CAUSES OF CONSTRUCTION DELAYS FOR HIGH RISE BUILDINGS: A QUANTITATIVE COMPARISON BETWEEN THE USA AND INDIA

A Paper
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Sciences

By

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In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Construction Management and Engineering

December 2010

Fargo, North Dakota

North Dakota State University
Graduate School

Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

ABSTRACT

Billa, Arun, M.S., Department of Construction Management and Engineering, College of Engineering and Architecture, North Dakota State University, December 2010. Causes of Construction Delays for High Rise Buildings: a Quantitative Comparison between the USA and India. Major Professor: Dr. Eric Asa

High rise buildings are complex, high risk, and multi-contractor projects which make them prone to construction delays. Delays can lead to time overrun, affect the total project duration and the total cost, and could result in litigation. Most construction schedules are deterministic and do not include the uncertainty and risk inherent in the diverse activities which constitute the construction project. Generally, high rise buildings are expensive undertakings and a schedule overrun could lead to significant time and money losses. Therefore, a high rise project manager must be able to estimate the potential delays and eliminate them if possible in order to reduce their impact on the success of the overall project.

The research study identified 42 possible construction delays through the literature study and grouped them into six categories according to their source and relevance. These groups include: general delays related to project, owner, contractor, consultant, resource, and miscellaneous delays. A questionnaire was developed to investigate severities of the identified six delay categories; in addition, some questions about project details, critical effects of delays, and most responsible people for the delays were added to ascertain more information from the survey. The questionnaire was sent to pre-identified construction professionals of the high rise construction industry all over the United States and India. The individual analysis of each country shows that change orders, given by the owner during construction, is the most severe cause of delay

for the USA, followed by severe weather conditions, as well as mistakes or errors in design and drawing documents. For India, the most severe cause of delay is the lack of communication and coordination among all parties involved in the construction, followed by improper construction methods and payment delays by the owner. The comparative analysis of two countries shows that there is a difference between the results and demonstrates that the presence of construction delays and their effects are more often and severe for India than the USA. It also shows that consultant related delays and miscellaneous delays are more severe for the USA than India and vice versa for the rest of the delay categories (general, owner, contractor, and resource related). All the participants of the two nations agreed that time overrun and cost overruns are the critical effects of construction delays, followed by disputes and arbitration. The present research study also includes the recommendations made by the survey participants.

ACKNOWLEDGEMENTS

It is my pleasure to thank my adviser, Dr. Eric Asa, who made this research paper possible with his commitment, encouragement, supervision, and support from the commencement of the research to its conclusion. His patience and kindness will never be forgotten. I have greatly enjoyed working with him and appreciate the help and opportunities he provided.

I also thank my supervisory committee members, Dr. Charles McIntyre, Dr. Darshi DeSaram, and Dr. Majura Selekwa. I would like to extend my sincere gratitude to all the participants of the research survey for their valuable input and suggestions.

I also wish to thank the faculty and staff of the Construction Management and Engineering Department for preparing me to deserve my Master's degree and succeed in future endeavors.

Special thanks to my parents and sister for their continuous support and love. Last but not the least, heartfelt thanks to all my friends and God.

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LIST OF ABBREVIATIONS

CPM	:	Critical Path Method
IPD	:	Integrated Project Delivery
IRB	:	Institutional Review Board
LEED	:	Leadership in Energy and Environment Design
NDSU	:	North Dakota State University
RII	:	Relative Importance Index
UAE	:	United Arab Emirates
USA	:	United States of America

CHAPTER 1. INTRODUCTION

1.1. Background

High rise buildings comprise a major role in the allocation of increasing population needs due to urbanization in large and developing cities. In all metropolitan cities, because of space scarcity and high population density, horizontal growth is not able to accommodate people, utilities and other amenities. Thus, the best way to develop is via vertical growth. High rise buildings are fulfilling this need and have been constructed in great numbers. But the construction of a high rise building is a complex, high risk, and multi-contractor project, which make them prone to construction delays and could lead to significant losses of both time and money. Since most of the projects are financed by banks and finance companies, if delays occur during the construction phase, high inflation rates, and increases in labor and material costs affect the overall budget (Marzouk *et al.*, 2008). An extended delay may cause work disruption and loss of productivity (Abdul-Rahman *et al.*, 2006).

Time and money are the most important aspects during the entire life of the construction of a project. Delays in the construction are very common but are very expensive in some situations (Aibinu and Odeyinka, 2006). By definition, a delay is the time overrun beyond the planned schedule (Assaf and Al-Hejji, 2006). Most construction projects face problems with construction delays, and the main cause is failure to finish the work within the scheduled time frame. Unfortunately, so many factors affect the time overrun; the major players in a construction project are the owner, the contractor, and the consultant. Sometimes disputes between them also push the project into trouble. The

delays can be classified into critical or non-critical, excusable or non-excusable, concurrent or non-concurrent, compensable or non-compensable (Yates and Epstein, 2006). An indicator of project efficiency is the successful completion of a project within the time frame and cost (Chan and Kumaraswamy, 1997).

In order to successfully complete the project and reduce the loss of productivity, the high rise construction manager should have good and thorough knowledge of delays that may occur and should plan an effective management system to address those delays. The present research investigates the plausible construction delay causes, their severity, and makes suggestions to amplify the productivity by minimizing the effect of delays.

1.2. Problem Statement

Delays during the construction of large building projects like high rise buildings are common. Time and money, two important issues for every construction project, are interconnected in this industry. Construction delays are often responsible for overall time overrun, which ultimately lead to budget overrun in many situations and drive the projects into losses. So, the potential causes of delays must be analyzed before the construction phase is started and minimized to handle the time and money as planned in the project schedule for the successful completion of the project.

1.3. Aims and Objectives

a) To identify the possible causes of delays during the construction of high rise buildings in the United States and India.

b) To find out the relative importance of the principal causes of construction delays.

c) To study the critical delay issues pertaining to the owners, contractors, clients and consultants.

d) To compare the results of the United States and India.

e) To make recommendations to minimize the delays and their effects.

1.4. Research Contributions

The research study investigates the important causes of delays for the construction of high rise buildings. Understanding these causes would be helpful for the construction professionals who work on the initial phases of construction planning in order to efficiently deliver the project plan. The main goal of the research study is to provide essential information on severe delay causes to project management teams who enable the project's success. Generally, the issues which make the project prone to delays are disputes between the major parties, legal issues, changes during the construction, accidents, environmental factors, and others. For the construction of high rise buildings, extra care must be taken when developing the project time schedule, which is possible only with prior knowledge of delay causes. The research study aims to provide knowledge of all construction delays that affect the project's success.

CHAPTER 2. LITERATURE REVIEW

2.1. Review of Previous Studies

The construction process of any building type is a cluster of interdependent activities. The time extension or late start of any activity affects the succeeding activities and leads to changes in the duration of the total project (Sweis *et al.*, 2008). Time and cost overruns have been identified as the important effects of delays in the construction industry. Most of the delays pertain to the three major construction bodies: owner, contractor, and consultant.

Ireland (1985) discusses the role of managerial actions in the cost, time and quality performance of high rise commercial building projects. The study was conducted on 25 high rise commercial building projects. The factors which can reduce the construction time and cost are increase in construction planning during design and coordination across the design-construction interface. The factors which increase construction time and cost are increases in variations to the contract, complexity of the building, number of stories, extent of industrial disputes, architectural quality, and change orders.

Sanvido *et al.* (1992) determined critical success factors for construction projects. The research was conducted on 16 selected construction projects. The design documents and coordination of the discipline during the design phase are the problems with both poor and good teams. Quality control by the general contractor is observed as the most common deficiency in achieving success. The study identifies four critical factors that affect project success: (1) a well organized team to manage, plan, design,

construct and operate the facility, (2) a series of contracts that allow teams to work together without conflicts, (3) good experience in the project management and construction facilities as well as statistical information by all parties during the construction.

Nkado (1995) conducted a survey study to determine time-related factors in the building construction from the perspective of the contractor. A total of 33 predefined factors were divided into six categories. The research identified the most important factors, which include: the contractor's programming of the construction work, the client's specified sequence of completion, form of construction, the client's and designer's priority on construction time, complexity of the project, project location, constructability of the design, availability of the construction management team, as well as the completeness and timeliness of project information.

