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International Journal of Project Management 30 (2012) 479–489

International Journal of Project Management

www.elsevier.com/locate/ijproman

Analysing factors affecting delays in Indian construction projects

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Received 5 January 2011; received in revised form 12 October 2011; accepted 20 October 2011

Abstract

Construction projects in India are experiencing widespread delays. Due to a dramatic shift in the capacity and volume of the Indian construction sector over the last decade, the need of a systematic analysis of the reasons of delays and developing a clear understanding among the industry professionals are highly crucial. Using a selected set of 45 attributes, this research first identified the key factors impacting delay in Indian construction industry and then established the relationship between the critical attributes for developing prediction models for assessing the impacts of these factors on delay. A questionnaire and personal interviews have formed the basis of this research. Factor analysis and regression modelling were used to examine the significance of the delay factors. From the factor analysis, most critical factors of construction delay were identified as (1) lack of commitment; (2) inefficient site management; (3) poor site coordination; (4) improper planning; (5) lack of clarity in project scope; (6) lack of communication; and (7) substandard contract. Regression model indicates slow decision from owner, poor labour productivity, architects' reluctance for change and rework due to mistakes in construction are the reasons that affect the overall delay of the project significantly. These findings are expected to be significant contributions to Indian construction industry in controlling the time overruns in construction contracts.
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Keywords: Time delay; Indian construction industry; Factor analysis; Regression modelling

1. Introduction

The Indian construction sector has acted as an engine of growth for the Indian economy for over the past five-decades and becoming a basic input for the socio-economic development of the country. 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. The investments made in construction were reported to be close to USD 50 billion in 2008 with persistent growth pattern expected for much of the next decade. Contribution of the industry in terms of employment is also significant providing 31.46 million jobs; with about 1.25 million engineering jobs in 2008–2009. As per government data, the demand for construction manpower is projected to grow at a consistent pace of 8%–9%, thereby resulting in an annual addition of around 2.5 million jobs to the existing stock with approximately 125,000 new engineering jobs being added annually. Regardless of the economic importance and employment generation of the sector, issues such as low productivity, limited mechanisation and lack of professionally qualified employees plague the industry.

While the importance of Indian construction sector over the past five years has grown significantly, lack of sophistication across the construction supply chain is one of the key issues in the industry. There is strong evidence of inconsistent performance of Indian construction projects and the trend is growing rapidly. Projects are reportedly failing across all the key performance measures including cost, time and quality performances. While understanding of the intrinsic factors affecting all these key performance measures is still an area of investigation at

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doi:10.1016/j.ijproman.2011.10.004

least in the Indian context, this research focuses on the analysis of performance in terms of timely delivery of construction projects. By earlier estimate, over 40% projects have reportedly been suffering from poor performance across the country (Iyer and Jha, 2005). In a separate study comparing the performance of international development projects in India, China, Bangladesh, and Thailand, Ahsan and Gunawan (2010) reported that construction projects in India showed the worst schedule performance (Ahsan and Gunawan, 2010). The study found that in India average schedule overrun is the highest (55% of actual schedule) compared to the other nations. Construction projects, especially infrastructure projects, in India have come under tremendous international scrutiny in the wake of the recent 2010 Commonwealth Games (Hindustan Times, August 2009). The current status report published by the Ministry of Statistics and Programme Implementation (MOSPI) highlighted that out of the 951 projects being monitored 309 projects have cost overruns and 474 projects are behind schedule. MOSPI has reported that "Of the total reported cost increase of USD 12.4 billion, USD 8.4 billion is on 466 delayed projects" (www.mospi.nic.in). Reasons for these problems range from land acquisition, improper planning and budgeting, to poor coordination and monitoring of the projects.

With this growing volume, schedule performance of the Indian construction sector is a certainly significant topic for investigation. While many studies have published on causes and factors affecting schedule and cost performance, most of the studies are area specific (Kim et al., 2008; Odeh and Battaine, 2002). Applicability of such research in Indian construction context still remains unexplored. There is a strong need to understand the attributes that cause the delays, understand the impact of these attributes, combine them into factors, and decipher the interdependencies between these factors. Thus, the primary objectives of this research are to identify the various attributes for construction delay, to identify the relationship between these attributes by statistical methods and to predict the impact of these identified attributes on construction delay using a regression model in the Indian construction sector.

2. Literature review

Delay in construction projects has been a research topic for decades. Research conducted in this area is broadly divided into two streams—one stream relating to attributes and factors that cause project delays and second stream relating to delay analysis. Some location specific work related to delay analysis reported by El-Razek et al. (2008), Sambasivan and Soon (2007) and Iyer and Jha (2005) highlighted the complexity on this issue across many countries. The first stream of literature focusing upon delay attributes and factors which is more relevant to this research is reviewed below.

Arditi et al. (1985) reported the causes of delay on Turkish public-sector construction projects in the 1970s and 1980s by surveying public agencies and contractors involved in public sector projects. This study divided the identified factors into those that are influenced by national economic policies and those that can be controlled by the public agencies and contractors (Arditi et al., 1985). Investigating the factors causing delay in construction projects in United Arab Emirates, Faridi and El-Sayegh (2006) reported that over 50% of construction projects experience delay due to factors such as delay in approval of construction drawings, poor pre-planning and slow decision making process. Comparing the key factors of construction delay across UAE, the Kingdom of Saudi Arabia (KSA) and Lebanon, the research asserted that delay in approval, owner's slow decision making and material shortages are common causes of construction delay across the region. However, the findings that other high ranked factors in UAE had no significant impact in KSA construction projects clearly highlight the fact that factors causing construction delay cannot be considered common across the countries. There is a clear need for critical analysis and validation of the factors in Indian context as well.

A survey to identify project delays in Saudi Arabia was conducted by Al-Khalil and Al-Ghafly (1999) reporting lack of agreement between project stakeholders in such identification. Al-Kharashi and Skitmore (2009) repeated this study in Saudi Arabia to highlight the chronic nature of the problem and disparity in the views of the project stakeholders. Olawale and Sun (2010) reported a study conducted in the UK to determine inhibiting factors and mitigating measures in practice relating to time and cost overruns on construction projects in the country. Nkadoa (1995) studied the issue of time performance of construction projects in UK from the contractors' perspective. Ling and Hoi (2006) provided time performance guideline for Singaporean contractors working in India.

