A Review on Schedule Delays in Infrastructure Projects

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Abstract **- The construction industry is a major sector of the economy for most of the developing countries. However, major infrastructure projects experience extensive schedule delays in the operational process. This research aims to identify the causes of schedule delays in the construction sector to assess and communicate its importance to the all project stakeholders, the owner, the contractor the consultant, etc. An extensive literature review is done to identify the causes of delays, methods of minimizing delays for minimizing the schedule delays while maintaining the quality, safety, and budget. Based on the review, different causes of schedule delay were identified. Further, techniques of analyzing causes of schedule delays using questionnaire surveys by made by various researchers previously during past twenty-one years were researched upon, compared, and discussed. Many researchers have used questionnaire surveys and categorized schedule delay causes by Frequency Index, Severity Index, and Importance Index followed by application statistical analysis tools like ANOVA test or Spearman's Correlation or Kruskall-Wallis test to find the degree of relationship between the variables. Consequently, this research suggests the robust analysis method for identification of schedule delays in the context of infrastructure projects. The scope of this research framework shall direct extensive analysis and adaptation of suitable statistical methods to provide a detailed insight on critical causes which are responsible for the schedule delays in infrastructure projects. The findings of this research can be used as a guide for the overall improvement and implementation in construction management practices by the construction agencies.**

Index Terms **- Infrastructure Projects, Schedule Delays, Predictive Analytics, Statistical Test, Construction Agencies.**

INTRODUCTION

Construction is one of the core sectors of India's economy and an important part of the industrial sector. The government of India aims to build 20 million affordable homes for the urban poor by 2022 which will provide support to residential construction. There has been a increase in expenditure towards infrastructure development by 20.9% in its 2018-19 budget, from Rs 4.9 trillion (US$75.9 billion) in the financial year 2017-2018, to Rs 6 trillion (US$89.2 billion). Contribution to GDP growth of the construction industry in terms of its critical role played by construction sometimes understated. If we increase efficiency of construction projects by means of cost-effectiveness and timeliness, it will certainly lead to cost saving for the country as a whole. A major criticism of the Indian construction industry is due to the growing rate of delays in project delivery. Indian construction industry suffers construction time and cost overruns. Effort directed to cost and time-effectiveness associated with managing time and cost, which in this research is to be approached via investigating causes of delay at construction projects in the India like other developing countries, such as Egypt, (M. E. Abd El-Razek et al. 2008), Kuwait (Koushki et al. 2005), Kuwait (Acharya et al. 2006), Saudi Arabia (Assaf et al., 1995 & 2006) and Malaysia (Abdul Rahman et al). The construction sector is counted as one of the most active sectors affecting the India's economy. With the economic development taking place in India, construction projects contribute to a large portion of the construction industry. Lot of continued focus has been made by construction industry and the government on minimizing the effects and controlling construction delays. The information available is diverse and widespread. Despite the necessity for such research, little work has been described in the literature concerning public projects in the Indian construction industry. The actual frequency and magnitude of causes of construction delays is not known, which has proven to be a serious and very expensive problem for the Indian construction industry.

EARLIER STUDIES

The below information gives details of literature survey of 47 research studies from around the globe covering all types of constructions projects during last 25 years for identification and minimizing the causes of schedule delays considered for this study. The distribution of selected research studies country wise and type of project is depicted in Figure 1.

Assaf et al. [1995] conducted a field survey for identifying causes of time overrun in Saudi Arabia which revealed 73 causes broadly ascribed to owners, consultants, and contractors as labor shortage, delay in interim payment, change orders by owners during construction, delays in checking and approving the design documents, awarding contracts to the lowest bidder, incompetent human resources, among others causes.

Kumaraswamy et al. [1998] conducted a survey of 83 factors for studying construction delays in Hong Kong. They analyzed data and ranking of factors and factor categories using relative importance index (RII) was done and concluded that poor site management and supervision, unforeseen ground condition, delays in design information, slow decision making, and client-initiated variations were among the major causes of delay. Similar findings were reported by Tommy Y. Lo et al. [2006] again in Hong Kong.

Odeh et al. [2002] researched the causes of delays in Jordan by a survey consisting of 28 delay causes categorized to 8 groups as client, contractor, consultant, material, labor & equipment, contract, contractual relationships, and external factors. Ranking of causes based on RII was done and results revealed top reason by consultants and contractors as inadequate contractor experience and low labor productivity, respectively.

