, which affects the overall project schedule and cost. Low productivity of labour will lead to increased working hours for completion of the task and otherwise to maintain fixed working hours labour quantity will be increased, either case extended schedule or increased labour on site to meet the deadline will contribute to cost overrun. Labour productivity in largescale projects like residential high-rise is significantly affected by the complexity of the structure. Shortage of skilled manpower and labour on site is also a cause for low labour productivity on site.

*7.5.4 Rework due to mistakes by Contractor*

Rework is a recurring cycle which causes schedule overrun, cost overrun and poor quality of work. Specially in case of Residential high-rise project which includes unit repetition and slab cycle repetition, error in one unit causes same error in all the units and rectifying those errors will cause rework at all levels and in all stages and hence it becomes a never-ending process causing exponential overrun of time and cost. Since contractor is responsible for execution of the project, it is his/her responsibility to ensure that the work executed on site is as per the correct drawings and specifications of material finalized as per the BOQ. Hence Rework due to mistake by contractor holds 4th rank with IMP.I. value of 48.84.

*7.5.5 Major disputes and Negotiation*

Due to disagreement among multiple stakeholders involved for Civil work, MEP services, safety consultancy, Finish work, etc., improper contract clauses or some other external factor like land ownership dispute, projects may get involved in disputes. There are severe repercussions involved with disputed project like cost overrun, schedule overrun, bad reputation and it may also lead to project abandoning. As a result, Major disputes and Negotiation with IMP.I value 48.84 is at 4th rank.

*7.5.6 Waiting time for approval of test and inspection by consultants*

Every job for a large-scale project needs testing and commission after completion, example MEP services, fire safety layout and equipment installation, HVAC system installation, etc. to ensure quality and prevent rework. In case of Residential high-rise such activities are a part of the critical path, hence delay in their testing and commissioning or rework will have significant impact on project's overall schedule. Such issues may arise due to lack of professionalism or lack of knowledge and experience with the consultant. Waiting time for approval of test and inspection by Consultant acquires 5th rank in the list with IMP.I. value of 47.60.

*7.5.7 Improper storage of material/ Damage of materials*

(Project Management Institute, 2017) classifies material management under physical resource management and defines it as allocating and using the physical resources needed for successful completion of the project in an efficient and effective way. There are many factors which contribute to poor material management in construction projects such as waste, transport difficulties, improper handling on site, misuse of the specifications, lack of proper work plan, inappropriate material delivery and excessive paperwork all adversely affect the material management (NANN LWIN PHU, 2014). Material management becomes an important consideration in case of residential high-rise as it involves large scale material procurement, materials that requires careful handling and their storage on site. Hence improper storage of material or damage of material on site holds 7th position with IMP.I. of value 47.12.

*7.5.8 Improper Project Planning by the Contractor*

Improper Project Planning by the Contractor is at 8th position with an IMP.I. value of 46.20. Contractor play an extreme vital role in execution of a project, hence it's important that s/he plans the project efficiently.

A construction project is normally recognized to be successful when it is finished within its budget, on its planning time and according to its standards and specifications (Khalid, 2019). Project Management Institution introduces project planning process as following steps: create project management plan, Gather requirements, Describe scope, Make Work Breakdown Structure (WBS), Express activities, order activities, Evaluate activity resources, Evaluate activity duration, create schedule, evaluate costs, Decide budget, Plan quality, create human resources plan, communication plan, Risk management Plan, clarify risks, Perform quantitative and qualitative risk analysis, Plan risk Reponses and finally Plan procurement (Khalid, 2019). Highrise Residential project involve Structural Complexity which needs to be efficiently pre planned to ensure smooth execution, there are various stakeholders involved which require a clear definition of who does what and who reports whom and it includes huge investment which needs to be planned well to ensure constant and unobstructed execution.

