

Analysis of Delays during Initial Phase of Construction Projects and Mitigation Measures

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Abstract—A perfect start is a key factor for project completion on time. The study examined the effects of delayed mobilization of resources during the initial phases of the project. This paper mainly highlights the identification and categorization of all delays during the initial construction phase and their root cause analysis with corrective/control measures for the Kuwait Oil Company oil and gas projects. A relatively good percentage of the delays identified during the project execution (Contract award to end of defects liability period) attributed to mobilization/preliminary activity delays. Data analysis demonstrated significant increase in average project delay during the last five years compared to the previous period. Contractors had delays/issues during the initial phase, which resulted in slippages and progressively increased, resulting in time and cost overrun. Delays/issues not mitigated on time during the initial phase had very high impact on project completion. Data analysis of the delays for the past five years was carried out using trend chart, scatter plot, process map, box plot, relative importance index and Pareto chart. Construction of any project inside the Gathering Centers involves complex management skills related to work force, materials, plant, machineries, new technologies etc. Delay affects completion of projects and compromises quality, schedule and budget of project deliverables. Works executed as per plan during the initial phase and start-up duration of the project construction activities resulted in minor slippages/delays in project completion. In addition, there was a good working environment between client and contractor resulting in better project execution and management. Mainly, the contractor was on the front foot in the execution of projects, which had minimum/no delays during the initial and construction period. Hence, having a perfect start during the initial construction phase shall have a positive influence on the project success. Our research paper studies each type of delay with some real example supported by statistic results and suggests mitigation measures. Detailed analysis carried out with all stakeholders based on impact and occurrence of delays to have a practical and effective outcome to mitigate the delays. The key to improvement is to have proper control measures and periodic evaluation/audit to ensure implementation of the mitigation measures. The focus of this research is to reduce the delays encountered during the initial construction phase of the project life cycle.

Keywords—Construction activities delays, delay analysis for construction projects, mobilization delays, oil and gas projects delays.

I. INTRODUCTION

THE oil and gas Industry is a major stimulant in Kuwait's economic growth and Kuwait Oil Company holds a major share of the country's economy. The premise of this paper is analysis of the delays encountered in many projects in the oil and gas sector during the last decade at the Kuwait Oil

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Company, which has drawn many concerns from the State authorities. The major thrust of this analysis is to evaluate the key factors that led to the time overrun in projects.

This paper studied each type of delay with some real examples supported by statistic results and mitigation measures.

Delay analysis carried out during the construction phase for Kuwait Oil Company projects handled by the project management teams in East Kuwait and South Kuwait. Construction delays are often the result of unplanned or mismanaged events, and a risk for the projects, which if identified, analyzed and managed in a systematic manner at inception, could be minimized and mitigated. Control or mitigation of the initial phase delays minimizes the chances of further delay [1]. Based on the analysis of projects spanning the past five years, 178 delay root causes were identified which impacted timely project completion. The delay impact and the occurrence of each causation were established for the past 17 executed projects, the impact rating was done on a 1 to 10 scale: 0 – No; 5 – Medium; 10-High, while the occurrence rating done by assessing the probability of the risk (0-100%).

On analysis of the delay ratings, it was observed that the root causes occurred during the initial construction phases of projects, including mobilization which contributed to 30% of project delays.

Brainstorming sessions were conducted with all stakeholders to ascertain potential areas of improvement based on the constraints/problems they encountered. Control measures were developed to ensure effective implementation to improve project delivery.

TABLE I
AVERAGE PROJECT DELAYS

Period	Delay (Days)
2000 to 2005	14
2006 to 2010	170
2011 to 2015	261

II. DELAY ANALYSIS

A. Project Delay Analysis Data Collection

Data related to project completion delays was collected for the period 2000 to 2015. A total of 68 projects were executed during this period. Average delays during the periods 2000 to 2005, 2006 to 2010 and 2011 to 2015 were calculated. A summary of the data is provided as per Table I.

B. Delay Analysis

Construction delays are considered as time lag or difference in duration of actual completion of activities from its specified

time as per contract or as late completion of activities compared to the baseline schedule, impacting project cost [1].

Delayed mobilization of resources mainly led to re-scheduling and re-sequencing of activities, loss of productivity and efficiency, increase in time-related costs, prevention of early completion, as well as extension of time and acceleration of works [2].