El-Razek et al. (2008) identified main causes of delays in Egyptian construction projects concluded that different parties of construction don't agree on the relative importance of various factors of delay, mostly blaming each other of delays using importance index and spearman rank correlation similar to Assaf et al. (1995). He also identifies the importance of team effort in the success of a project.

Lo et al. (2006) identified 30 causes of delay in Hong Kong construction projects under 7 categories namely client related, engineer related, contractor related, human behaviour related, project related, external factors and resource related. Using rank agreement factor (RAF), percentage agreement (PA) and percentage disagreement (PD) difference in perceptions of various construction practitioners on causes of delay.

In Nigeria, Aibinu and Odeyinka (2006) identified 43 factors of delay under 9 categories based on the works of Bramble and Callahan (1992) and Odeyinka and Yusif (1997). Based on covariance analysis and Pareto analysis it was found out that 88% of the factors contribute to 90% of delays and thereby concluded that there is no discernable difference among the different delay factors and none of them really stands out as a largest contributor to the problem.

In Malaysia Sambasivan and Soon (2007) adopted an integrated approach for causes and effects of construction delays. Out of 28 listed factors, they identified 10 important factors and six main effects of delays using relative importance index and Spearman rank correlation (Sambasivan and Soon, 2007).

In a separate study, Assaf and Al-Hejji (2006) identified that the most common cause out of the listed 73 causes of delay identified by all parties of construction is change of orders using frequency index (FI) and severity index (SI). Assaf et al. (1995) identified 56 causes of delay under 9 major groups and evaluated their relative importance by questionnaire survey and importance index. Using Spearman rank correlation, it was concluded that contractor owners and architects in general agree to the ranking of individual delay factors while contractors and architects substantially agree with the ranking of groups of delay factors while contractors and owners, and architects and owners don't agree.

In India, Iyer and Jha (2005) identified the project success and failure attributes and their latent property failure attributes being: conflict among project participants, ignorance and lack of knowledge, presence of poor project specific attributes and non-existence of cooperation, hostile socio economic and climatic condition, reluctance in timely decision, aggressive competition at tender stage, short bid preparation time.

Kumaraswamy and Chan (1998) examined eight delay factor categories: project related factors, client related factors, design team related factors, contractor related factors, materials, labour, plant and equipment, and external factors. Chan and Kumaraswamy (1997) found the relative importance of delay factors in Hong Kong. Five principal delay factors were identified: poor risk management, poor supervision, unforeseen site conditions, slow decision making involving variation, and necessary variation works.

Odeyinka and Yusif (1997) reviewed the causes of delays in housing projects and identified main categories as: client-, consultant-, and contractor-caused delays, and extraneous factors in Nigeria. The research asserted that client-caused delays predominately arise from design variation in projects. Mansfield et al. (1994) reviewed the causes of delays and cost overruns and found that there was a very good agreement between the respondents on those factors that could cause delays and cost overrun. The four most important items agreed on by the contractor, consultants, and public clients surveyed were the financing of and payment for completed works, poor contract management, change in site conditions, and shortages of materials.

From the above selected literature review, it has been apparent that in most studies, priority has been given to identifying the critical causes based on perceptions of different parties in construction. However, quantification of the dependencies of one factor over others has not found widespread coverage. For instance steps taken to control a critical reason might trigger a situation where other factor becomes critical and cause even more delay than earlier anticipated. Hence it is important to identify the relationship between various factors of delay. Work is yet to be done in identifying the relationship between the various reasons of delay and also prediction of impact on that delay.

3. Research methodology

For this research, a questionnaire survey approach has been adopted to find the impact of various attributes on delay in the Indian construction sector drawing from various international researchers mentioned above. A survey of construction professionals representing various stakeholders involved in construction projects in India was conducted. Heterogeneity of respondents is an important criteria in capturing the impact of various attributes on construction delay (Sambasivan and Soon, 2007). In this study, the heterogeneity in the survey sample was maintained by approaching to the selected group of respondents representing the key industry roles across the construction sector.

3.1. Preparation of questionnaire

Identification of critical attributes for the study and preparation of questionnaire is a crucial step for the success of the research. Significant amount of work has already been done on causes of construction delay and there is a well documented and peer-reviewed set of delay attributes available in the literature. For this research, the questionnaire has been prepared by incorporating the key delay attributes reported in the literature. A total of 45 delay attributes were identified under six broad categories namely project related, site related, process related, human related, authority related and technical issues. To reflect the cross-section of the already available delay attributes in the Indian context, personal interviews with Indian construction experts were also conducted. The final questionnaire survey was on design based on these two inputs. The attributes are listed in Table 1. A five point Likert scale (1 very low, 2 low, 3 average, 4 high, 5 very high) was adopted where respondents were asked to rank the importance and impact of a particular attribute on delay in one of their selected projects. The research was designed to be used with two statistical techniques namely factor analysis and regression modelling (Doloi, 2009; Field, 2005). In addition, descriptive analysis was also performed on the attributes using the raw data collected in the survey. Descriptive analysis is an important measure for ranking the attributes in terms of their criticality as perceived by the respondents. This is similar to the analysis of the basic statistics on collected samples to investigate the trends of perceptions of certain industry practices based on first hand experiences of the practitioners. As such analysis does not provide any meaningful outcomes in terms of understanding the clustering effects of the similar attributes and the predictive capacity, further analysis is required using advanced statistical methods. Factor analysis was used to reduce the attributes for investigating the clustering effects while regression analysis was performed for deriving a predictive model based on the best fit attributes for forecasting time performance in the project (Doloi, 2009; Field, 2005).

Descriptive statistics namely Relative Importance Index (RII) has been used to highlight the relative importance of attributes as perceived by the respondents (Assaf et al., 1995; Faridi and El-Sayegh, 2006; Iyer and Jha, 2005; Kumaraswamy and Chan, 1998). Factor analysis is primarily used to get greater insight among numerous correlated but seemingly unrelated attributes into a much fewer underlying factors (Doloi, 2009; Iyer and Jha, 2005). The results form a firm basis for identifying the criticality of attributes on construction impact. However

Table 1
Identification of attributes and sources.