Ogunlana *et al.* (1996) studied construction delays in the fast growing economy of Thailand compared with other economies. The study surveyed 12 high rise building construction projects in Bangkok, Thailand. The main problems for the delays include resource supply problems. The study groups the problems in developing economies in three categories: problems of shortages or inadequacies in industry infrastructure, problems caused by clients and consultants, problems caused by contractor incompetence/inadequacies. A total of 26 delay causes were identified which pertain to owners, designers, construction managers/inspectors, contractors, resource suppliers, and others. Change orders are the most frequent reason for creating delays traceable to construction owners. Delays from owners include two types: unavoidable delays and deliberate policy. The delays from designers are due to drawings that are incomplete or

improperly detailed. For most of the delays, the contractors were blamed due to reasons such as finance, planning and scheduling, site organization, materials and equipment management, coordination and resource supply. The recommendations made by the study include improvement in infrastructure, providing proper training for efficient project management, and supplying adequate supports that enable contractors to execute the project efficiently.

Kaming *et al.* (1997) investigated the factors influencing construction time and cost overruns of high rise building projects in Indonesia. The study states that each variable of delay and cost overrun was evaluated by its importance, frequency, and severity. Design changes were ranked as the most important delays, followed by inadequate planning, inaccuracy of materials estimating. The causes of most frequent delays were design changes, poor labor productivity, and equipment shortages. Design changes, poor labor productivity and inadequate planning were identified as the most severe problems. The most important, frequently occurring, and severe causes of cost overruns are inaccuracy of quantity take-off, material cost increases due to inflation and cost increase due to environmental restrictions.

Chan and Kumaraswamy (1997) developed a comparative study of causes of time overruns in the Hong Kong construction industry. This study uses the findings of Ireland (1985) to make it comprehensive. The study identifies 83 probable causes of delays, which were grouped into eight major categories. The study observed the most significant sources of delays: poor site management and supervision, unforeseen ground conditions, low speed of decision making involving all project teams, client initiated variations, and necessary variations of work. The clients and consultants claimed that

most of the delays are due to the lack of the contractor's experience in planning and monitoring on site, whereas, contractors stated that lack of design experience of consultants is the major cause of delay. The comparative study of Hong Kong, Saudi Arabia, and Nigeria observed many variations in the results because of the difference in countries and economies. The recommendations made by the research study to minimize the delays in construction include: effective site management, supervision by contractor and consultant, effective data communication between various groups and levels involved in a project, comprehensive strategies for reducing variations, and avoiding or resolving some of the avoidable problems.

Al-Momani (2000) surveyed 130 projects in Jordan to investigate the delay causes and outlines the causes of construction delays. The results conclude that the major causes of delays are poor design, change orders, weather, site conditions, late delivery, and economic conditions.

Odeh and Battaineh (2002), identify major causes of delays in the construction industry due to the traditional type of contracts and their relative importance. The study used the results of Ogunlana, *et al.* (1996), and Al-Momani (2000). The study uses a survey of 28 well recognized causes of delay, which were formed in eight major groups. The study concludes that the most important factors of delays are owner interface, inadequate contractor experience, financing and payments of completed work, labor productivity, site management, slow decision making, construction methods, improper planning, and sub-contractors. The research study recommends that joint efforts of all parties reduce the delays. Some of the findings to reduce the causes and effects of construction delays include improving the contractual relationships among all the

parties, limiting owner interference, implementing new approaches to contract award, and developing human resources.

Aibinu and Jagboro (2002) focus on the effects of construction delays on project delivery as well as its minimizing techniques in the Nigerian construction industry. The study was built upon the results of Chan and Kumaraswamy (1997). The findings show that the client related delays are frequent, and the significant effects are time and cost overruns, followed by disputes, total abandonment, arbitration and litigation. Two methods were identified to minimize the cost and time effects: the acceleration of subsequent site activities to reduce or, if possible, eliminate time overrun as well as the inclusion of allowance in pre-contract estimate to buffer cost overrun.

Chan *et al.* (2004) studied the factors that affect the success of a construction project. The study uses the research results of Sanvido *et al.* (1992), Chan and Kumaraswamy (1997), and Kaming *et al.* (1997) and concludes that five major variables affect project success: project related factors, project procedures, project management actions, human related factors, and external environment factors.

Long *et al.* (2004) discusses problems encountered in the management of large construction projects in developing countries through a case study from Vietnam. The study was built upon the findings of Ogunlana, *et al.* (1996), Chan and Kumaraswamy (1997), and Al-Momani (2000) and reveals that project delays and cost overruns are the most severe problems in the construction industry. A total of 62 problems were identified and divided into five major groups: incompetent designers and contractors; poor estimation and change management; social and technological issues; site related issues; improper techniques and tools. Most of the problems in the construction are

related to human and management problems. The important problems are inaccurate time estimation, slow site clearance, slow government permits, lack of capable owner's representatives, obsolete technology and unsatisfactory site compensation, high ratings in terms of degree of occurrence and level of influence. The people most responsible for these problems are the consultants and the contractors. The recommendations include the introduction and improvement in effective construction management at corporate, process, project and activity levels to produce good performances and results.

Iyer and Jha (2005) identify the factors that affect cost performance of Indian construction projects. The study used the findings of Chan and Kumaraswamy (1997) and explores the project success, failure attributes, and critical success, which are failure factors that affect the cost of project. The study reveals 30 success attributes and 23 failure attributes. The important success attributes are effective monitoring and feedback by the project manager, coordinating ability and rapport of project management with top management. The important failure attributes are poor human resource management and labor strike, negative attitude of project management and project participants. The critical success factors are project manager's competence, top management support, project manager's coordination and leadership skill, top management and owner involvement in the project, interaction between project participants, owner's competence, and favorable climatic conditions. The critical failure factors are conflict among project participants, ignorance and lack of knowledge, indecisiveness, hostile socio-economic and climatic condition, reluctance in making timely decision, aggressive competition in tender stage, and short bid preparation time.

Abdul-Rahman *et al.* (2006) investigated the causes of delays and delay mitigation in the Malaysian construction industry. The study identifies the causes of construction delays and suggests recommendations to overcome the effects of delays. The major causes of delays are financial problems, client's interference, manpower problems and poor site management, sub-contractors, authority approvals, design problems, construction methods, labor shortage and lack of skills, poor planning and scheduling. The recommended possible actions to minimize the effects of delays are: the increase of productivity by working overtime, request for extension of time, and conducting more site meetings with all functional groups.

Yates and Epstein (2006) show how claims are generated during a construction project, their causes, and the methods used to minimize the claims in relational contracting. The research investigated technical and legal approaches used to analyze the practices in the construction industry. The categories of damages that can be recovered by delays are: labor escalation, material escalation, increased engineering and supervision, loss of productivity or loss of efficiency, interest, equipment costs, impact costs, field office overhead, main office overhead, insurance, and bonding/loss of bonding. The actual damages suffered by an owner include: loss of use, additional damages related to loss of use, increased interest, and additional professional fees for architects and engineers. To minimize the claims, the recommended solutions are: focusing on potential delay claims from the inception of the project, giving a reasonable contract completion date, excusing the delays due to uncertainties like bad weather conditions, and setting a reasonable and specific amount for liquidated damages. The study suggests that the proper implementation of CPM scheduling reduces the incidence

of delay claims. Other important ways to reduce the possibility of delay claims are addressing problems and documenting job progress in a proper way. With respect to weather delays, force majeure clauses, which help owners pay for delay claims, should contain as much specific and objective criteria as possible. In order to reduce errors, it would be advisable to have a contractual process for additional reviews and sign offs of the drawings by the construction manager and contractor.

Assaf and Al-Hejji (2006) studied the causes of delays in large construction projects. The study used the research results of Chan and Kumaraswamy (1997), Kaming *et al.* (1997), and Al-Momani (2000) and determined 73 causes of construction delays, summarized in nine groups. This research concludes that the average time overrun is in-between 10% and 30% of the actual duration and the most severe causes are related to contractors and labor. The most common delay between all the parties involved in the construction is change orders. According to the owners and consultant's point of view, the main reason for delays is awarding the contract to the lowest bidder without considering much about his/her ability and experience.