Table I depicts significant increase in delays in the past 15 years for projects at Kuwait Oil Company: a 55% increase was recorded in last five years compared to the previous period. The delays were analyzed using trend chart (Fig. 1), scatter

plot (Fig. 2), binomial process capability report (Fig. 3) and Pareto chart (Fig. 4) as part of the 6-sigma case study carried out by the Kuwait Oil Company.

Project delay trend chart (Fig. 1) illustrates the trend of project completion delays for the period 2000 to 2015. The trend chart analysis concludes that number of delayed projects and the extent of delays have considerably increased in the last five years.

Projects completed in the last five years were selected for detailed analysis to identify the delay root causes.

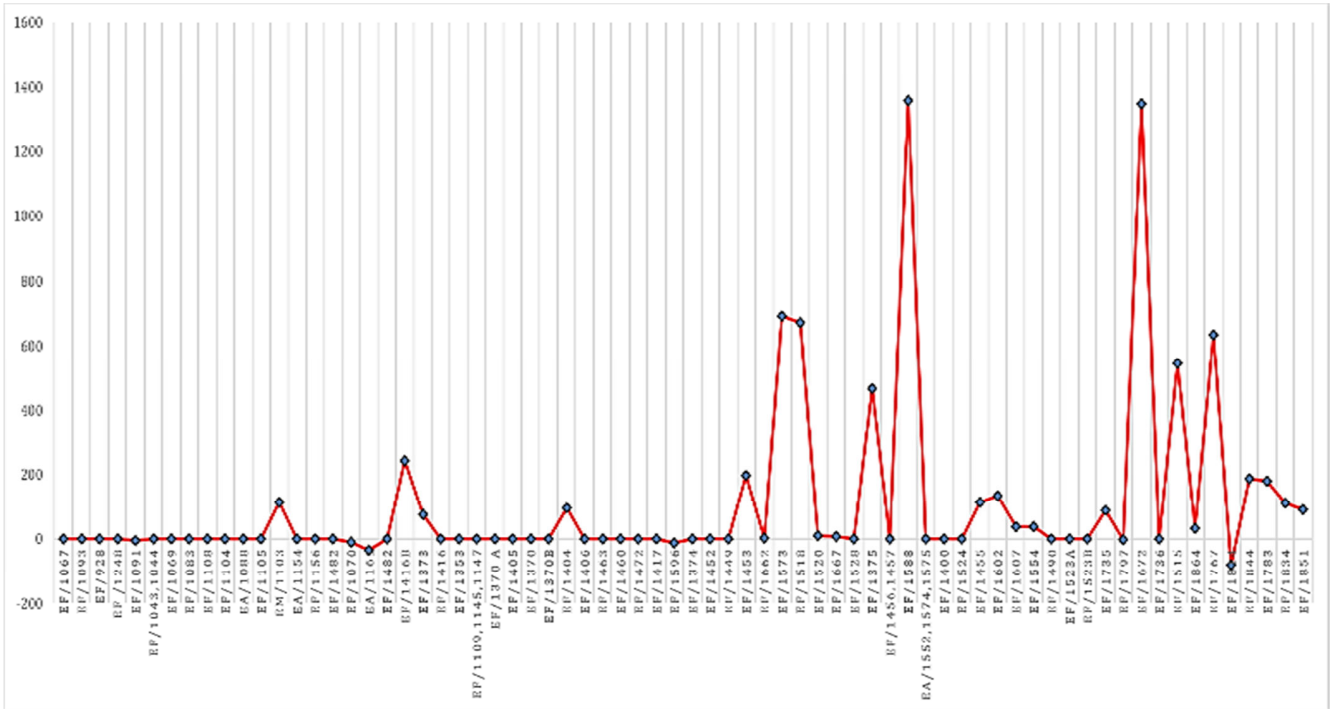


Fig. 1 Project Delay Trend Chart (2000 – 2015)