Category	Attributes affecting delay	Source
Project related	R1. Increase in scope of work	Semple et al. (1994); Sambasivan and Soon (2007); Satyanarayana and Iyer (1996)
	R2. Ambiguity in specifications and conflicting interpretation by parties	
	R3. Faulty soil investigation report	
	R4. Rework due to change of design or deviation order	
	R5. Unrealistic time schedule imposed in contract	
	R6. Non availability of drawing/design on time	
	R7. Rework due to error in execution	
Site related	R8. Restricted access at site	Aibinu and Odeyinka (2006); Lo et al. (2006); Satyanarayana and Iyer (1996)
	R9. Extreme weather conditions	
	R10. Slow decisions from owner	
	R11. Delay in material delivery by vendors	
	R12. Site accidents due to negligence	
	R13. Site accidents due to lack of safety measures	
	R14. Unforeseen ground conditions	
	R15. Hostile political conditions	
	R16. Inaccurate specification of site condition	
Process related	R17. Delay in material to be supplied by the owner	Iyer and Jha (2005); Satyanarayana and Iyer (1996);
	R18. Delay in approval of completed work by client (i.e. stage passing)	
	R19. Delay in material procurement by contractor	
	R20. Delay in approval of shop drawings and samples	
	R21. Delay in running bill payments to the contractor	
	R22. Delay in handing over of site	
	R23. Delay in finalisation of rates for extra items	
	R24. Improper storage of materials leading to damage	
Human related	R25. Consultant or architect's reluctance for change	Iyer and Jha (2005); Satyanarayana and Iyer (1996); Sambasivan and Soon (2007)
	R26. Poor site management and supervision	
	R27. Conflict between owners and other parties	
	R28. Lack of skilled operators for specialised equipments	
	R29. Poor coordination among parties	
	R30. Frequent change of sub contractors	
Authority related	R31. Obtaining permission from local authorities	Assaf et al. (1995); Iyer and Jha (2005); Satyanarayana and Iyer (1996);
	R32. Bureaucracy in client's organisation	
	R33. Poor organisational structure for client or consultant	
	R34. Changes in government regulations and laws	
	R35. Lack of control over sub contractor	
	R36. Poor means of contracting	
Technical issues	R37. Lack of motivation for contractors for early finish	Chan and Kumaraswamy (1997); Sambasivan and Soon (2007); Faridi and El-Sayegh (2006)
	R38. Improper planning of contractor during bidding stage	
	R39. Financial constraints of contractors	
	R40. Poor labour productivity	
	R41. Inadequate experience of contractor	
	R42. Change in material prices or price escalation	
	R43. Inefficient use of equipments	
	R44. Use of improper or obsolete construction methods	
	R45. Unrealistic inspection and testing methods proposed in contract	

the analysis is unable to depict the underlying relationship. An attempt to achieve this multiple regression analysis is considered a most suitable method to derive the relationship between the attributes (Doloi, 2009). With these research design issues in mind a survey of Indian construction professionals was conducted. Various methods such as email, online, mail, and telephone discussions were used to collect the information from experts.

3.2. Respondent's profile

Respondents are selected from a wide range of professionals engaged in the Indian construction sector (contractors, clients and engineers).

All the respondents identified had experience in relatively large engineering construction projects in the Indian context. The sample consisted of owners, architects, structural engineers, service engineers, project managers, contract administrators, design managers and construction managers. Table 2 shows a brief description of respondents' profile in terms of professional role and experience who participated in the study. As seen, the mix of disciplines was well proportioned in the sample. In order to get the best possible response commensurate by the experience and expertise, introductory conversations and email contacts were made with each respondent to explain and make the objectives of the research clear. A total of 110 questionnaires were mailed both by hard copy and via email, out of which 77 valid responses were obtained with a

Table 2
Respondent's profile.

Nature of work	Experience (years)				Total	% by professional role
	<5	5–10	10–20	>20		
Client	3	3	2	8	16	21
Contractor	15	16	12	8	51	66
Design/architect	4	4	2	0	10	13
Total	22	23	16	16	77	
% by experience	29	30	21	21		

response rate of 70%. Though the sample size is relatively small, the quality of the responses was considered to be highly reliable for the analysis due to relevant industry experiences, personal level interactions and clear understanding of the questionnaires among the respondents (Vaus, 2001). Amongst the respondents, the highest proportion (66%) was from the contractors involved in construction activities followed by the clients (21%). Respondents from the roles of architects and design managers were 13%. The average experience of the respondents was about 15 years with 21% over 20 years.

3.3. Ranking of attributes

Many researchers (Assaf et al., 1995; Faridi and El-Sayegh, 2006; Iyer and Jha, 2005; Kumaraswamy and Chan, 1998) are of the opinion that mean and standard deviation of each individual attribute is not a suitable measure to assess overall rankings as they do not reflect any relationship between them and hence used RII which can be calculated using the following equation:

$$\text{RII(Relative Importance Index)} = \frac{\Sigma w}{AxN}$$

W Weight given to each attribute by respondent
A Highest weight
N Total number of respondents

The attributes are arranged in ascending order of ranks, attribute with highest RII or rank 1 indicates that it has the maximum impact on the delay while the attribute with lowest rank indicates that it has the least impact on delay duration. However RII doesn't talk about the relationship between the various attributes.

To identify if there is a relationship between the selected attributes, Spearman rank correlation is used (Field, 2005). It assesses how well the relationship between two variables can be described using a monotonic function. The sign of the Spearman correlation indicates the direction of association between X and Y. A Spearman correlation of zero indicates that there is no tendency for Y to either increase or decrease when X increases.

3.4. Factor analysis

Factor analysis is a powerful statistical technique that aims at providing greater insight among numerous correlated but seemingly unrelated variables into a much fewer underlying factors (Doloi, 2008; Doloi, 2009). In order to evaluate the adequacy of the survey data for factor analysis, Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity (Field, 2005) were conducted. The value of KMO represents the ratio of the squared correlation between variables to the squared partial correlation between variables. It varies from 0 to 1. A value close to 1 indicates that the pattern of correlations is relatively compact and hence factor analysis should give distinct and reliable results (Field, 2005). A minimum value of 0.5 has been suggested (Kaiser, 1974). In this research of the 45 attributes, a total of 27 attributes are selected based on correlation.