Aibinu and Odeyinka (2006) studied the causative factors of construction delays in the Nigerian construction industry. The study used the findings of Nkado (1995), Ogunlana *et al.* (1996), Chan and Kumaraswamy (1997), and Kaming *et al.* (1997) and identifies 44 factors that contribute to delays. It was revealed that 88% (or 39) of the factors are placed in highest priority and are responsible for 90% of the overall delays. The mean percentage of time delays range from 19 to 181% for the construction projects. The mean percentage of cost overrun arising from delay expenses ranges from 19 to 45%. All the identified factors of delay are categorized into nine different groups.

The results reveal that the top ten causes of delays include: contractor's financial difficulties, client's cash flow problem, architect's incomplete drawings, sub-contractor's slow mobilization, equipment breakdown and maintenance problems, supplier's late delivery of ordered materials, incomplete structural drawings, contractor's planning and scheduling problems, price escalation and sub-contractor's financial difficulties. The results conclude that the activities and roles in the construction of any project are interdependent, and the delay of any activity may create imbalance and affect the overall project.

Faridi and El-Sayegh (2006) studied the significant factors causing delay in the UAE construction industry. The study was built upon the findings of Ogunlana *et al.* (1996), Kaming *et al.* (1997), and Odeh and Battaineh (2002). They found forty-four major causes of construction delays that affect the UAE construction industry. All the causes are grouped into eight categories: contractor, consultant/designer, owner, financial, planning and scheduling, contractual relationship, government regulations and unforeseen conditions. The Relative Important Index (RII) was used to analyze the causes of delays. The questionnaire survey revealed that 50% of the construction projects experienced time overrun. The preparation and approval of drawings, inadequate early project planning, and a slow decision making process by the owner were ranked high by both contractors and consultants. The inputs of construction professionals who have more experience contradict with the people who have less. The more experienced people considered the major causes of delays the inadequate early planning of the project and unsuitable leadership of the construction manager. Contrastingly, the less experienced people considered manpower, poor supervision and

poor site management the major causes of delays. The other causes listed among the top ten delays include: non-availability of materials on time, government regulations, and financing by contractors.

Murali and Wen (2007) conducted a study on the causes and effects of construction delays in the Malaysian construction industry. The study used the research findings of Ogunlana *et al.* (1996), Chan and Kumaraswamy (1997), Al-Momani (2000), Aibinu and Jagboro (2002), Odeh and Battaineh (2002), and Assaf and Al-Hejji (2006). The survey collected the feedback of 150 respondents and identifies 28 different causes and six different effects of delay, which are categorized mainly into eight major groups. The top ten most important causes of delays include: contractor's improper planning, contractor's poor site management, inadequate contractor experience, inadequate client's finance and payments for completed work, problems with sub-contractors, shortage in material, labor supply, equipment availability and failure, lack of communication between parties and mistakes during the construction stage. The six main effects of delay are time overrun, cost overrun, disputes, arbitration, litigation and total abandonment.

Marzouk *et al.* (2008) shows an assessment of construction engineering related delays for Egyptian projects. This research presents knowledge based expert system related to engineering delays, which include: 22 causes of claims, their respective code, delivery system and the responsible party. These delays are grouped into three categories: design development delays, workshop drawing delays and changes by project party's delays. The study conducted questionnaire surveys of consultants, contractors and employers and concludes that for all the respondents, the most important cause is the mistake/changes in the design documents. The least important cause is the delay in the

approval stage due to unforeseen conditions. For consultants, the most important causes are the delays in responding to contractor's queries, occurrence of unforeseen conditions attributable to workshop drawing submission delays. For contractors, the most important causes include the delay in receiving design documents that are needed to start the preparation of the workshop drawing process and the delay in the preparation process due to lack of resources, inexperience, and management errors. The greatest difference occurs between the views of respondents in case there is a delay in responding to contractor's queries.

Sweis *et al.* (2008) discusses the delays in construction projects in Jordan. The delays are summarized into three groups: input factors, internal environment and exogenous factors. There were 40 potential causes of delays, and the main causes are too many change orders from owner, financial difficulties faced by contractor and poor planning, or scheduling of the project by the contractor. The study shows that the 5% - 10% increments in the original budget are a result of change orders itself.

Abd-El-Razek *et al.* (2008) discusses the causes of delay in building construction projects in Egypt. The study used the research results of Assaf and Al-Hejji (2006). A list of 32 causes of delays was given by the interviewers, all of which are categorized into nine major groups. The study concludes that the most important causes of delays are: financing by contractor during construction, delays in contractor's payment by owner, design changes by owner or his agent during construction, partial payments during construction and no utilization of professional construction/ construction management. The study found that the owner and the contractors often blame each other and have opposite views. Within the top ten important causes of delays, three of the

causes are under the contractor's responsibility, three under the owner's responsibility, three under common responsibility, and one under the consultant's responsibility. The study concludes that all the parties in a construction project contribute to the delays and suggests that the prevention or mitigation of delay has to be a joint attempt and based upon teamwork.

2.2. Summary of Literature Study

This literature study observes that delays in construction are common and many of projects in the construction industry sustain time and cost overruns. This literature review identifies that the studies of Chan and Kumaraswamy (1997), Aibinu and Jagboro (2002), and Assaf and Al-Hejji (2006) are more comprehensive. This study also identifies that the research in this particular area has been expanding since 2002, and most of the recent studies use the research findings of previous studies. The literature study reveals that change orders by owners, financial problems of contractors, and project management issues are the most severe problems, which have been experienced by most of the delayed projects. Additionally, the three parties blame each other as the source of construction delays. However, many research studies reveal that the contractor is the main body who leads the projects into delays mainly because of poor performance, inability to work, lack of experience, and financial problems. The literature study also observes that the major problems relate to the contractor, the owner, the consultant, government regulations, and weather conditions. Table 1 lists all the causes of delays extracted from the literature analysis. The count in this table for a particular delay cause depends on how many times it was used independently by different research studies. If a

particular cause of delay is used by five different studies, then the count is five. The ranks are given based upon the count value.

2.3. Identification of Possible Delays

Based upon the literature review, this study extracts several causes of delays from all the previous research studies. These delay causes were refined based upon importance, severity, and relevance. Some of the similar delay causes were merged together, and also some new delay causes were added. Thus, the possible total number of delay causes ended up at 42 for the construction of high rise buildings. Table 2 lists all the possible causes of delays identified by the present study, and all the causes of delays extracted from the previous studies are listed in Table 1.

Table 1: Causes of delays extracted from previous research studies

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Owner	Confusing requirements					x			x								2	14
	Conflicts between owner and other parties						x			x							2	14
	Change orders	x	x	x	x	x		x	x	x	x	x	x	x	x	x	14	2
	Delay in approvals			x				x		x					x		4	12
	Failure of the owner to have the work site available to the contractor in a timely manner								x	x							2	14
	Funding shortage					x											1	15
	High interest rate					x											1	15
	Improper project feasibility study					x	x										2	14
	Interference in contractor's decisions					x			x					x			3	13
	Lack of capable representatives					x	x										2	14
	Lack of clear bidding process					x											1	15
	Lack of strategic management					x	x										2	14
	Owner's financial difficulties	x		x	x	x		x		x	x		x	x	x	x	11	5

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 1. (Continued)

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Owner	Owner's poor contract management					x						x	x				3	13
	Payment delays to contractor							x		x		x			x	x	5	11
	Poor coordination								x								1	15
	Slow decision making	x	x	x	x	x			x	x	x	x	x	x	x	x	13	3
	Unclear responsibility					x	x	x									3	13
	Unreasonable constraints to owner					x				x							2	14
Contractor	Contractor's financial difficulties	x	x			x		x	x	x	x	x		x	x	x	11	5
	Conflicts between contractor and other parties		x				x			x	x						4	12
	Delay in mobilization	x								x	x						3	13
	Delays of sub contractors	x			x			x	x	x		x	x		x	x	9	7
	Improperly allocating labor, material, and other resources on the project		x				x		x			x					4	12
	Improper monitoring and control					x		x		x		x					4	12
	Improper planning and scheduling	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15	1