*7.5.9 Improper Site Management by PMC and Contractor*

Improper Site Management by PMC as well as contractor were identified as major contributors to delay in Residential high-rise project holding the 10th (IMP.I. 44.88) and 8th (IMP.I. 46.20) position in the list respectively. Residential Highrise projects deal with various different domains of activities and their supporting activities simultaneously progressing on site. It is imperative to establish effective coordination between various activities to prevent disputes, wastage of materials, ensure availability of essential resources, maintenance of huge machineries employed, storage of material and sharing of common resources. Poor site management may cause low productivity on site and other resource mismanagement which may lead to schedule overrun.

*7.5.10 Ineffective delay penalties*

Ineffective delay penalty is at 8th position with IMP.I. value of 46.20. Contract management is one of the most crucial verticals in Project Management as it deals with legal aspects and terms and conditions between the parties involved. A proper contract type is chosen to encourage the owner and contractor to work rationally together to achieve the best outcomes in accordance to their common objectives and within the expected risk (Suprapto, et al., 2016). The contract must safeguard the interest of the parties involved at the same time its important to impose penalty for those who disregard the contract conditions to ensure harmony and avoid discrepancy between the parties and project execution.

*7.5.11 Delay in obtaining permissions from Government authority*

Delay in obtaining permission from government authority is at 8th rank with IMP.I. score of 46.20. Before starting the execution of a project, one must be ready with all the approvals and drawings on site (Piyush Shivhare (29th June, 2020) Telephonic Interview). Gaining permission for commencement is one of the most crucial activity for high-rise residential project execution as the without CC, execution cannot start and the project will be delayed before starting. Delay in obtaining permission from the Government authority can be due to multiple reasons like lack of awareness of the client, undue demands by the government officials, negligence of government officials, improper documents submission or simply because of multiple approvals from multiple departments.

*7.5.12 Improper communication Management*

The Project Management Body of Knowledge guide defined project communication management as "one of the main knowledge areas in project management which include the processes requires to ensure timely and appropriate generation, collection, distribution, storage, retrieval and ultimate disposition of project information" (Project Management Institute, 2017). Communication covers all task related to producing, compiling, sending, storing, distributing and managing project records. It also requires an accurate report on the project status, performance, change and earned value (Rahman & Gamil, 2019). Construction of large scale projects like Highrise involves various stakeholders (owners, contractor, sub-contractor, consultants and workers) who are responsible for communicate information to all hierarchical levels as, where and when required for appropriate execution of the project as per the specifications, this complex fragment of the industry causes improper communication among various personnel involved in the project. Without proper communication of the objective among stakeholders, delays can be caused due to misinterpretation and wrong execution of project activities. Delays caused by poor communication can be in the form of slow information flow, improper communication channels, wrong design, wrong interpretation, rework and more (Gamil, et al., 2019).

*7.5.13 Low Financial Capability of contractor*

Project Cost Management Includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget (Project Management Institute, 2017). Improper cost management may cause delayed payment and insufficient cashflow which may affect the overall project productivity and delayed procurement process.

A delayed payment by a party who is involved in the process of payment claim may have an influence on the supply chain of payment in whole (Abdul-Rahman, et al., 2009). A cash flow management is directly proportional to the progress of work (Dipti R. Shetye, 2013). Highrise residential project includes a complex network of various stakeholders and simultaneous execution work, hence it is imperative to have a financially strong contractor to ensure continuous cashflow for unhindered progress of the project. Most of the high-rise residential project suffer delay due to low financial capability of contractor which has IMP.I. value of 46.08 with 9th rank.

## 8 ROOT CAUSE ANALYSIS

Root cause of the reasons of construction delay from data analysis were identified on the basis of literature study and interviews. The causes were classified into Manpower, Management, Environment and Other factors. All the stakeholders responsible the causes were classified under 'Manpower', all the causes related to site, weather or surroundings were categorized under 'Environment', causes concerning to management of the Project were listed under 'Management' head and the remaining causes were grouped under 'Other Factors'.