The other 18 were found to have no significant correlation with one another and hence were excluded from further analysis. The KMO value for selected 27 variables is 0.78 which is deemed good for this study.

Components extracted: Principal component analysis is used to reduce numerous correlated attributes into much fewer underlying factors. As discussed, 27 out 45 attributes are used in this analysis. A total of seven principal components (factors) were evolved. Results are tabulated in Table 4. These seven factors explained 70.64% of total variance. Varimax rotation is used for better interpretation of results on the orthogonal factors.

3.5. Discussion of the extracted factors

3.5.1. Lack of commitment

First factor named *lack of commitment* explains 11.61% of total variance of the linear component (factor) and contains four attributes. Commitment from all the parties involved is essential for successful completion of any project (Iyer and Jha, 2005). First attribute *site accidents due to lack of safety measures* is due to lack of commitment from both client and contractor towards the project. Site accidents not only harm individuals and consume time, but also it is observed that productivity of labour reduces significantly after an accident. Time is also wasted in attending to accidents and replacing the injured person by a person with lesser or irrelevant skills. This then relates to the efforts required on training and development. These can be avoided if client and contractor are committed to appropriate safety measures adopted on the site. Second attribute *lack of motivation for contractor for early finish* (i.e. *no incentive for early finish* etc.) clearly links lack of commitment from the client and other stakeholders. Third attribute *use of improper or obsolete construction methods* is a result of unprofessional engagement and perhaps without an appropriate commitment to project from the contractor. Improper construction method compromises the safety and quality standards and affects the productivity, which potentially increases the duration of the project. Fourth attribute *delay in material delivery by vendors* shows the lack of commitment in terms of contractor's procurement planning prior to construction phase of project. Ignorance of the lead time for material delivery by the vendors potentially result material shortage, which has reportedly been one of the significant causes of schedule delay across construction projects (Kadir et al., 2005).

Table 3
Ranking of attributes.

Attributes	ΣW	RII	Rank
R11. Delay in material delivery by vendors	270	0.739726	1
R6. Non availability of drawing/design on time	269	0.736986	2
R39. Financial constraints of contractor	265	0.726027	3
R1. Increase in scope of work	262	0.717808	4
R31. Obtaining permissions from local authorities	261	0.715068	5
R17. Delay in material to be supplied by the owner	261	0.715068	6
R10. Slow decision from owner	259	0.709589	7
R26. Poor site management and supervision	255	0.69863	8
R19. Delay in material procurement (action by the contractor)	255	0.69863	9
R5. Unrealistic time schedule imposed in contract	253	0.693151	10
R40. Poor labour productivity	252	0.690411	11
R41. Inadequate experience of contractor	251	0.687671	12
R20. Delay in approval of shop drawings and samples	249	0.682192	13
R21. Delay in running bill payments to the contractor	249	0.682192	14
R4. Rework due to change of design or deviation order	248	0.679452	15
R30. Frequent change of sub-contractor	246	0.673973	16
R22. Delay in handing over of site	245	0.671233	17
R29. Poor coordination among parties	245	0.671233	18
R38. Improper planning of contractor during bidding stage	242	0.663014	19
R35. Lack of control over sub-contractor	242	0.663014	20
R7. Rework due to errors in execution	234	0.641096	21
R44. Use of improper or obsolete construction methods	233	0.638356	22
R9. Extreme weather conditions	233	0.638356	23
R15. Hostile political conditions	233	0.638356	24
R23. Delay in finalization of rates for extra items	228	0.624658	25
R25. Consultant or architect's reluctance for change	226	0.619178	26
R12. Site accidents due to negligence	226	0.619178	27
R13. Conflicts between owner and other parties	224	0.613699	28
R36. Delay in approval of completed work by client (i.e. stage passing)	224	0.613699	29
R2. Ambiguity in specifications and conflicting interpretation by parties.	223	0.610959	30
R13. Site accidents due to lack of safety measures	223	0.610959	31
R36. Poor means of contracting	222	0.608219	32
R14. Unforeseen ground conditions	221	0.605479	33
R42. Change in material prices/price escalation	220	0.60274	34
R3. Faulty soil investigation report	217	0.594521	35
R32. Bureaucracy in client's organisation.	216	0.591781	36
R28. Lack of skilled operators for specialised equipment	215	0.589041	37
R8. Restricted access at site	211	0.578082	38
R33. Poor organisational structure for client or consultant	210	0.575342	39
R43. Inefficient use of equipment	207	0.567123	40
R16. Inaccurate specification of site condition	204	0.558904	41
R24. Improper storage of materials leading to damage	201	0.550685	42
R45. Unrealistic inspection and testing methods proposed in contract	200	0.547945	43
R37. Lack of motivation for contractor for early finish	189	0.517808	44
R34. Changes in government regulations and laws	187	0.512329	45

Table 4
Factor analysis—components extracted.

Reason ID	Reason description/factor name	Factor loading	% variance explained
Factor I: *lack of commitment*			
R13	Site accidents due to lack of safety measures	0.823	11.61%
R37	Lack of motivation for contractor (viz. incentive for early finish etc.)	0.630	
R44	Use of improper or obsolete construction methods	0.540	
R11	Delay in material delivery by vendors	0.537	
Factor II: *inefficient site management*			
R2	Ambiguity in specifications and conflicting interpretation by parties	0.760	10.97%
R40	Poor labour productivity	0.740	
R35	Lack of control over sub contractor	0.578	
R41	Inadequate experience of contractor	0.515	
Factor III: *poor site coordination*			
R6	Non availability of drawing/design on time	0.754	10.90%
R10	Slow decision from owner	0.724	
R5	Unrealistic time schedule imposed in contract	0.645	
R26	Poor site management and supervision	0.401	
Factor IV: *improper planning*			
R9	Extreme weather conditions	0.771	10.84%
R28	Lack of skilled operators for specialised equipments	0.638	
R43	Inefficient use of equipment	0.601	
R29	Poor coordination among parties	0.558	
R19	Delay in material procurement (by the contractor)	0.494	
Factor V: *lack of clarity in project scope*			
R4	Rework due to change of design or deviation order	0.836	10.57%
R7	Rework due to errors in execution	0.657	
R30	Frequent change of sub contractor	0.562	
R1	Increase in scope of work	0.495	
R24	Improper storage of materials leading to damage	0.478	
Factor VI: *lack of communication*			
R31	Obtaining permissions from local authorities	0.775	8.66%
R18	Delay in approval of completed work by client (i.e. stage passing)	0.773	
R25	Consultant or Architect's reluctance for change	0.755	
Factor VII: *Sub-standard contract*			
R36	Poor means of contracting	0.861	7.09%
R38	Improper planning of contractor during bidding stage	0.719	