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 1. (Continued)

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Contractor	Inaccurate cost estimating			x		x						x		x			4	12
	Inaccurate time estimating					x						x		x			3	13
	Inadequacy of site inspection	x	x			x			x		x						5	11
	Inadequate experience			x	x	x						x	x		x	x	7	9
	Inadequate modern equipment					x			x								2	14
	Inappropriate construction methods	x			x	x		x		x		x	x	x			8	8
	Incompetent project team		x			x	x			x							4	12
	Lack of competent subcontractors/suppliers				x	x		x	x	x			x			x	7	9
	Lack of necessary skills	x				x			x					x		x	5	11
	Material waste					x											1	15
	Mistakes during construction stage				x					x		x	x				4	12
	poor communication		x							x							2	14
	Poor contract management					x							x	x		x	4	12
	Poor labor and management relations					x						x					2	14

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 1. (Continued)

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Contractor	Poor site management	x			x	x		x	x	x		x	x	x	x		10	6
	Severe overtime					x											1	15
Consultant	Design changes	x		x			x			x	x	x			x	x	8	8
	Impractical design					x		x	x						x		4	12
	Inadequate experience	x		x		x	x			x		x					6	10
	Inadequate project management assistance					x			x							x	3	13
	Lack of involvement through project life					x					x					x	3	13
	Lack of responsibility					x								x			2	14
	Lack of standardization in design					x					x						2	14
	Mistakes/ errors in design and drawing documents	x	x		x		x	x	x	x	x	x		x	x	x	12	4
	Poor communication between consultant and other parties						x			x							2	14
	Preparation and approval of drawings				x					x	x	x	x		x		6	10

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 1. (Continued)

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Consultant	Unforeseen conditions in design development													x			1	15
	Slowness in approvals	x	x		x	x			x			x	x	x			8	8
Others	Accidents during construction							x		x						x	3	13
	Ambiguous project scope					x											1	15
	Bureaucracy			x		x	x			x	x				x	x	7	9
	Excessive contractors/subcontractors	x				x											2	14
	Equipment failures	x	x					x		x	x	x	x				7	9
	Equipment shortage		x	x				x		x	x					x	6	10
	Fraudulent practices and kickbacks					x											1	15
	Improper quality assurance/control				x	x							x				3	13
	Inaccurate material estimation			x													1	15
	Inaccurate site investigation					x		x						x		x	4	12
	Inappropriate type of contracts used					x		x		x						x	4	12
	Inclement weather	x		x	x	x	x			x	x	x	x	x	x	x	12	4

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 1. (Continued)

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Others	Inefficient equipment		x						x				x			x	4	12
	Labor shortage	x	x	x	x			x		x	x	x	x		x	x	11	5
	Labor productivity			x	x		x	x		x	x	x	x		x	x	10	6
	Lack of communication among parties		x		x	x	x	x	x	x		x	x			x	10	6
	Lack of comprehensive dispute resolution				x	x				x							3	13
	Lack of constructability					x											1	15
	Material shortage	x	x	x	x	x		x		x	x	x	x	x		x	12	4
	Non-value-added works					x											1	15
	Obsolete technology					x											1	15
	Pollution during construction					x											1	15
	Price fluctuations		x	x		x											3	13
	Skilled labor											x					1	15
	Slow delivery of materials	x	x							x	x	x			x	x	7	9
	Slow government permits	x	x			x				x	x	x	x		x	x	9	7

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 1. (Continued)

Group	Delay Causes	References															Count	Rank
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
Others	Slow site clearance					x		x						x			3	13
	Unforeseen ground conditions	x	x		x	x		x		x	x	x	x	x	x	x	12	4
	Unrealistic imposed contract duration				x	x				x							3	13
	Unreasonable regulatory framework					x											1	15
	Unreasonable risk allocation					x											1	15
	Unsatisfactory site compensation					x								x			2	14
	Unstable regulatory framework		x			x	x				x						4	12

References: A.Nakado (1995) , B.Ogunlana *et al.* (1996), C.Kaming *et al.* (1997), D. Odeh and Battaineh (2002), E.Long *et al.* (2004), F. Iyer and Jha (2005), G. Abdul-Rahman *et al.* (2006), H.Yates and Epstein (2006), I. Assaf and Al-Hejji (2006), J. Aibinu and Odeyinka (2006), K. Faridi and El-Sayegh (2006), L. Murali and Wen (2007), M. Marzouk *et al.* (2008), N. Sweis, *et al.* (2008), O. Abd-El-Razek *et al.* (2008)

Table 2: Possible causes of delays sorted in alphabetical order

S. No	Causes of Delays
1	Accidents during construction
2	Change orders during construction by owner
3	Changes in contract
4	Changes in government regulations and laws
5	Changes in material prices
6	Conflicts between consultants and other parties involved in the project
7	Conflicts between contractor and other parties involved in construction
8	Conflicts between owner and other parties involved in construction
9	Contractor's inexperience
10	Delay in approval of design, and drawings
11	Delay in mobilization
12	Delay in obtaining approvals from government authorities
13	Delay in progress payments by owner to contractor
14	Delay in settlement of contractor's claims
15	Delay in site preparation and delivery to contractor
16	Delays by sub-contractor
17	Delays in material delivery
18	Equipment failures
19	Financial difficulties experienced by contractor
20	Frequent changes of sub-contractors
21	Improper construction methods and rework due to errors during construction

Table 2. (Continued)

S. No	Causes of Delays
22	Inadequate technical study by the contractor during the bidding stage
23	Ineffective equipment
24	Ineffective planning and scheduling by contractor
25	Inexperienced consultant and design team
26	Inexperienced technical staff
27	Lack of communication and coordination among all the parties
28	Lack of skilled manpower
29	LEED certification process and requirements
30	Mistakes, and errors in design and drawing documents
31	Owner's financial difficulties
32	Payment delays to subcontractors by main contractor
33	Poor estimation of project duration, productivity and resources
34	Poor performance in monitoring and tracking of work performed
35	Poor performance of consultant
36	Severe weather conditions (snow, temperature, storms, wind)
37	Shortage of equipment
38	Shortage of materials
39	Slowness in owner's decision to approve design
40	Too many change orders by consultant
41	Type of construction contract, project bidding and award
42	Unavailability of project management crew

CHAPTER 3. RESEARCH METHODOLOGY

3.1. Survey Planning

This research study carried out structured questionnaire surveys all over the United States and India to figure out the causes of delays. The scope of the study is limited to the construction of high rise buildings, including residential and commercial type of buildings. This study also aimed to invite the experienced construction professionals of the high rise construction industry to participate in the research survey. These people included owners, contractors, architects, construction managers, and civil engineers. The contacts and business addresses of survey participants were obtained based on various sources available (Engineering News Record, Handbook of Association of General Contractors, personal contacts, internet, and etc.). The questionnaire was sent for survey in late January 2009 and distributed to a total of 295 construction professionals in the two countries. Table 3 shows the detailed numbers of the survey questionnaire recipients and respondents.

The collected quantitative and qualitative data from the survey was subjected to analysis using statistical methods for the two countries individually; thus, the critical causes of delays were determined for each country. A comparative analysis is shown at the end of this study in order to provide an overall picture of differences between the two countries. The statistical analysis of the data reveals the actual causes of delays and their severity; also, the delays are ranked based on their severity. The final results include the survey participants' recommendations to minimize the determined delay causes for the

construction of high rise buildings. The flow chart showing research methodology is demonstrated in Figure 1.

Table 3: Number of recipients and respondents of research survey

Description	USA	India	Total
Questionnaire sent	171	124	295
Responses received	16 (9.4%)	11 (8.9%)	27 (9.1%)

3.2. Questionnaire Design

Through the literature review and analysis, this study determined a total of 42 important delay causes for the construction of high rise buildings. Table 1 shows the identified causes of delays. All the delay causes are compiled into 6 groups: general delays related to the project, owner, contractor, consultant, resources, and miscellaneous delays. Table 4 lists all the causes of delays according to their groups. In addition, some general questions regarding project typology, critical effects of delays, people responsible for the delays, among others, were added to the questionnaire to obtain more important information from the respondents. These questions are helpful in analyzing the survey results. For all the delay causes, respondents were asked to indicate their preference level on a scale (Likert scale) range from 1 to 5 (Strongly disagree, Disagree, Neutral, Agree, Strongly agree). The five point Likert scale gives the participant optimum chances to indicate the preference from strongly disagree to strongly agree. A sample of the questionnaire is attached in Appendix A.