Ahmed, S. M et al. [2002] conducted study in Florida, USA for finding the causes of delays using survey data from general contractors and by ranking of the data across six categories, found that building permits approval, change order, changes in drawings, incomplete documents, and delayed Inspections as top five causes for delay.

Alwi S et al. [2003] determined the most important causes of delays within building projects in Indonesia identified by small and large contractors and the data was compared for agreement and correlated using spearman rank correlation coefficient.

Koushki et al. [2005] identified top three main causes of time-delays as changing orders, owners' financial constraints and owners' lack of experience in the construction business with help of survey data from developers and owners of residential construction projects in Kuwait. They employed frequency analysis, Standard deviation and mean for arriving at conclusions.

Assaf et al. [2006] identified the most common cause of delay in construction projects of Saudi Arabia by contractors, consultants, and clients as change orders. Frequency index, importance index and survey data from 57 construction professionals was used for above and 76% contractors identified that average delay on projects was 10-30% of original duration.

Abdul Rahman et al [2006] and Faridi et al. [2006] studied diverse type of construction projects in Malaysia and UAE respectively and reported poor site management and supervision of contractor and shortage of labor as causes of delay.

Acharya et al. [2006] reported frequent interruptions from public, changed site condition, failure to provide required construction site, unrealistic project time estimation and design errors as critical causes of delay in Korean construction projects among a survey of 208 respondents and 19 delay causes.

Alaghbari et al. [2007] using Mean score and ranking reported top five causes of delay by contractors were financial problems, shortage of materials on site, poor site management, construction mistakes and defective work, delay in delivery of materials to site and coordination problems with others. Top five reasons for delays by clients were financial problems, slowness in making decisions, contract modifications, lack of coordination with contractor and lack of construction knowledge.

Le-Hoai et al. [2008] studied delay and cost overruns by using frequency, severity and importance indices and reported that there was good agreement (Spearmans Rank Correlation values) between pair of parties from consultants, owners, and contractor. Toor et al. [2008] studied Thai construction companies involved in airport construction project and concluded following top five problems as lack of standardization in design, lack of contractor's experience and control over project, inadequate experience of staff, lack of competent subcontractors/suppliers and unrealistic project schedule.

Sweis et al. [2008] reported financial difficulties faced by the contractor and too many change orders by the owner were the leading causes whereas Tume et al.

[2008] reported top five factors as improper planning, lack of effective communication, design errors, shortage of material supply, slow decision making, and financial issues.

M. E. Abd El-Razek et al. [2008] researched the causes of delay in building construction projects in Egypt and identified top cause of delay by both the owner and consultant as financing by contractor during construction. The view of the consultant can be considered with a degree of impartiality and as transitional between contractor and the owner. Furthermore, the contractor results identified this cause as first within his responsibility and the third most important cause. These results reveal how this cause can greatly affect a project delay and highlight the importance of using cash flow analysis. The cash flow requirements among the projects within the whole organization can be coordinated based on a realistic schedule on the project level.

Kaliba et al., [2009] researched for identification of major causes of time overrun in construction projects in road construction projects in Zambia and concluded following causes of time overrun as financial deficiencies on the part of the client or the contractor, changes in design drawings, contract modifications, delayed payments, economic problems, material procurement problems, staffing problems, unavailability of equipment, poor supervision, poor coordination on site, construction mistakes, labor disputes and strikes, changes in specifications.