3.5.2. Inefficient site management

Factor two, named *inefficient site management* explains that 10.96% of total variance of the linear component comprises four key attributes. Inefficient site management is mentioned as one of the top five reasons for construction delay in Kadir et al. (2005). First attribute *ambiguity in specifications and potential for conflicting interpretation by parties* poses an enormous challenge to the contractors for rolling out an appropriate management plan onsite. Second attribute *poor labour productivity* is caused either by employing unskilled labour or due to lack of proper supervision over them which comes under inefficient management skills of the supervisor onsite. In case there is unavailability of work force with the required skill set and hiring of unskilled labour is inevitable, they must be trained properly

before putting them at work. Third attribute *lack of control over sub contractor* reflects the inefficient management skills of main contractor. This perhaps links to lack of clear contractual framework and objective criteria for engaging subcontractors in Indian projects. Lack of control over subcontractor may lead to unwanted conflicts, low productivity and development of negative attitudes on the site. Fourth attribute *inadequate experience of contractor* is due to lack of site management skills of the client. Inexperienced contractor may not be able to cope up with the progress of work or may not understand the complexity of project leading to misinterpretation and confusion. Inadequate experience of contractor in turn leads to improper management of site and thus cause time overruns.

3.5.3. Poor site coordination

Third factor named *poor site coordination* explains that 10.903% of total variance of the linear component contains four attributes. Poor site coordination has reportedly been one of the key failure parameters for most Indian projects (Iyer and Jha, 2005). First attribute under this factor, *non availability of drawing/design on time* is generally due to lack of coordination between construction site and design office. Non availability of drawings not only makes resources idle but also disturbs contractor's momentum. Second attribute, *slow decision from owner* is due to lack of proper coordination between owner and consultant or owner and contractor. This occurs when contractor or consultant fails to make client understand the time significance of decision to be taken or owner's decision is not communicated properly to concerning parties. Third attribute *unrealistic time schedule given in contract* is due to lack of coordination between client and contractor about the realistic difficulties at the site. Though unrealistic schedule not only causes time overrun, it also compels contractors for compromising quality of construction leading to mistakes and reworks in construction activities. Fourth attribute *poor site management and supervision* clearly highlights the lack of coordination between various bureaucratic hierarchies involved in Indian construction industry. Efficient site management and effective supervision is one of the vital factors for achieving success in Indian projects.

3.5.4. Improper planning

Fourth factor named *Improper planning* explains that 10.84% of total variance has five underlying attributes. Improper planning has been found to be one of the most important causes of delay in Malaysian construction context (Sambasivan and Soon, 2007). First attribute under this factor, *extreme weather conditions* (with factor loading = 0.771) is certainly an issue in Indian conditions. Extreme weather conditions are generally ignored during planning phase of construction which leads to improper estimation of labour productivity and thereby improper estimate of activity duration. It also signifies lack of contingency measures for inclement weather conditions. Second attribute *lack of skilled operators for specialised equipment* (with factor loading = 0.638) is a situation caused due to lack of proper equipment planning. In present day scenario, skilled workers is considered to be one of the most scarce resources in the context of high volume construction projects in India and thus proper planning of human resources is inevitable across all projects. Third attribute *inefficient use of equipment* (with a factor loading = 0.601) results from untimely mobilisation of equipment leading to idling of resources. This attributes also perhaps links to non-availability of the skill operators on the job site. Fourth attribute (with factor loading = 0.558) *poor coordination among parties* generally occurs due to improper flow of information between various parties of construction which occurs due to lack of planning in order of events. Fifth attribute (with factor loading = 0.495), *delay in material procurement* (by contractor) is a result of improper scheduling or lack of understanding of lead time of materials delivery. While the delay of delivery of materials has been identified as one of the most important reasons for project delays in Malaysian projects (Sambasivan and Soon, 2007), these findings clearly highlight the significance of this attribute in Indian context as well.

3.5.5. Lack of clarity in project scope

Fifth factor, named as *lack of clarity in project scope* explains that about 10.57% of total variance of the linear component contains five attributes. First attribute *rework due to change in design or deviation order* (with a factor loading of 0.861) is an effect caused by improper design brief and poor coordination between the owner, designer and engineer. Second attribute *rework due to errors in execution* (with a factor loading of 0.657) contributes to delay as the rework itself consumes time and resources. Rework due to errors in execution implies project manager's lack of understanding of scope or design of the project. Furthermore, if there are errors in execution cost of rework, the cost is usually borne by the contractor, which eventually leads to financial constraints and lack of motivation of contractors to complete the project on time. Third attribute *frequent change of sub-contractor* (with a factor loading of 0.578) is due to lack of understanding of the project complexity and scope of the project manager, leading to award of sub contract to incapable sub-contractors. Fourth attribute *increase in scope of work* clearly comes under lack of clarity of project scope by owner and designer. Increase in scope of work at a later stage delays the project completion due to change in quantities and change in project schedule. Increase in scope of work may further delay project due to unavailability of appropriate spare resources with the contractors. In fact, increase in scope of work results into a complete drain out of the contractor's resources and reduce his capability to follow the time plan. Fifth attribute *improper storage of materials leading to damage when necessary* (with a factor loading of 0.524) occurs due to lack of awareness and negligence by the project manager on proper inventory planning and storage of materials onsite. Improper storage resulting to the non availability of material when needed is one of the key causes across most projects and should be considered seriously in relation to required lead time for procuring materials when needed.