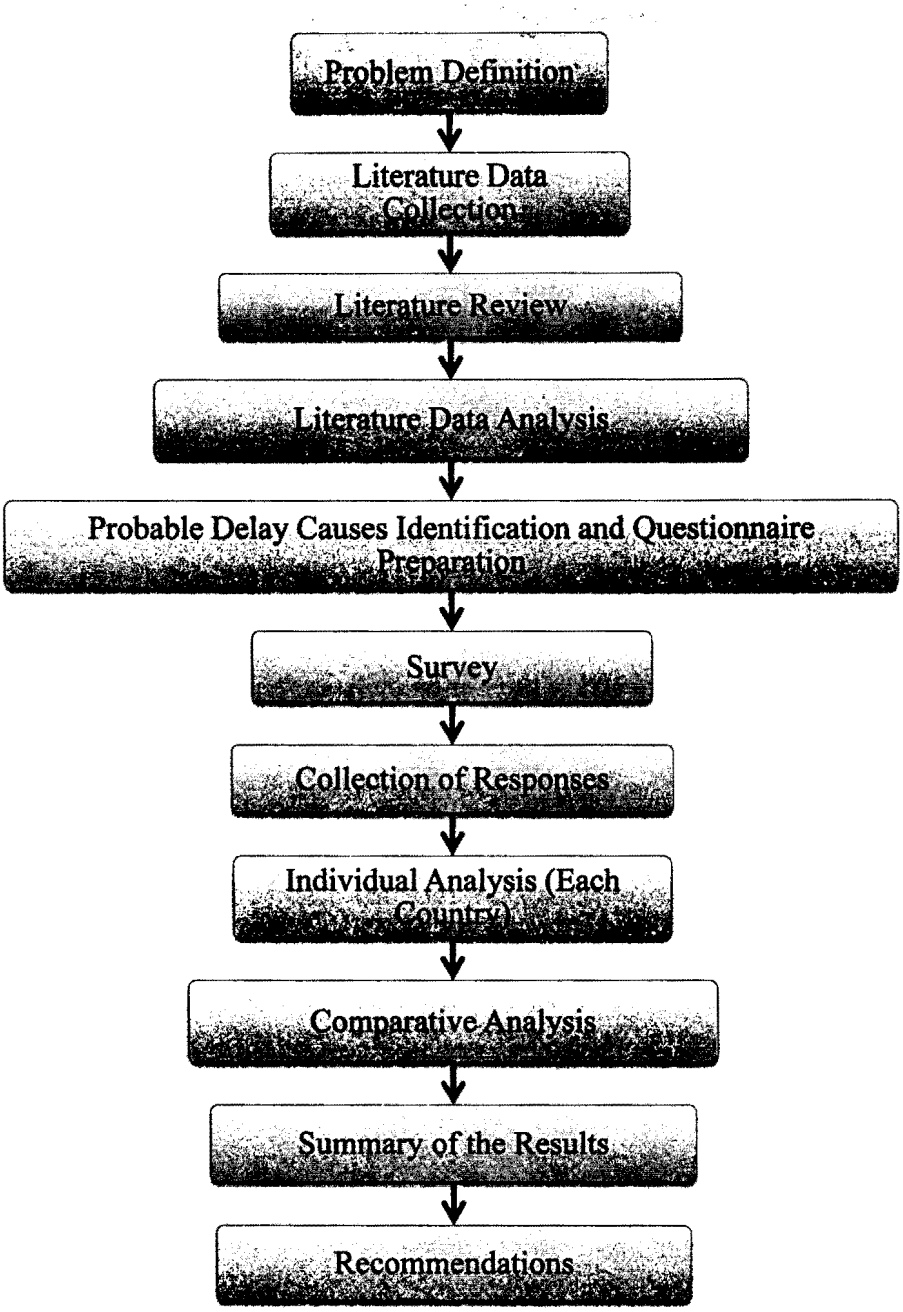

Figure 1: Flow chart showing research methodology

Table 4: Possible causes of delays according to delay categories sorted in alphabetical order

Category	Causes of Delays
General delays	Changes in contract
	Lack of communication and coordination among all the parties
	LEED certification process and requirements
	Poor estimation of project duration, productivity and resources
	Type of construction contract, project bidding and award
	Unavailability of project management crew
Contractor related delays	Conflicts between contractor and other parties involved in construction
	Contractor's inexperience
	Delay in mobilization
	Delays by sub-contractor
	Financial difficulties experienced by contractor
	Frequent changes of sub-contractors
	Improper construction methods and rework due to errors during construction
	Inadequate technical study by the contractor during the bidding stage
	Ineffective planning and scheduling by contractor
	Inexperienced technical and administrative staff
	Payment delays to subcontractors by main contractor
	Poor performance in monitoring and tracking of work performed
Consultant related delays	Conflicts between consultants and other parties involved in the project
	Delay in approval of design, and drawings
	Inadequate experience of consultant and design team
	Mistakes, and errors in design and drawing documents
	Poor performance of consultant
	Too many change orders by consultant

Table 4. (Continued)

Category	Causes of Delays
Owner related delays	Change orders during construction by owner
	Conflicts between owner and other parties involved in construction
	Delay in progress payments by owner to contractor
	Delay in settlement of contractor's claims
	Delay in site preparation and delivery to contractor
	Owner's financial difficulties
	Slowness in owner's decision to approve design
Resource related delays	Changes in material prices
	Delays in material delivery
	Equipment failures
	Ineffective equipment
	Lack of skilled manpower
	Shortage of equipment
	Shortage of materials
Miscellaneous delays	Accidents during construction
	Changes in government regulations and laws
	Delay in obtaining approvals from government authorities
	Severe weather conditions (snow, temperature, storms, wind)

3.3. Selection of Analysis Method

The study analyzed several possible methods in order to select an appropriate method for the analysis of the survey results. The study adopted the relative importance index (RII) method used by Abd El-Razek *et al.* (2008), Aibinu and Jagboro (2002), Chan and Kumaraswamy (1997), Faridi and El-Sayegh (2006), Iyer and Jha (2005), Murali and Wen (2006), Odeh and Battaineh (2002) to perform statistical analysis that

determines the important causes and effects of construction delays, which was the only method used by most of the previous research studies in this area. This method is appropriate because it calculates the weighted average of the participants' opinions altogether depends on different ranks given to a particular cause of delay. Table 5 lists all the analysis methods used by previous research studies in this area. The relative important indexes are calculated using the formula

$$\text{RII}\ (\%) = \frac{\sum_{i=1}^{5} W_i X_i}{5N}\ X\ 100 \qquad (1)$$

Where, W_i = Weight assigned to i^{th} response

W_i = 1,2,3,4 and 5 for i = 1,2,3,4 and 5, respectively

X_i = Number of respondents for i^{th} response

i = Response category index = 1,2,3,4, and 5 for Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree respectively

N = total number of respondents. Finally, the index is multiplied by 100 to be calculated as a percentage.

The RII value ranges from 0 to 100%. The severity of the delay cause increases as the RII value increases. A higher RII value indicates that the cause is more severe, and a lower RII value indicates that the cause is less severe. The RII values are then used to determine the severity ranks for each delay cause. These rankings made it possible to cross compare the relative importance of the delay causes for the two nations, India and the United States.