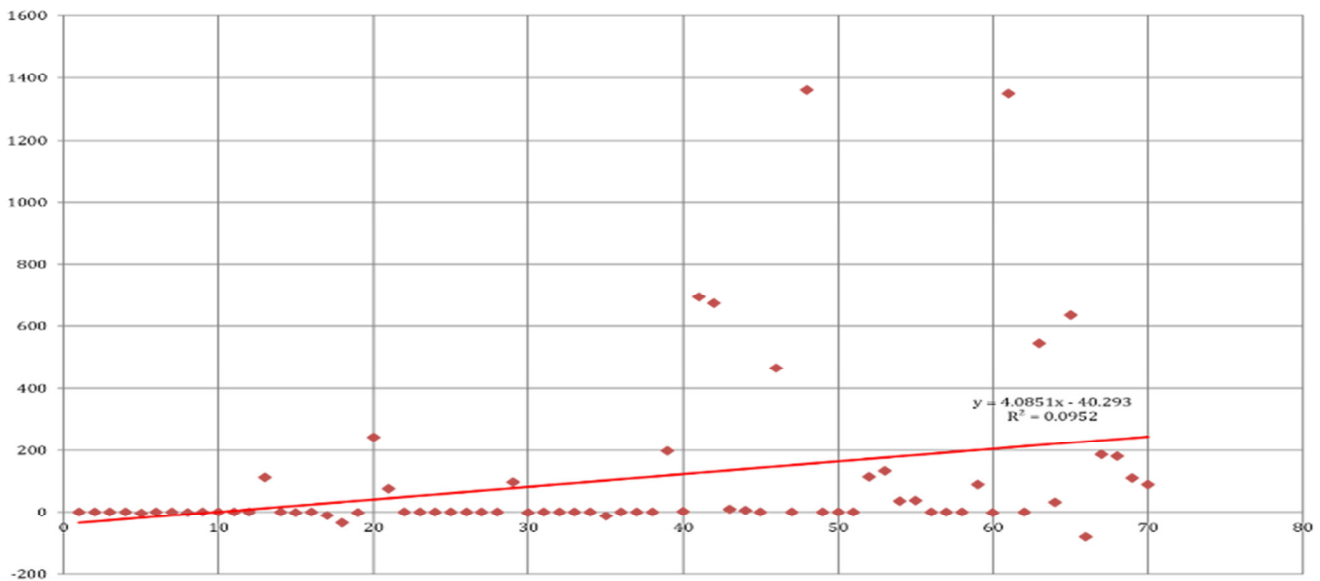


Fig. 2 Scatter Plot for Delay with line of best fit (2000 – 2015)

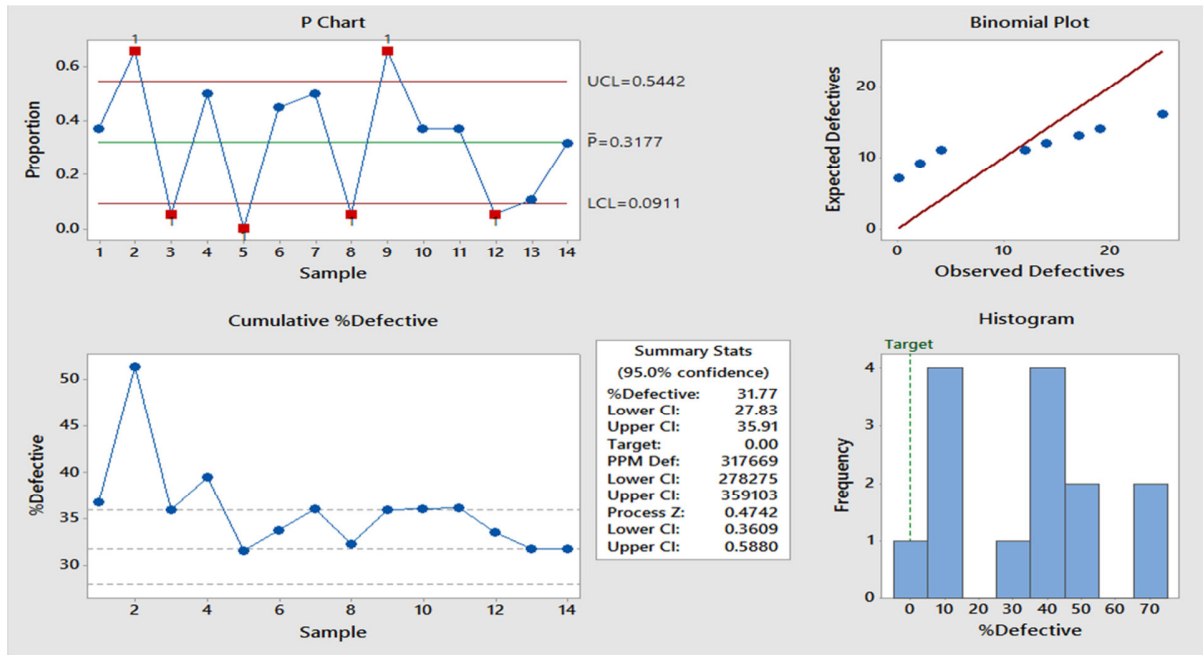


Fig. 3 Binomial Process Capability Report (Delay Construction Phase)