Table 6 Root Cause Analysis

| S. No. | Causes of Delay | Group | Construction Stage | Root Cause | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Manpower** | **Management** | **Environment** | **Other Factor** |
| A22 | Reluctance for proposed change | Consultant | Execution/ Pre-Construction | Client<br>Consultant | | | |
| A32 | Low productivity of labor | Labour and Equipment | Execution | Client<br>PMC<br>Consultant<br>Contractor<br>Labour | Site Management<br>Resource Management<br>Communication Management | climate or weather condition<br>Unforeseeable Events | Loss of Motivation<br>Non-Conventional Technology<br>Equipment Failure |
| A3 | Poor time estimate | PMC | Pre-Construction | Client | Improper Project appraisal; Improper Productivity Calculation | | |
| A38 | Original planned contract duration is unrealistic | Contract | Pre-Construction | PMC | Tender and Contract Management | | |
| A17 | Rework due to mistakes | Contractor | Execution | PMC<br>Client<br>Contactor<br>Consultant | Communication Management<br>Site Management | Environmental Condition | Lack of Security on site |
| A37 | Major disputes and negotiations | Contract | Execution/ Pre-Construction | All stakeholder | Contract Management | | Land ownership<br>Government Policies |
| A21 | Waiting time for approval of test and inspection | Consultant | Execution | Consultant<br>PMC Contractor | Communication Management | extra monetary demands by the consultant for approval | |
| A31 | Shortage of skilled manpower and labor | Labour and Equipment | Execution | Client<br>Contractor | Resource Management<br>Tender and Contract Management | Unforeseeable Events | Government Policies<br>Market Condition |
| A27 | Improper storage of material/ Damage of materials | Material | Execution | Consultant<br>Contractor<br>PMC | Insufficient storage facility on site<br>poor handling operations<br>Inefficient material procurement<br>Communication Management | climate or weather condition<br>site condition | Lack of Security on site |
| **S. No.** | **Causes of Delay** | **Group** | **Construction Stage** | **Root Cause** | | | |
| | | | | **Manpower** | **Management** | **Environment** | **Other Factor** |
| A12 | Improper project planning | Contractor | Pre-Construction | PMC<br>Client<br>Contractor | Scope Definition<br>Cost Management<br>Schedule Management | climate or weather condition<br>site condition | Government policies<br>Disputes on site |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | Resource Management | | other unforeseeable events |
| | | | | | Risk Management | | |
| | | | | | Communication Management | | |
| | | | | | Tendering and Contract | | |
| A16 | Poor site management | Contractor | Execution | PMC | Physical Resource Management | Weather Condition | Government policies |
| | | | | Client | Construction Logic | Site conditions | Disputes on site |
| | | | | Contactor | Communication Management | Unfavorable Environmental Condition | |
| | | | | Labour | Risk Management | | |
| | | | | | Schedule Management | | |
| | | | | | Cost Management | | |
| A39 | Ineffective delay penalties | Contract | Pre-Construction | Client | Tender and Contract Management | | |
| | | | | Contractor | | | |
| A40 | Delay in obtaining permissions from Government Authoity | Approval | Pre-Construction | Client | Absence of approval management team | | Complex Government approval procedure |
| | | | | Government Officials | | | corrupt Practices |
| A13 | Low financial capability | Contractor | Execution | Client | Resource Management | Unforeseeable Events | Government Policies |
| | | | | Contractor | Tender and Contract Management | | Market Condition |
| A2 | Poor site management | PMC | Execution | PMC | Physical Resource Management | Weather Condition | Government policies |
| | | | | Client | Construction Logic | Site conditions | Disputes on site |
| | | | | | Communication Management | Unfavorable Environmental Condition | |
| | | | | | Risk Management | | |
| | | | | | Schedule Management | | |
| | | | | | Cost Management | | |

## 9 CONCLUSION

The research aimed at proposing preconstruction preventive measures for delays in construction project before the execution begin.