Table 5: Survey analysis methods adopted by previous studies

Author	Method Used	Formulae
Abd El-Razek, *et al.*, (2008)	RII, Spearman's Correlation	$RII = \sum_{i=1}^{4} \frac{a_i \times x_i}{3}$ $r_s = 1 - \frac{6\sum d^2}{(n^3 - n)}$
Aibinu, and Jagboro (2002)	RII Regression Analysis	$RII = \frac{4n_1 + 3n_2 + 2n_3 + 1n_4 + 0n_5}{4N}$ Regression Analysis $y = a + bx$
Al-Khalil, and Al-Ghafly (1999)	Null hypothesis testing	Null hypothesis testing $= \frac{(f-e)^2}{e}$
Al-Momani (2000)	Regression Analysis	Regression Analysis - $y = a + bx$
Assaf, Al-Hejji (2006)	FI, Spearman's Correlation	Spearman's correlation $r_s = 1 - [(6\sum d^2)/(n^3 - n)]$
Chan, Kumaraswamy (1996)	Mean Score, Spearman's Correlation	$MS = \frac{\sum(f \times s)}{N}, (1 \le MS \le 5)$ $r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$
Chan, Kumaraswamy (1997)	RII, Rank Agreement Factor	$RII = \frac{\sum W}{AxN}, (0 \le index \le 1)$ $RAF = \frac{\left(\sum_{i=1}^{N} \lvert R_{i1} - R_{i2} \rvert\right)}{N}$
Chan, Kumaraswamy (2002)	RII	$RII = \frac{\sum r}{A\,X\,N}$

Table 5. (Continued)

Author	Method Used	Formulae
Faridi, El-Sayegh (2006)	RII, Spearman's Correlation	$RII = \frac{\sum_{i=1}^{4} W_i X_i}{\sum_{i=1}^{4} X_i}$ $r_s = 1 - \frac{6 \sum d^2}{(N^3 - N)}$
Iyer, and Jha (2005)	RII	$RII = \frac{\sum W}{A X N}$
Murali, Wen (2007)	RII, Spearman's Correlation	$RII = \frac{\sum W}{A X N}$
Odeh, Battaineh (2002)	RII, Spearman's Analysis	$RII = \frac{\sum_{i=1}^{5} W_i X_i}{\sum_{i=1}^{5} X_i}$ $r_s = 1 - \frac{6 \sum d^2}{N(N^2 - 1)}$
Sweis, *et al.* (2008)	One way ANOVA analysis	

CHAPTER 4. ANALYSIS AND DISCUSSION OF RESULTS

4.1. Analysis and Discussion of USA Results

The research study collected sixteen (16) responses through the structured questionnaire survey from construction professionals in the United States high rise building construction industry. These responses represent the construction information of sixteen (16) different high rise building projects. According to the role of respondents, a total of six (6) responses were from architects and ten (10) responses were from construction managers. Of the sixteen (16) high rise building projects, four (4) projects were residential high rise projects and the remaining twelve (12) projects were commercial high rise projects. The respondents indicated that 62.5% of the projects experienced time delays and 69.2% of the delayed projects experienced cost escalations beyond the planned budget as the direct effect of construction delays. The respondents also indicated that the United States high rise construction companies are experiencing time delays at an average of 23.2% of their total projects. The average time delay percentage figure was obtained from the information collected from the total percent of delayed projects of respondents companies.

The study shows that the critical factors affecting/contributing to construction delays are time overrun (81.3%) and cost overrun (75%), followed by disputes (50%), arbitration (37.5%), litigation (6.3%), and total abandonment of the project (6.3%). Figure 2 shows the results for the critical effects of construction delays. The analysis indicates that the owner (31.3%) is the person most responsible for many of the delays. The contractors (18.8%), subcontractors (18.8%), and both owner and contractors

(18.8%) together are the second group most responsible for delays since all three stakeholders are given equal priority. Finally, the consultants (12.5%) are the people least responsible for delay causes. Figure 3 shows the results of people most responsible for delays in the USA.

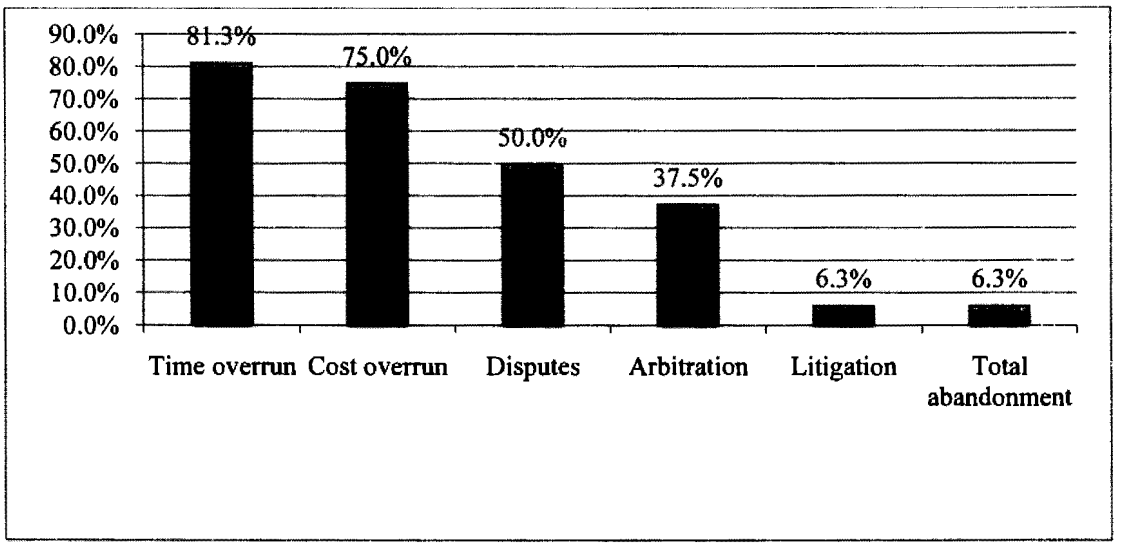

Figure 2: Critical effects of delays (USA)

The analysis of the severe delay causes shows that change orders during construction by the owner (77.33%) is the most severe source of delay. The next severe delay causes are severe weather conditions (snow, temperature, storms, wind) (77.14%), mistakes and errors in design and drawing documents (76.0%), lack of communication and coordination among all the parties (75.71%), and slowness in the owner's decision to approve design (74.67%). The other delays in top ten severe delays are conflicts between contractors and other parties involved in construction (73.33%), delay in the approval of design and drawings by consultants (73.33%), too many change orders by consultants (73.33%), conflicts between consultants and other parties involved in the project (72.0%), and delays in material delivery (72.0%). The lease severe delay causes

are equipment failures (55.71%), financial difficulties experienced by the contractor (52%), unavailability of the project management crew (51.43%), shortage of equipment (51.43%), and LEED certification process and requirements (47.14%). All the probable delays are listed in Table 6 according to their severity ranks and relative importance indices.

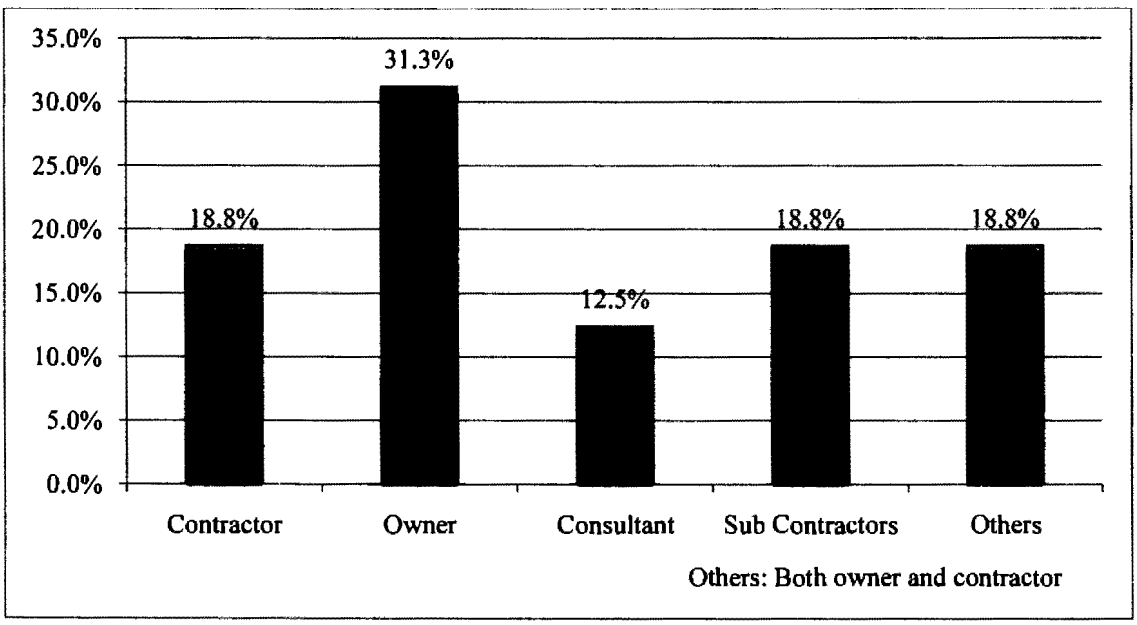

Figure 3: Most responsible people for delays (USA)