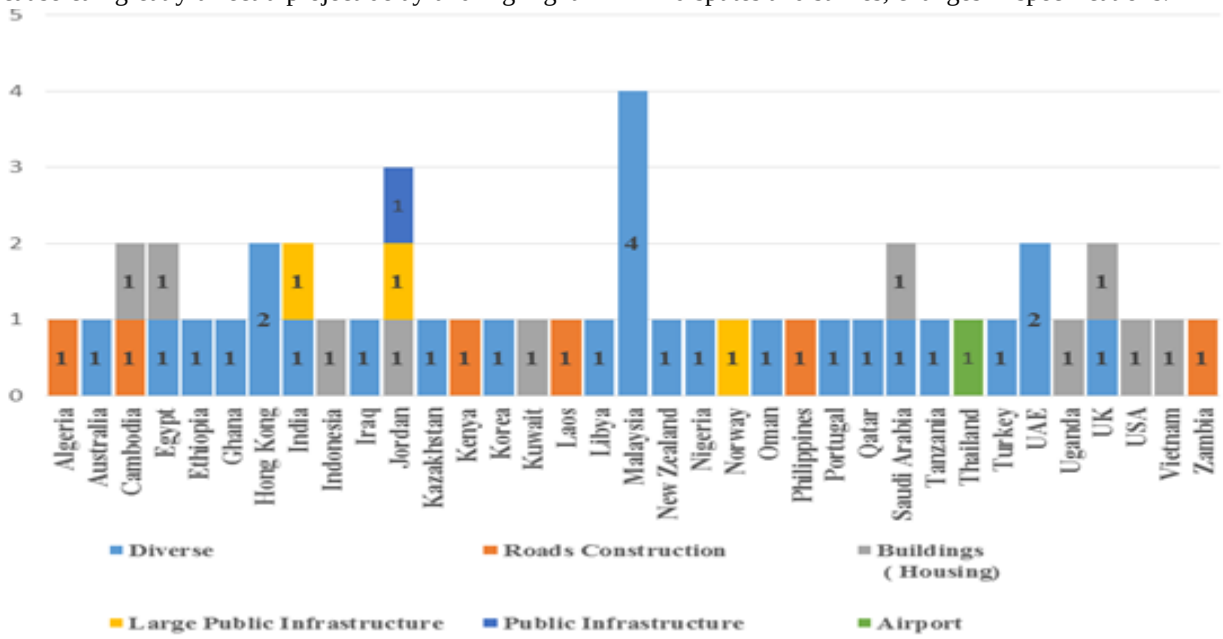

Figure 1: Earlier Studies considered in this study by country and project type

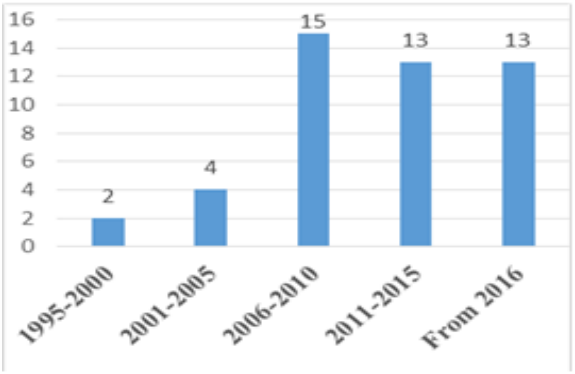

Figure 2: Earlier Studies considered in this study

Olawale et al. [2010] reported schedule delay factors, cost overrun factors of projects in UK and its mitigating measures based on relative importance index (RII). The major schedule delay factors were identified as design changes, inaccurate evaluation of project's time, complexity of works, risk and uncertainty associated with projects, non-performance of subcontractors, lack of proper training and experience of PM, discrepancies in contract documentation, low skilled manpower, conflict between project parties and unpredictable weather conditions.

Motaleb et al. [2010] studied delays in UAE and based on RII concluded that Change orders, lack of capability of client representative, slow decision

making by client, lack of experience of client in construction, poor site management and supervision significant factors of delays.

Alnuaimi et al. [2010] investigated the causes of change orders in public construction projects of Oman and ranked 24 causes discussed effects and remedies for the top change orders/variations.

Memon et al. [2011] studied the responses from project management consultant (PMC) in Malaysia for causes of time overrun and top ten causes reported were Cash flow and financial difficulties faced by contractors, inadequate contractor experience, contractor's poor site management, shortage of site workers, ineffective planning and scheduling by contractors, escalation of material prices, practice of assigning contract to lowest bidder, subcontractors problems, poor communication among parties and poor change management.

Distribution of selected research studies by year of publication is depicted in Figure 2 whereas distribution of selected research studies by type of projects is depicted in Figure 3. The summary of the earlier studies is presented in the Table 1.