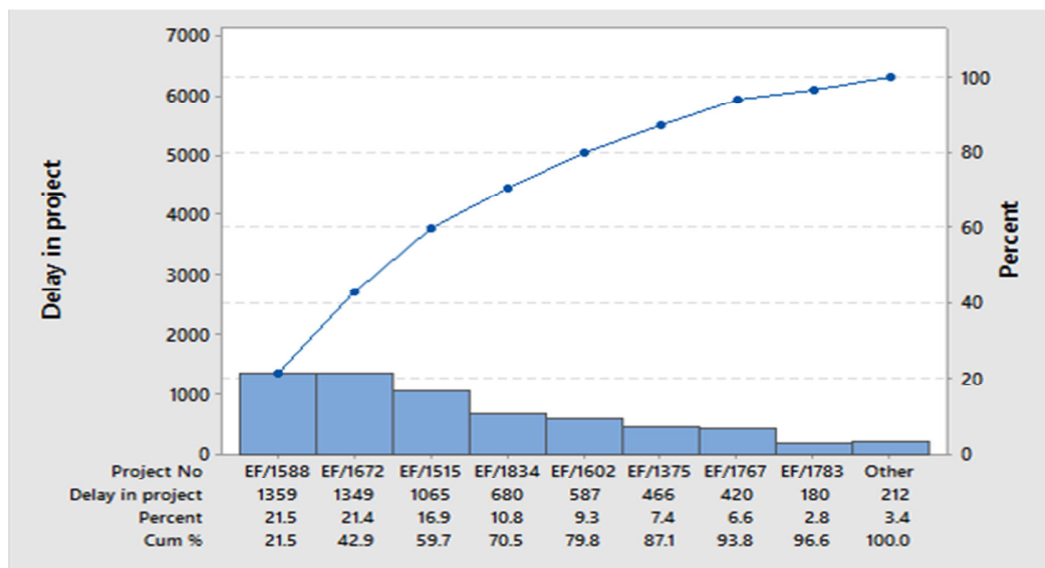


Fig. 4 Pareto Chart of Project (Day of Delays)

C.Delay Factors

Delay factors collated from a “Delay Root Cause Analysis” study carried out by Kuwait Oil Company to identify all the delays encountered in projects from inception to final closure. Assessment of the study outcome provided a total of 178 delay factors (Fig. 5) for the construction phase, along with their impact rating.

Delay factors directly attributed to the delays during the initial phase of construction were segregated. Out of 178 delay factors, 30 were identified which delayed the initial construction phase of projects.

Detailed analysis depicted that the total impact due to the 30 delay factors during the initial construction phase of the

project contributed to 30% of the total delays for the entire construction phase.

Table II lists all the 30 delays identified during the initial construction phase along with their respective impact rating on the overall Construction Phase.

The delay factors were reviewed along with the study carried out by Divya, Ramya [3] and Ren, Atout and Jones [4] and Borvorn Israngkura Na Ayudhya [5] to look for the normal trends of delays across all construction projects related to initial phase delays.

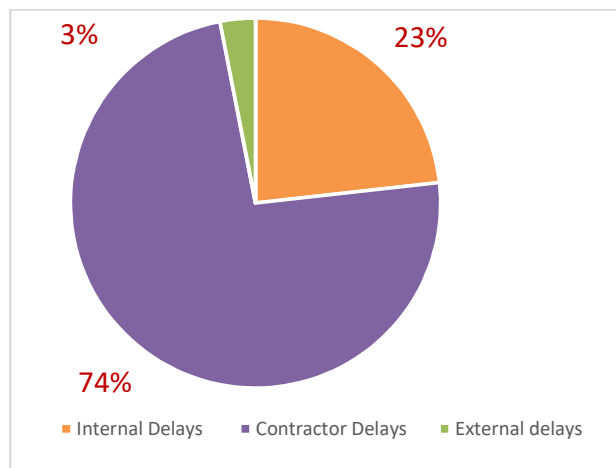


Fig. 5 Categorization of Delay impact rating during Construction phase of projects