As is apparent from most of the research studies around the globe, change orders is one of the most important reasons for construction delays in the building construction industry. The results of the present study proved that change orders by the owner is the most important cause of delays for high rise building projects in the USA as well. This should be considered severe since the plans of owner may change as the needs and financial difficulties change. The major part of land in the USA has been experiencing natural calamities like hurricanes, tornados, blizzards, and floods every year. This

particular reason might be the cause for respondents ranking the severe weather conditions cause as the second important cause of delay. Mistakes in design and drawings, lack of communication between parties, conflicts between parties, delays in approval of design and drawings, and material delivery delays rise due to the ineffective and poor performance of project management processes. But, as is also indicated, the unavailability of a project management crew is one of the least severe causes of delay. This shows that the efforts of a project management crew need to be escalated for efficient project delivery. The least severe delay causes show that there are relatively very few problems with equipment or financial difficulties of contractor. The money, energy savings, and other advantages of green buildings have been attracting many owners to build green structures. The study shows that the green building practices and their certification (LEED) procedures do not affect the project completion.

Table 6: Causes of construction delays for high rise buildings (USA) sorted in order of rank

Category	Causes of Delays	RII	Rank
O	Change orders during construction by owner	77.33	1
M	Severe weather conditions (snow, temperature, storms, wind)	77.14	2
C2	Mistakes, and errors in design and drawing documents	76.00	3
G	Lack of communication and coordination among all the parties	75.71	4
O	Slowness in owner's decision to approve design	74.67	5
C1	Conflicts between contractor and other parties involved in construction	73.33	6

Category- G: General Delays, O: Owner related delays, C1: Contractor related delays, C2: Consultant related delays, R: Resource related delays, M: Miscellaneous delay

Table 6. (Continued)

Category	Causes of Delays	RII	Rank
C2	Delay in approval of design, and drawings	73.33	7
C2	Too many change orders by consultant	73.33	8
C2	Conflicts between consultants and other parties involved in the project	72.00	9
R	Delays in material delivery	72.00	10
G	Changes in contract	71.43	11
M	Delay in obtaining approvals from government authorities	71.43	12
C1	Ineffective planning and scheduling by contractor	70.67	13
C1	Poor performance in monitoring and tracking of work performed	70.67	14
C1	Delays by sub-contractor	70.67	15
O	Owner's financial difficulties	69.33	16
C2	Poor performance of consultant	69.33	17
R	Lack of skilled manpower	68.57	18
O	Delay in site preparation and delivery to contractor	68.00	19
C1	Inexperienced technical and administrative staff	68.00	20
O	Conflicts between owner and other parties involved in construction	66.67	21
C1	Improper construction methods and rework due to errors during construction	66.67	22
G	Poor estimation of project duration, productivity and resources	65.71	23
M	Changes in government regulations and laws	65.71	24
C1	Inadequate technical study by the contractor during the bidding stage	65.33	25
R	Shortage of materials	65.33	26
G	Type of construction contract, project bidding and award	64.29	27
O	Delay in progress payments by owner to contractor	64.00	28
O	Delay in settlement of contractor's claims	62.67	29
C1	Frequent changes of sub-contractors	61.33	30
C2	Inadequate experience of consultant and design team	61.33	31

Category- G: General Delays, O: Owner related delays, C1: Contractor related delays, C2: Consultant related delays, R: Resource related delays, M: Miscellaneous delays

Table 6. (Continued)

Category	Causes of Delays	RII	Rank
C1	Payment delays to subcontractors by main contractor	60.00	32
C1	Contractor's inexperience	58.67	33
R	Ineffective equipment	58.57	34
M	Accidents during construction	58.57	35
C1	Delay in mobilization	57.33	36
R	Changes in material prices	57.33	37
R	Equipment failures	55.71	38
C1	Financial difficulties experienced by contractor	52.00	39
G	Unavailability of project management crew	51.43	40
R	Shortage of equipment	51.43	41
G	LEED certification process and requirements	47.14	42

Category- G: General Delays, O: Owner related delays, C1: Contractor related delays, C2: Consultant related delays, R: Resource related delays, M: Miscellaneous delays

4.2. Analysis and Discussion of Results from India

The total number of responses collected through the research survey from India is eleven (11). Of these eleven (11) responses, six (6) responses were collected from architects and five (5) from construction managers. The respondents shared their experience through the survey by providing their recent high rise building project information. These projects are taken from different parts of the country. Considering the type of project, the number of residential projects is ten (10) and the remaining one (1) project is commercial. The survey results show that 90.9% of the surveyed projects experienced overall time delay, and all the projects experienced cost overruns as the result of construction delays. The average percent of high rise projects experiencing construction delays in India is 65.75%, which is very high. This figure might not be the accurate since it represents the previous project experiences of eleven (11) construction

companies. However, these results show that the Indian high rise construction industry has been facing serious troubles because of construction delays.

The results of the study show that time overrun (81.8%) and cost overrun (81.8%) are the most important effects of the construction delays, followed by disputes (72.7%), litigation (36.4%), arbitration (27.3%), and total abandonment (9.1%). It is also evident that time and cost overruns are equally important, which show that cost overrun takes place for every project when overall time overrun is the ultimate effect of construction delays. The critical effects of construction delays for high rise projects according to their severity are shown in Figure 4. The study also shows that subcontractors (27.3%) are responsible for most of the delays, followed by the contractors (18.2%), owners (18.2%), consultants (18.2%), and government laws (9.0%). Additionally, the owner, contractor, and consultant are equally responsible for the delays. In the others category, the participants indicated that government laws also play some part in delaying the project. The most responsible entities for construction delays, according to respondent's preferences, are shown in Figure 5.

The analysis of the severe causes for construction delays shows that lack of communication and coordination among all the parties involved in the construction (85.45%) and improper construction methods (85.0%) are the most severe causes of delays. The next severe causes are payment delays by the owner (84.0%), inexperienced technical and administrative staff (82.22%), poor performance in tracking performed work (82.22%), slowness in owner's decision to approve design (80.0%), ineffective planning and scheduling by the contractor (80.0%), owner's financial difficulties (78.0%), conflicts between owner and other parties (78.0%), and the delay in approval of

designs and drawings by consultants (75.56%). The least severe delay causes are severe weather conditions (60%), LEED certification process and requirements (58.18%), poor performance of consultants (57.78%), shortage of equipment (57.78%), equipment failures (57.78%), and inadequate experience of consultants and design teams (55.56%). The possible severe causes of delays according to the relative importance indexes and their ranks are listed in Table 7.