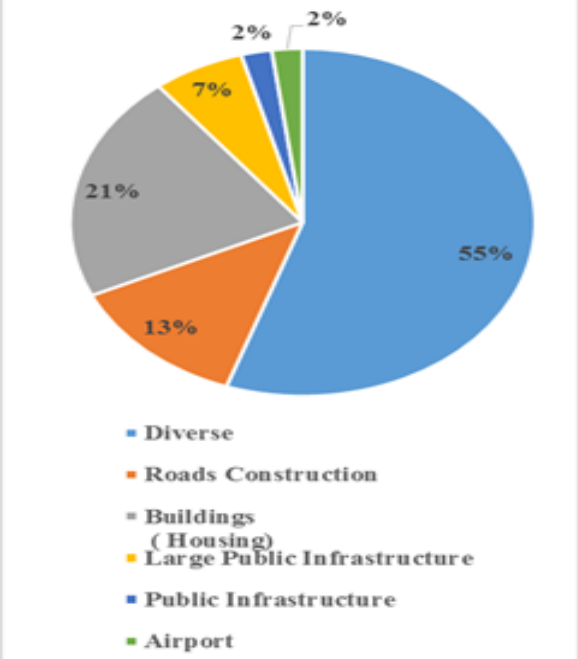

Figure 3: Distribution of type of projects in earlier studies considered.

Kazaz et al. [2012] 34 factors were categorized to 7 groups as Environmental, financial, labor, managerial, owner, project and resource. Factors were ranked based on RII of factors calculated from the responses revealed that design and material changes, delay of payments, cash flow problems, contractor's financial problems, poor labor productivity, estimation problems, lack of feasibility studies, construction defects, unbalanced number of workers, fluctuation in material prices were top ten causes of time extensions. Akinsiku et al. [2012], Wong et al. [2012] and Kikwasi, et al. [2012] reported significant causes of delays as changes in design, lack of consultant experience, lack of finance by contractor and late progress payments by owner, shortage of labor/skills.

Doloi H et al. [2012] researched major factors impacting delay in Indian construction projects. They used a selected set of 45 attributes to identify and establish the relationship between the critical attributes for developing prediction models for assessing the impacts of these factors on delay. Personal interviews of construction experts and a questionnaire survey formed the basis of this research. The significance of the delay factors were examined using Factor analysis and regression modelling. Subsequently, they concluded that the most critical factors of construction delay were, lack of commitment, inefficient site management, poor site coordination, improper planning, lack of clarity in project scope, lack of communication and substandard contract.

Buertey et al. [2013] reported changes in design, poor consultant coordination, change orders and poor communication by owner, ineffective coordination by contractors and shortage of equipment while Shehu et al. [2014], Marzouk et al. [2014] and Muhwezi, et al. [2014] reported poor planning/construction methods used by contractor and shortage of materials as common delay causes. Emam et al. [2015] observed that slow response from utilities agencies, design changes during construction, poor planning and scheduling, lack of control on progress and scope changes were some of the significant causes of delay. Atibu et al. [2015] studied delays in road construction projects in Kenya by using survey data and RII and found that major causes of project delays were payment by client, delayed decision making and paperwork in client organization, inadequate planning and scheduling, and rain.

McCord et al. [2015] investigated delay factors in private housing construction projects in Northern Ireland. 75 delay causes identified from literature were used for the questionnaire survey. Which were grouped in 10 categories and these causes were ranked

on the basis of Relative Importance Index. They reported that deficiencies in site management, ineffective communication policies and a lack of coordination between parties involved in the construction as the significant causes of delays. Santoso et al. [2016] observed that work during rainy season, flooding, land acquisition for project, award of project to lowest bidder (inhibiting qualified bidders), repeated equipment breakdowns were significant delay factors in road construction projects in Cambodia.

Durdyev et al. [2017] found that the main causes of delays for residential projects in Cambodia were shortage of materials on site, unrealistic project scheduling, late delivery of material, shortage of skilled labour, complexity of project, labour absenteeism, rain effect on construction activities, design changes, delay by subcontractor and accidents due to poor site safety.

Mohammed et al. [2017] studied 48 causes in 8 groups of diverse type projects in Iraq and reported that inadequate the financial allocations as top cause in client group, and lack of coordination in design drawings between disciplines in designer group. While causes of incompetent contractor, lack the financial ability, missing material supply schedule, using obsolete construction equipment and unskilled labor in the groups associated with the contract, the contractor, the materials, the equipment, and the manpower respectively. Gebrehiwet et al. [2017] studied 52 causes of delay in Ethiopian construction projects and reported that the important causes of delay as