3.5.6. Lack of communication

Sixth factor *lack of communication* explaining 8.66% of variance has three attributes associated with it. It explains the

importance of proper communication in construction which has reportedly been one of the critical success factors for achieving cost performance in Indian projects (Iyer and Jha, 2005). The first attribute under this factor, *obtaining permissions from local authorities* (with a factor loading of 0.775) is caused due to lack of communication with local authorities. It may be due to delay in applying permission or lack of follow up or misinterpretation of applied permission by local authorities. Failure to get permission from local authorities may not only delay the work but also may cause legal complications which causes further delay. Second attribute *delay in approval of completed work by client* (*stage passing*) (with factor loading = 0.773) occurs due to lack of communication between contractor and the approval authority. Lack of communication can be both ways i.e. either client is unaware of completed work or order of approved work is not communicated back to contractor. Delay in approval of completed work not only causes delay due to interruption of further work, but also delay in payment to contractor which in turn causes financial difficulties. Financial difficulties of contractors has reportedly been one of the important reasons of delay in construction projects (Assaf and Al-Hejji, 2006; Odeh and Battaine, 2002; Sambasivan and Soon, 2007). Third attribute (with a factor loading = 0.755) describes the *consultant or architect's reluctance to change* which is due to improper communication of necessity for change in the overly exercised bureaucratic process. It is the responsibility of the project manager to explain to the architect the practical difficulties being faced and thus the need for change. Thus second factor stresses on the importance of communication during various stages of construction. The significance of this attribute has not been reported in past researches conducted in other contexts.

3.5.7. Sub-standard contract

Seventh factor, named Sub-standard contract explains that 7.09% of total variance comprises two key attributes. Substandard contract itself is hazardous to construction as if the contract is not properly administered; it leads to many conflicts and misinterpretations leading to costly arbitrations and litigations. Satyanarayana and Iyer (1996) has highly emphasised on the significance of effective contract administration especially in Indian construction projects. First attribute *poor means of contracting* refers to the selection of inexperienced or amateur contractor with inadequate experience or skill set required for the project. Since the main entity of a contract is the involvement of at least two parties, a substandard contractual agreement potentially implies significant treats in terms of following the responsibilities in the project. Selection of inefficient contractor may also affect the work of other parties involved in construction. Second attribute *improper planning during bidding stage* (with a factor loading of 0.711) is one important reason of delay which is generally overlooked in analysis of construction delays (Al-Kharashi and Skitmore, 2009; Bramble and Callahan, 1992). In most of the construction companies, people who apply for bid are different from who actually execute the work. Hence there is a tendency that people who apply for bid tend to be a bit overly optimistic and don't envisage for various practical contingencies. Furthermore, in the advent of construction boom over last decades, a degree of optimism on the time and cost performance is quite common across most construction projects in India (Satyanarayana and Iyer, 1996). Thus the contractual framework generally tends to have both optimistic cost and duration which may not be practically possible resulting to time and cost overruns. Following the optimism, the improper planning of contractor during bidding stage becomes the substandard contract in the latter stage of the project.

3.6. Mathematical validity of factor analysis

Once factors have been extracted, it is necessary to cross check if factor analysis measured what was intended to be measured i.e. the attributes in each factor formed collectively explain the same measure within target dimensions (Doloi, 2009). If attributes truly form the factor identified, it is understood that they should reasonably correlate with one another but not the perfect correlation though. By calculating Pearson correlation using SPSS we can estimate the extent of correlation among various variables. The values of Pearson correlation are tabulated in Table 5. We find that Pearson bivariate correlations are greater than 0.4 in most of the cases among different attributes in all the factors. From these results, we can ensure that factors formed in factor analysis contain attributes which are related. For reliability analysis, which is required to ensure the construct of the model over time (i.e. consistency of measured attributes and scale), Cronbach's alpha test was performed on entire data as well as attributes in each factor which are shown in Table 6. The value of $C\alpha$ could be anywhere in the range of 0 to 1, where a higher value denotes the greater internal consistency and vice versa.

The value of $C\alpha$ is inflated by a large number of variables, so there is no set interpretation as to what is an acceptable limit (Zhang, 2005). However, a rule of thumb applies to most situations with the following ranges: $C\alpha > 0.9$ denotes excellent, $0.9 > C\alpha > 0.8$ as good, $0.8 > C\alpha > 0.7$ as acceptable, $0.7 > C\alpha > 0.6$ as questionable, $0.6 > C\alpha > 0.5$ as poor and $0.5 > C\alpha$ denotes unacceptable (Doloi, 2009). The value of $C\alpha$ for all attributes calculated is 0.944 which is considered to be excellent.

3.7. Regression analysis

As already stated, the reasons of delay evolving from factor analysis are further analysed by linear multiple regression for potentially developing a predictive model in Indian construction context. While factor analysis depicts the existence of clusters of large correlation coefficients with measurable underlying dimensions, such dimensions (or factors) do not possess predictive power of any order on the measured phenomena. The factors are extracted based on parsimonious explanation of the maximum amount of common variance in a correlation matrix using the smallest number of exploratory concepts and the extracted factors are perceived to be of equal importance. However, multiple regression analysis fits

Table 5
Correlation matrix for the attributes.

	R13	R37	R44	R11
R13	1			
R37	0.585	1		
R44	0.493	0.551	1	
R11	0.524	0.481	0.571	1

Factor I

	R2	R40	R35	R41
R2	1			
R40	0.498	1		
R35	0.408	0.579	1	
R41	0.392	0.489	0.502	1

Factor I I

	R6	R10	R5	R26
R6	1			
R10	0.579	1		
R5	0.474	0.462	1	
R26	0.442	0.509	0.331	1

Factor I II

	R9	R28	R43	R29	R19
R9	1				
R28	0.56	1			
R43	0.467	0.685	1		
R29	0.478	0.333	0.323	1	
R19	0.396	0.421	0.397	0.588	1

Factor I V

	R4	R7	R30	R1	R24
R4	**1**				
R7	0.56	1			
R30	0.48	0.577	1		
R1	0.444	0.554	0.522	1	
R24	0.416	0.535	0.432	0.367	1

Factor V

	R31	R18	R25
R31	1		
R18	0.455	1	
R25	0.5	0.558	1

Factor VI

	R36	R38
R36	1	
R38	0.53	1

Factor VII

a predictive model combining a set of independent variables in the entire dataset and without considering the common variance (value of R^2) in the correlation matrix (Field, 2005). Value of R^2 provides a good gauge of substantive size of relationship between the predicting or dependent variable and the independent variables.