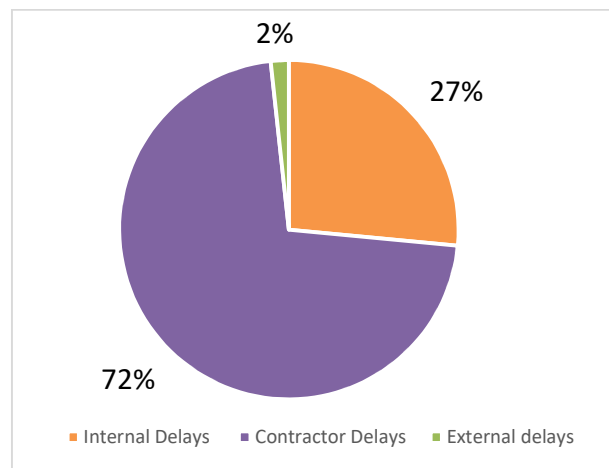


Fig. 6 Categorization of Delay impact during the initial phase of Construction for projects

TABLE II
INITIAL CONSTRUCTION PHASE DELAY FACTOR AND IMPACT RATING

Delay Factors	Impact
Inadequacy/discrepancy in Contract documents, survey, drawings etc. by Company.	1.04%
Delay in project Site office location approval, EOD clearance by Company	0.38%
Delays in Reservation of line routes / areas, E&I requirements for the Contract by Company	1.20%
Delays in issue of mobile PLANT clearance certificate by Company	0.32%
Delay in issue of Gate passes and Work permits by Company	0.71%
Delay in issuing excavation notification & loading notes by Company	0.61%
Delay due to non-inclusion of requirement in Contract (like computers, internet etc.) by Company	0.43%
Delay/cancellation due to change in the site condition by Company	0.85%
Non-availability of work front due to Operational reasons, Site readiness/handover delays from Company	0.81%
Complexity in implementation of control mechanisms for Contractor's performance shortfalls (termination etc.)	1.11%
Delay due to Permit applicant late endorsement and permit issuer late issue of permit by Company	0.43%
Delay contribution due to Incompetency/ absence of Contractor key personnel	3.21%
Delay in mobilization of Contractor manpower and temporary facilities	1.25%
Delay in submission/approval of Program of Work by Contractor	0.65%
Delay due to finalization Contractor visa quota due to unrealistic manpower histogram submitted during the bid stage of project by Contractor	0.32%
Delay in P&ID submission and approvals by Contractor	0.55%
Noncompliance to Contract requirements by Contractor	1.06%
Unrealistic price breakdown in progress measurement sheet by Contractor	0.84%
Incompetent Contractor Design consultant / subcontractor: Lack of understanding	3.79%
Delay in proposal and approval of Design Subcontractor and Vendors by Contractor	0.76%
Delay due to Contractor Design consultant non-availability full time during Completion of design scope.	1.07%
Delay in carrying out site survey by Contractor	1.16%
Delay in carrying out the bore hole at approved work site locations by Contractor	0.43%
Delay due to improper site survey by Contractor	0.80%
Delay due to mobilization of subcontractor on time by Contractor	0.75%
Delay in Survey reports & documents submittals by Contractor	1.23%
Delay due to more Temporary gate passes application, late application for Permanent gate passes by Contractor	1.26%
Delay due to lack of Manpower by Contractor	1.17%
Delay due to lack of Equipment by Contractor	1.07%
Delay due to Security restrictions for Contractor worker's entry to the KOC restricted area by Company	0.51%

Fig. 6 represents the 30 delay factors during the initial phase for which detailed analysis of the impact rating and control measures carried out for the major contributors; rating > 3%. Thirteen out of 30 delay factors with impact rating greater than 3% were identified:

➤ Inadequacy/discrepancy in Contract documents, survey, drawings etc. by Company.

- Delays in Reservation of line routes/areas, E&I requirements for the Contract by Company.
- Complexity in Company implementation of control mechanisms for Contractor's performance shortfalls (termination etc.).
- Delay contribution due to Incompetency/absence of key personnel by Contractor.