Major contributors to delay in Residential high-rise were identified as Reluctance for proposed change (53.28), Low productivity of labor (50.32), Poor time estimate(48.96), Rework due to mistakes (48.84), Major disputes and negotiations (48.84), Waiting time for approval of test and inspection (47.60), Shortage of skilled manpower and labor (47.52), Improper storage of material/ Damage of materials (47.12), Improper project planning (46.20), Poor site management by contractor (46.20), Ineffective delay penalties (46.20), Delay in obtaining permissions from Government Authority (46.20), Low financial capability of contractor (46.08), Original planned contract duration is unrealistic (46.08) and Poor site management by PMC (44.88).

Root cause analysis of the causes identified implied lack of proper communication plan to ensure efficient delivery of information among various stakeholders, Scope change by client must be avoided, Contract clauses must be decided to safeguard the interest of all the parties involved and should also impose penalty for those who disregard the contract clauses, Lack of supervision and security on site is also one of the major concerns in High rise residential, Poor Site management and need to enhance labour productivity are some of the causes identified for the major contributors to delay in construction of Residential high-rise.

The considerations to prevent delay in Residential high-rise construction is to ensure smooth slab cycle, prevent error as it may grow exponentially because of multiple units in residential high-rise and also special consideration is required for structural execution of the project. Preventive measures for pre-construction phase were proposed as follows:

### *9.1 Efficient Labour Productivity Calculation*

To incorporate various factors (like site condition, material availability, etc.) and uniqueness of the project together for efficient labour productivity calculation, it is proposed to involve local professional and use of methods like simulation for labour productivity calculation near to accuracy. Improved productivity calculation will ensure efficient Project planning which will result in efficient project delivery.

*9.2 Relational Contract*

Relational contract includes Integrated Project Delivery in which owner, architect, engineer, contractor, sub-contractor, and all other stakeholders are all party to the contract. This method involves overlapping of designing and pre-construction stage with bidding and construction, thorough risk assessment and efforts of all the parties bind in contract put holistically towards the success of the project. Such contract will ensure to enhance the commitment to work, reduce disputes, better communication among stakeholders and quality delivery of the project on time within the budget.

*9.3 Centralized communication via Virtual Platform*

Effective communication is significant for adequate risk assessment. Research suggest to have a Centralized Communication Virtual platform to ensure efficient communication irrespective of time and location of the stakeholders to ensure efficient decision making and coordination.

*9.4 Efficient risk management*

Conventional method of risk management includes risk register maintenance. The research proposes to analyses the risk associated severities quantitatively in terms of time and cost to communicate the intensity of risk to the stakeholders effectively.

*9.5 Single Window Approval System*

Single Window Approval System will not only resolve the time-consuming complex approval procedure but also the issues faced due to corruption and will ensure proper cost management. There were other preventive measures identified on the basis of suggestion made by respondents in survey:

- It is important to finalize the drawing before execution starts and there must be no interference by the contractor or client there after except for minor necessary changes.
- Emphasize on modular coordination to mitigate the risk in terms of cost due to nonstandard sizes and efficient use of framework can be done.
- All the permission related to project, design and drawings; planning must be completed before execution the project
- Use of Construction methods reducing in situ construction such as use of preformed shuttering, use of precast components etc. to reduce the risk of delay during construction.
- Changing project bidding method from least cost to cost incentive based this will allows better quality control).
- Setup robust team to deal with regulatory bodies for approvals.
- Identifying the critical activities and focusing majorly on their smooth progress.
- Conduct a proper research and analysis to prepare schedule of work for a well-balanced construction project execution.
- Value engineering can be adopted to speed up the process.

## 10 LIMITATION

Although Case Study is one of the most important tools of a research work but because of global Pandemic situation, the research was limited within few research tools that is literature review, Online survey and Telephonic interview. No site visits could be performed which significantly affected the expected data for Case Study.

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