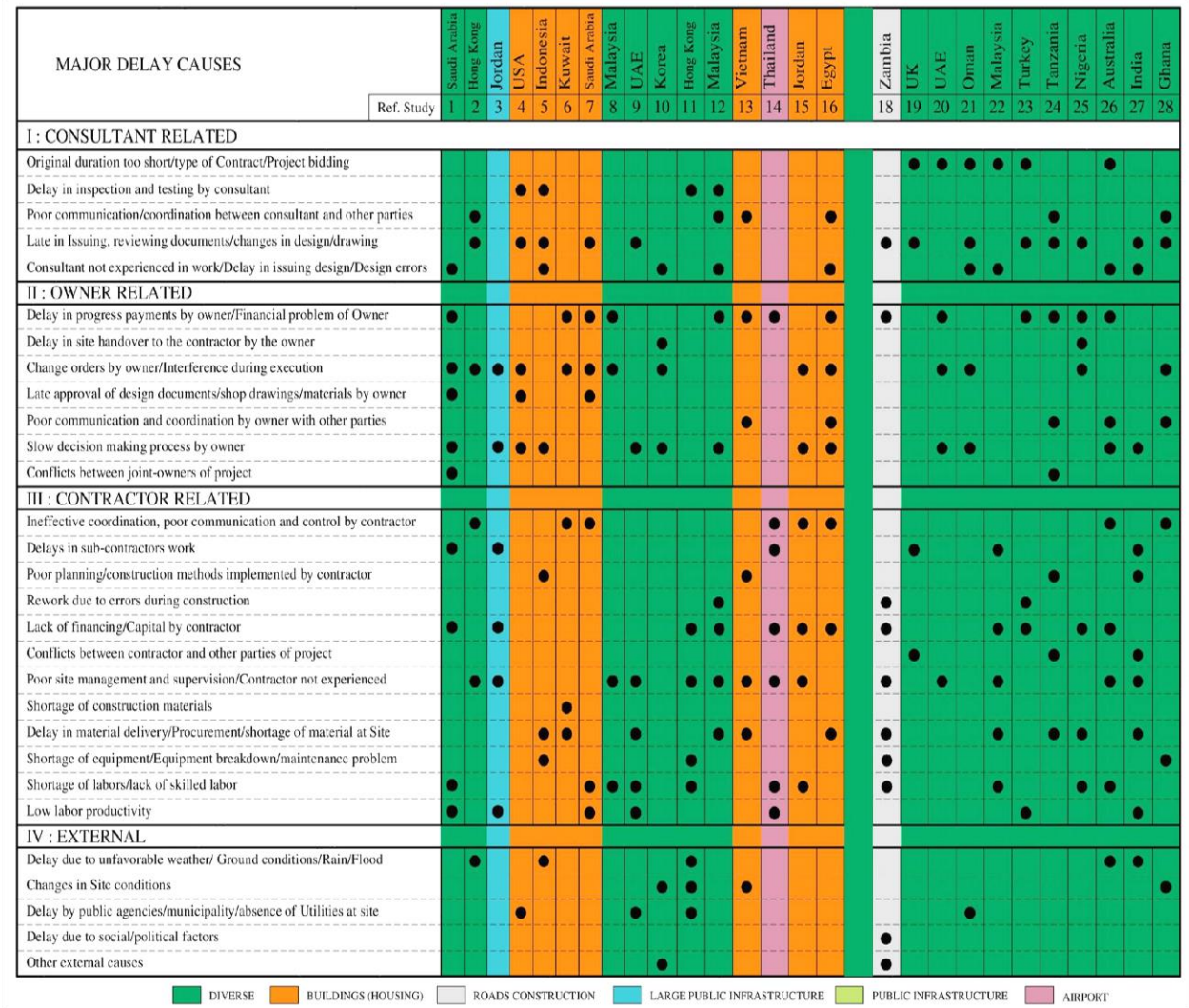

Table 1 Major causes of Delays in Construction, Number below name of the country indicate the reference study considered