Before performing the regression analysis, some of the key underlying assumptions should be met in the predictor variables. In this research, the parametric test was conducted by analysing the homogeneity of variance (Levene's test) on the selected attributes before performing the regression analysis (Field, 2005). The results of Levene's test being significant ($p<0.05$) suggest the rejection of the null hypothesis that variances between variables are zero and thus the regression analysis is tenable. The independent variables used are the attributes resulted from the factor analysis as shown in Table 4. Dependent variable is the impact of overall delay on project which has been asked separately to every respondent focusing on a selected project. These attributes are entered into regression model stepwise as categorical variables. Thus the regression model framed to measure the overall impact of delay caused by individual attributes can be expressed generally as

$$Y = a + b_1X_1 + b_2X_2 + \ldots b_mX_m \pm e$$

where Y is dependent variable, a is constant and intercepts at Y axis; b_1 to b_m are estimated regression coefficients; X_1 to X_m are values of predictor or independent variables, e is error.

Forward stepwise process is used to formulate the regression model. Since it may not be the best fitting model, predictor variables with significant correlation with dependent variable is identified using Spearman correlation and models are again formulated with forward pass backward stepwise and forced entry. Out of formed models, the optimum model is selected based on strength of correlation (R^2) which is a direct measure of % variance explained (Field, 2005). As the value of R^2 changes rapidly with the addition of new independent variables in the model, a good measure of strength in the model is *adjusted*

Table 6
Reliability Cronbach's alpha for the attributes.

Attributes	Cronbach's alpha (C_α)
Attributes in factor I	0.816
Attributes in factor II	0.761
Attributes in factor III	0.773
Attributes in factor IV	0.811
Attributes in factor V	0.825
Attributes in factor VI	0.749
Attributes in factor VII	0.71
All attributes selected for factor analysis	0.91

Table 7
Regression model.

Source	Coefficient	Std error	Prob.	R^2/adj R^2
Intercept	−0.853	0.346	0.0163	R^2=0.766/adj R^2=0.747 F=41.219
R10	0.368	0.082	0.0000	p=0.00001 Dublin–Watson=2.224
R25	0.177	0.079	0.0283	
R40	0.165	0.076	0.0321	
R26	0.299	0.090	0.0014	
R7	0.325	0.067	0.0011	

R^2 values. The adjusted R^2 values and the change from R^2 values give the idea of how well the model generalises the predictive strength of the dependent variable (Doloi, 2009). In an ideal case, values of R^2 and adjusted R^2 should be the same. The difference between R^2 and adjusted R^2 gives the predictive strength of the model, the lesser the difference is, the stronger the model (Field, 2005).Based on the goodness of the model fit, the values shown in Table 7 are acceptable with reasonable strengths.

The final regression model for impact of delay can be expressed as:

$$\begin{aligned}\text{Impact of Delay} = {} & (-0.853)\\ & +0.368(\text{Slow decision from owner})\\ & +0.177(\text{Consultant or Architect's reluctance for change})\\ & +0.165(\text{Poor labour productivity})\\ & +0.299(\text{Poor site management and supervision})\\ & +0.325(\text{Rework due to errors in execution}).\end{aligned}$$

As seen clearly from the regression model, slow decisions from owner (R10) and rework due to errors in execution (R7) have maximum impact on delay duration in Indian construction projects. Slow decisions from owner and consultant's reluctance for change (R25) are usually the results of overly exercised bureaucracy in project development environment. Rework due to errors in execution is again the result of lack of appropriate quality planning and implementation of quality control processes onsite. Poor labour productivity (R40) is partly due to use of unskilled labour without appropriate match to the required trade practices. Poor site management and supervision (R26) experienced across most Indian projects is partly due to lack of commitments and ad-hoc approaches among the construction professionals. These findings seem to have the synergy across practices in developing countries which are somewhat comparable to the findings of Aibinu and Jagboro (2002) and Sambasivan and Soon (2007).

Comparing the above findings of the regression model with the descriptive ranking of the attributes in Table 3, a clear contrast in terms of perceived importance of the attributes and their degree of impacts on time delay is visible. Considering the top five attributes reported in Table 3, none of them were found to be significant in terms of predictability of delay in construction projects in Indian context. Rather, attributes R10 and R17 in seventh and 21st ranks respectively possess significant predictive power in the regression model. Combining with the other three attributes R26, R25 and R40, all five attributes in the regression model show a clear contribution in terms for achieving time performance in Indian construction projects. Such contrast highlights the fact what while descriptive analysis is useful and informative, criticality of these attributes in terms of their relationships with the measured phenomena needs to be evaluated further based on the relevant statistical methods (Field, 2005; Iyer and Jha, 2005).

4. Conclusion

This research reveals that one of the most critical factors of construction delay is the lack of commitment. This finding is indeed a clear contrast to the findings of El-Razek et al. (2008) that financial problem of a contractor is the most important cause. Inefficient site management is certainly another key factors affecting time performance of most construction projects in India. This is perhaps due to lack of formal training among the site professionals who usually develop their supervisory skills by experience. Most notably, the importance of this factor, however in different orders, has been identified in the previous research on cost performance context in Indian construction projects (Iyer and Jha, 2005). Based on RII we can infer that material shortage is the most significant factor in construction delays. This finding supports the findings by Sambasivan and Soon (2007) where material shortage was one of the key factors affecting time delay in Malaysian construction projects. The result of the regression model asserted that slow decision from owner, poor labour productivity, architects' reluctance for change and rework due to mistakes in construction are the reasons affecting the overall delay of Indian construction project significantly. While lack of commitment with four key attributes was found to be the most influencing factor, none of these attributes found to have any significant predictive power in the regression analysis. However, slow decision from owner and rework due to errors in executive (regression coefficients 0.368 and 0.326 respectively) are found to have greater predictive power in the regression model. Poor site management (with regression coefficient 0.299) is one of the other key attributes clearly affecting delay in Indian construction projects. Similar poor labour productivity and consultant's reluctance for change (with regression coefficients 0.165 and 0.177 respectively) also need attention in achieving time success in Indian projects.