- Delay in mobilization of manpower and temporary facilities (Mobilization delay) by Contractor.
 - Noncompliance to Contract requirements by Contractor.
 - Incompetent Contractor Design consultant/subcontractor: Lack of understanding.
 - Delay due to Contractor Design consultant non-availability full time during Completion of design scope.
 - Delay in carrying out site survey by Contractor.
 - Delay in Survey reports and documents submittals by Contractor.
 - Delay due to more Temporary gate passes application, late application for Permanent gate passes by Contractor.
 - Delay due to lack of Manpower by Contractor.
 - Delay due to lack of Equipment by Contractor.
12. Contractor key personnel performance shall be evaluated on a yearly basis and updated on completion of the project.
 13. Key personnel with poor performance shall not be approved in any future projects.
 14. Enforce deductions for absence of contractor key personnel.
 15. Enforce availability of contractor key personnel from the commencement date of the contract.
 16. Advance payments/payments to be linked to mobilization activities like site office, site survey, and major engineering deliverables.
 17. Concession request for noncompliance to be identified and submitted in the initial phases of the project.
 18. Quarterly confidential report to include contractor design consultant evaluation.
 19. Shortlisting of Contractor design consultant based on project criticality/complexity.
 20. Ensure compliance with Technical requirements/details for critical deliverables during bid evaluation.
 21. Contract terms and conditions shall clearly stipulate Contractor Design Consultant full time availability at site up to design completion.
 22. Ensure contractor's submittal of gate pass request based on manpower and equipment histogram well in advance taking into consideration the lead time in the issue of gate passes.
 23. Check gate pass request availability for manpower and equipment to ensure manpower and equipment deployment as per approved histogram.
 24. Manpower deployment details to be reviewed in the monthly progress review meeting based on the look ahead schedule.

Each delay analyzed based on their impact in 17 previously completed projects during the period 2011 to 2015. All the major delayed projects had most of the above delay factors significantly contributing to the overall project delays. On the contrary, projects completed with minimum delay or completed on time had no impact/minor impact due to the above delay factors. Also, these projects had a more collaborative approach from the project team (company and contractor) towards completion of the project and had no major disputes/claims.

III. CONTROL MEASURES

Control measures were identified to mitigate the delay impact of the 13 factors during the initial phase of construction projects.

1. Ensure utilization of standardized package for Tender preparation.
2. Review of Lessons learnt/concession request, ongoing project issues and necessary incorporation as applicable.
3. Follow check lists to ensure verification of all requirements and fulfillment of pre-requisites for each stage.
4. Task force team with specialist to be established for second review of FEED/Tender Package for critical and high value projects.
5. All land reservations, Electrical & Instrumentation reservations, clearance to be obtained during the FEED stage the concerned teams
6. Lock-out system to be followed on reserved panels to avoid utilization/allocation to others.
7. Demarcation of reserved land with sign board highlighting the project/contact details.
8. Periodic stringent evaluation of confidential report based on contractor performance and prompt action for consecutive performance shortfalls.
9. Implement mechanism for blacklisting the Contractors with poor performance in three consecutive quarters for any running project.
10. Evaluation and interview of contractor key personnel shall be carried out by a panel of two or more Company personnel.
11. Selection criteria along with evaluation criteria shall be developed for evaluation of the Contractor key personnel.

IV. CONCLUSION

A construction project is commonly acknowledged as successful when it is completed on time, within budget, in accordance with specifications and to stakeholder's satisfaction.

Initial construction phase delay is often a critical challenge to projects, leading to increased construction costs, due to time extension, acceleration of works, as well as loss of productivity; disruption of work, loss of revenue through lawsuits, as well as project abandonment.

Delay will result in extensions of time which can be attributed to the contractor or the company which will further result in penalty, increased cost due to inflation, termination of contract, court cases etc. resulting in delay damages [1]. Therefore, causes of time delay are of critical importance for asset utilization by Company and to the Contractor profitability.

The critical factors causing the serious delay were identified. The impact level of these factors on construction duration can be different from project to project [6]. Based on the analysis, critical factors during the initial phases of construction are related to the contractor: mobilization of resources (key personnel, manpower and equipment) on time,

delay due to incompetency of design consultant. A major delay contributor from the Company was due to discrepancies in contract documents and delay in reservations. Implementation of appropriate control measures from project commencement and timely actions would minimize project delays.

Periodic evaluation/audit is mandatory to ensure timely and precise implementation of the mitigation measures. Timely completion of Projects is the key to achieve Company's strategic objective, optimize Contractor overhead costs promoting business interests and upholds the corporate image.

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