MAJOR DELAY CAUSES	Malaysia	Egypt	Uganda	Qatar	Kenya	UK	Cambodia	New Zealand	Cambodia	Iraq	Ethiopia	Philippines	Norway	Algeria	Jordan	India	Kazakhstan	Laos	Portugal	Frequency (%)
Ref. Study	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
I : CONSULTANT RELATED																				
Original duration too short/type of Contract/Project bidding		●				●	●	●	●				●	●						28%
Delay in inspection and testing by consultant													●		●				●	15%
Poor communication/coordination between consultant and other parties						●		●					●							21%
Late in Issuing, reviewing documents/changes in design/drawing			●	●				●		●	●	●			●	●	●			47%
Consultant not experienced in work/Delay in issuing design/Design errors		●	●			●				●	●			●					●	36%
II : OWNER RELATED																				
Delay in progress payments by owner/Financial problem of Owner	●	●			●	●	●		●	●	●			●	●	●	●	●		60%
Delay in site handover to the contractor by the owner															●	●				9%
Change orders by owner/Interference during execution		●		●	●			●					●	●	●	●			●	51%
Late approval of design documents/shop drawings/materials by owner		●												●		●			●	15%
Poor communication and coordination by owner with other parties						●		●					●							19%
Slow decision making process by owner	●		●	●	●	●		●					●		●	●	●			51%
Conflicts between joint-owners of project																				4%
III : CONTRACTOR RELATED																				
Ineffective coordination, poor communication and control by contractor	●					●		●					●					●		30%
Delays in sub-contractors work	●								●											17%
Poor planning/construction methods implemented by contractor	●	●	●	●	●			●		●			●	●			●		●	32%
Rework due to errors during construction																	●		●	36%
Lack of financing/Capital by contractor	●		●			●				●					●	●		●		43%
Conflicts between contractor and other parties of project	●																			9%
Poor site management and supervision/Contractor not experienced			●				●		●	●	●								●	45%
Shortage of construction materials	●	●	●										●							11%
Delay in material delivery/Procurement/shortage of material at Site									●		●						●			32%
Shortage of equipment/Equipment breakdown/maintenance problem							●						●				●	●		17%
Shortage of labors/lack of skilled labor		●							●				●			●	●	●		36%
Low labor productivity							●										●			19%
IV : EXTERNAL																				
Delay due to unfavorable weather/ Ground conditions/Rain/Flood		●	●		●		●	●				●								23%
Changes in Site conditions																				11%
Delay by public agencies/municipality/absence of Utilities at site	●			●		●					●	●			●				●	23%
Delay due to social/political factors												●								4%
Other external causes																				4%

DIVERSE BUILDINGS (HOUSING) ROADS CONSTRUCTION LARGE PUBLIC INFRASTRUCTURE PUBLIC INFRASTRUCTURE AIRPORT

Table 1 (Continued) Major causes of Delays in Construction, Number below name of the country indicate the reference study considered

corruption, missing utilities at site, inflation in materials prices, lack of material quality, late issue of design documents, delayed delivery of materials, poor site management and performance. Cabahug et al. [2018] studied road construction projects in Philippines and reported that major causes of delays as road right of way, change in quantity of materials leading to variation orders, peace and order and heavy rain. Zidane et al. [2018] studied large infrastructure projects in Norway and reported the following major causes of delay as poor planning and scheduling, slow decision making, bureaucracy within project organizations, shortage of resources, poor communication and coordination between parties, slow inspections by consultant, design changes during construction and lack of commitment of owners.

Late issue of drawings, delay in progress payment by owner, change orders, slow decision by owners and contractors financial problems were main causes commonly reported by Rachid et al. [2019], Ahmad et al. [2019] and Prasad et al [2019] who studied projects in Algeria, Jordan and India respectively.

Hossain et al. [2019] studied Kazakh construction projects and reported that contractors related causes like poor planning, rework due to errors in construction, shortage of labor/equipment/materials and delayed supply of materials were important delay causes. Bounthipphasert et al. [2020] studied road construction projects in Laos and concluded that contractor cash flow, delayed payment by owner, difficulties in financing project by contractor, financial issues related to owner and insufficient equipment and vehicles for the work as top five causes of delay. Arantes et al. [2020] studied causes of delays in construction projects in Portugal by using Questionnaire responses from 94 experienced professionals from the industry and used SPSS program to analyse the data and ranked the causes in order of severity, then factor analysis was conducted to extract the underlying causes of delays and development of respective mitigation measures in Portuguese construction projects.

From above earlier studies, 29 causes of delays (different causes which are mentioned in earlier

studies were combined for this study as it would direct to same cause for example consultant not experience in job, delay in issuing design and design errors are combined into one cause) are selected for this study and broadly divided into 4 categories as Consultant related, Owner related, Contractor related and External for further analysis and use for proposed survey.