Despite a clear understanding of these key factors among the research communities, a sincere attempt to address this chronic issue of time overrun is yet to materialise amongst practitioners in the Indian construction industry. Traditionally, the approach to managing construction is quite ad-hoc on Indian projects and need for adopting a systematic approach has not been realised across the board. This became evident on the world arena during the execution stage of programmes and projects during the recently concluded Commonwealth Games 2010. In the advent of the rapid urbanisation and fast growth in construction industry, these factors must be considered and well-integrated in the main stream construction processes for improving industry practices across the construction projects. Benchmarking data on performance of Indian construction projects is not available.

Recently efforts to measure, especially on large infrastructure projects, time and cost performance have begun. In 2009, the Bureau of Indian Standards released the first guideline on construction project management. The path forward requires setting of standards, benchmarking performance, skills development, and research undertakings in project management. Via this research the authors have attempted to highlight some of these issues. Consequently these findings are envisioned to be significant contributions to the Indian construction industry in controlling the time overruns on construction projects.

4.1. Limitations of the research

Though best efforts were put in this research and findings do make a significant contribution for industry, this research has some limitations. First the sample size of 77 is considered to be on the smaller side for statistical analysis. Secondly the respondents are not evenly distributed among the professional roles which may have induced some bias in responses. Thus the model formed may be further honed based on detailed discussions and suggestions from industry experts. The relationship between various reasons of delay and its impact on overall project delay has to be detailed further which is the author's intended future work.

References

Ahsan, M.K., Gunawan, I., 2010. Analysis of cost and schedule performance of international development projects. International Journal of Project Management 28, 68–78.

Aibinu, A.A., Jagboro, G.O., 2002. The effects of construction delays on project delivery in Nigerian construction industry. International Journal of Project Management 20, 593–599.

Aibinu, A.A., Odeyinka, H.A., 2006. Construction delays and their causative factors in Nigeria. Journal of Construction Engineering Management 132, 667–677.

Al-Khalil, M., AL-Ghafly, M., 1999. Important causes of delay in public utility projects in Saudi Arabia. Journal of Construction Management and Economics 17.

Al-Kharashi, A., Skitmore, M., 2009. Causes of delays in Saudi Arabian public sector construction projects. Construction Management and Economics 27, 3–23.

Arditi, D., Akan, G.T., Gurdamar, S., 1985. Reasons for delays in public projects in Turkey. Construction Management and Economics 3, 171–181.

Assaf, S.A., Al-Hejji, S., 2006. Causes of delay in large construction projects. International Journal of Project Management 24, 349–357.

Assaf, S.A., Al-Khalil, M., Al-Hazmi, M., 1995. Causes of delays in large building construction projects. ASCE Journal of Management in Engineering 11, 45–50.

Bramble, B.B., Callahan, M.T., 1992. Construction Delay Claims. Wiley Law Publications, New York.

Chan, D.W., Kumaraswamy, M.M., 1997. A comparative study of causes of time overruns in Hong Kong construction projects. International Journal of Project Management 15, 55–63.

Doloi, H., 2008. Analysing the novated design and construct contract from the client's, design team's and contractor's perspectives. Construction Management and Economics 26, 1181–1196.

Doloi, H., 2009. Analysis of pre-qualification criteria in contractor selection and their impacts on project success. Construction Management and Economics 27, 1245–1263.

El-Razek, A.M.E., Bassioni, H.A., Mobarak, A.M., 2008. Causes of delay in building construction projects in Egypt. Journal of Construction Engineering Management 134, 831–841.

Faridi, A., El-Sayegh, S., 2006. Significant factors causing delay in the UAE construction industry. Construction Management and Economics 24, 1167–1176.

Field, A., 2005. Discovering Statistics Using SPSS. Sage, London.

Iyer, K.C., Jha, K.N., 2005. Factors affecting cost performance: evidence from Indian construction projects. International Journal of Project Management 23, 283–295.

Kadir, M.R.A., Lee, W.P., Jaafar, M.S., Sapuan, S.M., Ali, A.A.A., 2005. Factors affecting construction labour productivity for Malaysian residential projects. Structural Survey 23, 42–54.

Kaiser, H.F., 1974. An index of factorial simplicity. Psychometrika 39, 31–36.

Kim, H., Soibelman, L., Groblera, F., 2008. Factor selection for delay analysis using knowledge discovery in databases. Automation in Construction 17, 550–560.

Kumaraswamy, M.M., Chan, D.W.M., 1998. Contributors to construction delays. Construction Management and Economics 16, 17–29.

Ling, F.Y.Y., Hoi, L., 2006. Risks faced by Singapore firms when undertaking construction projects in India. International Journal of Project Management 24, 261–270.

Lo, T.Y., Fung, I.W.H., Tung, K.C.F., 2006. Construction delays in Hong Kong civil engineering projects. Journal of Construction Engineering Management 132, 636–649.

Mansfield, N., Ugwu, O., Doran, T., 1994. Causes of delay and cost overruns in Nigerian construction projects. International Journal of Project Management 12, 254–260.

Nkadoa, R.N., 1995. Construction time-influencing factors: the contractor's perspective. Construction Management and Economics 13, 81–89.

Odeh, A.M., Battaine, H.T., 2002. Causes of construction delay: traditional contracts. International Journal of Project Management 20, 67–73.

Odeyinka, H.A., Yusif, A., 1997. The causes and effects of construction delays on completion cost of housing projects in Nigeria. Journal of Financial Management of Property and Construction 2, 31–44.

Olawale, Y.A., Sun, M., 2010. Cost and time control of construction projects: inhibiting factors and mitigating measures in practice. Construction Management and Economics 28, 509–526.

Sambasivan, M., Soon, Y.W., 2007. Causes and effects of delays in Malaysian construction industry. International Journal of Project Management 25, 517–526.

Satyanarayana, K.N., Iyer, K.C., 1996. Evaluation of delays in Indian construction contracts. Journal of the Institution of Engineers (India) 77, 14–22.

Semple, C., Hartman, F., Jergeas, G., 1994. Construction claims and disputes: causes and cost/time overruns. ASCE Journal of Construction, Engineering and Management 120 (4), 785–795.

Vaus, D.A., 2001. Research Design in Social Science, Sage Publications Ltd. London.

Zhang, X., 2005. Concessionaire's financial capability in developing build–operate–transfer type infrastructure projects. Journal of Construction Engineering and Management 131, 1054–1064.