The frequency of each cause reported in earlier studies was calculated in the last column of Table 1 as

$$frequency\ (\%) = \frac{No\ of\ times\ a\ cause\ is\ reported}{Total\ No\ of\ studies\ considered} \quad \text{.....Eq (1)}$$

From table 1 it can be seen that most frequently reported cause of delay under consultant category was late in Issuing, reviewing documents/changes in design/drawing (47%) followed by consultant not experienced in work/delay in issuing design/design errors (36%). Under Owner category most frequently reported cause of delay was (also found to be top cause across all categories) delay in progress payments by owner/financial problem of Owner (60%), followed by Change orders by owner/Interference during execution (51%) and Slow decision-making process by owner (51%). Under contractor category, most frequently reported cause of delay was poor site management and supervision/contractor not experienced (45%) followed by rework due to errors during construction (36%) and shortage of labors/lack of skilled labor (36%). Under external category, most frenquntly reported causes were delay due to unfavorable weather/ ground conditions/rain/flood (23%) and delay by public agencies/municipality/ absence of utilities at site (23%).

From the above literature it is evident that, maximum research for evaluating the delay causes is done using the mean score and standard deviation techniques and least work is made using linear regression and Anova technique.

The author tries to attempt a study with methodology which is presented in Figure 4 (flow chart)

RESEARCH FRAMEWORK

The majority of the existing works carried out for identification of schedule delays were questionnaire surveys with traditional statistical techniques. This paper provides a framework of different methods on schedule delays identification techniques and its mitigation measures. Many authors developed different techniques out of which maximum work has been carried out on delays using traditional statistical inference methods whereas minimum work has been carried out on prediction of delays using actual data from numerous similar previous projects using multivariate regression and its mitigation. The Research Framework for identification & mitigation of schedule delays in infrastructure projects is presented in Figure 4

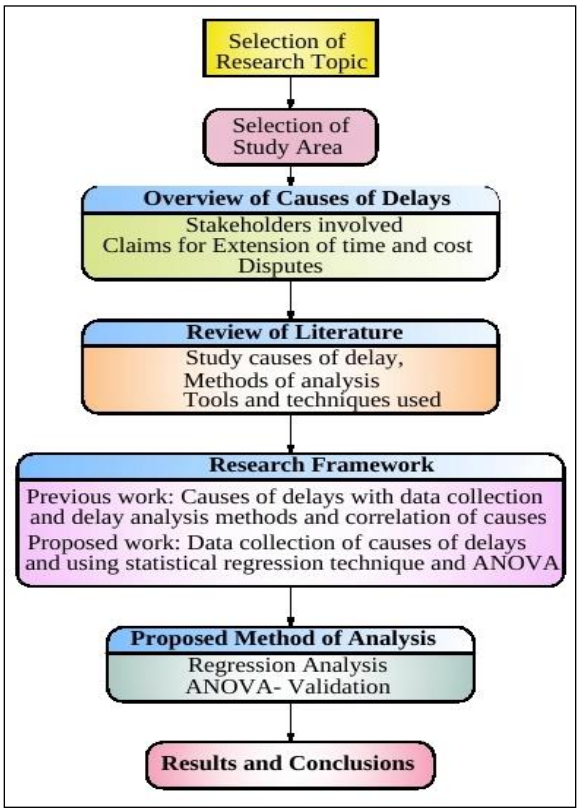

Figure 4: Research Framework for identification and mitigation of schedule delays

PROPOSED FRAMEWORK

The proposed framework analysis procedure consists of following tasks.

1. Design a questionnaire survey based on causes studied in literature review as presented in Table 1 above, to collect data from selected construction professionals of public and private sector on construction delays encountered in their projects.
2. The collected data will be checked for pre-processing and subsequently different parameters of delays are selected based on the responses and

analyzed by statistical regression modelling in Excel Regression Analysis program.

A linear regression equation has the form

Y= a + bX ……Eq (2)

Where Y is the dependent variable, X is the independent variable, b is the slope of the line and a is the y-intercept.

3. The expected results of the regression model will be validated by ANOVA test to find the significance of the relationship between the selected parameters.

   Finally, the research will be concluded based on the results and discussions with validation of the model.
4. Suitable recommendations for schedule delay mitigation measures will be drawn from the findings of the study.

CONCLUSIONS

This paper explored different researchers view on identification of causes of schedule delays in infrastructure projects. Extensive analysis for adaptation of suitable statistical methods for identification of critical causes responsible for the schedule delays and its mitigation were identified. The findings of this research can be used as a guide for the overall improvement and implementation in construction management practices by the construction agencies.

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