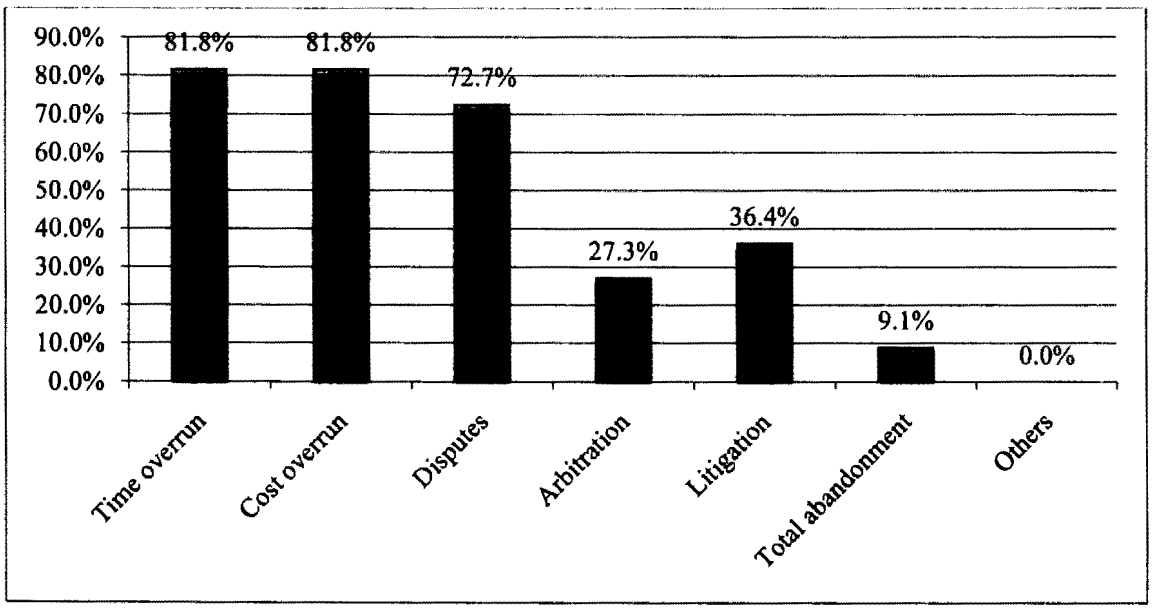

Figure 4: Critical effects of delays (India)

As is evident in the case of India, an improper project management system is the main cause of delays. Most of the top ten causes of delays pertain to project management issues. The main aim of the project management crew is to plan and organize the project life in a systematic manner, direct the workforce to let the project go smoothly, and make the crew maintain good and healthy communication. Failing to accomplish these issues could lead to the specified delays. The financial difficulties and irresponsible behavior by the owner are also part of the major problems. Having less knowledge over

the project, lack of initial study on how the project life cycle goes, poor participation in the design phase, and improper project estimation or cost escalations due to change orders may result in difficulties with the owner. The Indian construction projects have fewer problems with severe weather conditions since the Indian weather is a mix of dry and tropical climates. Also, the problems with equipment and consultants are relatively less.

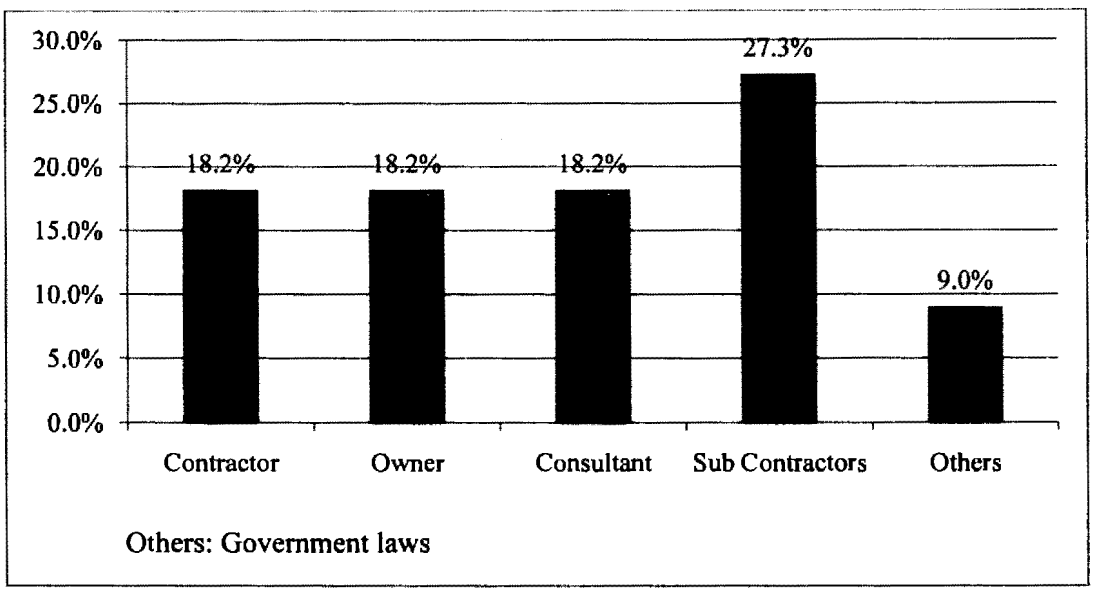

Figure 5: People most responsible for delays (India)

Table 7: Severe causes of delays for high rise buildings (India) sorted in order of rank

Category	Causes of delays	RII	Rank
G	Lack of communication and coordination among all the parties	85.45	1
C1	Improper construction methods and rework due to errors during construction	85.00	2
O	Delay in progress payments by owner to contractor	84.00	3
C1	Inexperienced technical and administrative staff	82.22	4

Category- G: General Delays, O: Owner related delays, C1: Contractor related delays, C2: Consultant related delays, R: Resource related delays, M: Miscellaneous delays

Table 7. (Continued)

Category	Causes of delays	RII	Rank
C1	Poor performance in monitoring and tracking of work performed	82.22	5
O	Slowness in owner's decision to approve design	80.00	6
C1	Ineffective planning and scheduling by contractor	80.00	7
O	Owner's financial difficulties	78.00	8
O	Conflicts between owner and other parties involved in construction	78.00	9
C2	Delay in approval of design, and drawings	75.56	10
C2	Too many change orders by consultant	75.56	11
G	Poor estimation of project duration, productivity and resources	74.55	12
O	Delay in settlement of contractor's claims	74.00	13
C1	Delays by sub-contractor	73.33	14
M	Delay in obtaining approvals from government authorities	73.33	15
G	Unavailability of project management crew	72.73	16
G	Type of construction contract, project bidding and award	72.00	17
C1	Payment delays to subcontractors by main contractor	71.11	18
C1	Conflicts between contractor and other parties involved in construction	71.11	19
C2	Mistakes, and errors in design and drawing documents	71.11	20
R	Delays in material delivery	71.11	21
O	Change orders during construction by owner	70.00	22
R	Lack of skilled manpower	70.00	23
M	Changes in government regulations and laws	68.89	24
O	Delay in site preparation and delivery to contractor	68.00	25
C1	Delay in mobilization	66.67	26
C1	Inadequate technical study by the contractor during the bidding stage	66.67	27
C1	Frequent changes of sub-contractors	66.67	28
R	Shortage of materials	66.67	29

Category- G: General Delays, O: Owner related delays, C1: Contractor related delays, C2: Consultant related delays, R: Resource related delays, M: Miscellaneous delays

Table 7. (Continued)

Category	Causes of delays	RII	Rank
C1	Financial difficulties experienced by contractor	64.44	30
M	Accidents during construction	64.44	31
G	Changes in contract	63.64	32
C1	Contractor's inexperience	62.22	33
R	Changes in material prices	62.22	34
C2	Conflicts between consultants and other parties involved in the project	60.00	35
R	Ineffective equipment	60.00	36
M	Severe weather conditions (snow, temperature, storms, wind)	60.00	37
G	LEED certification process and requirements	58.18	38
C2	Poor performance of consultant	57.78	39
R	Shortage of equipment	57.78	40
R	Equipment failures	57.78	41
C2	Inadequate experience of consultant and design team	55.56	42

Category- G: General Delays, O: Owner related delays, C1: Contractor related delays, C2: Consultant related delays, R: Resource related delays, M: Miscellaneous delays

CHAPTER 5. COMPARATIVE ANALYSIS

5.1. Comparative Analysis of the USA and India

This research study compares the survey results of the USA and India to establish the differences between the two construction industries. The analysis shows that there is a clear difference between the results of the two nations. The Indian high rise construction industry has been facing more problems with construction delays than the American construction industry. The results show that 28.4% of the Indian projects are experiencing more time delays than American projects. The Indian projects are experiencing cost overrun every time (100% of projects) along with the presence of overall time overrun, whereas in the USA, 69% of projects are experiencing cost escalations as the effect of overall time overrun. The results showing the relationship between time and cost overrun for the projects involved in the survey are presented in Figure 6.

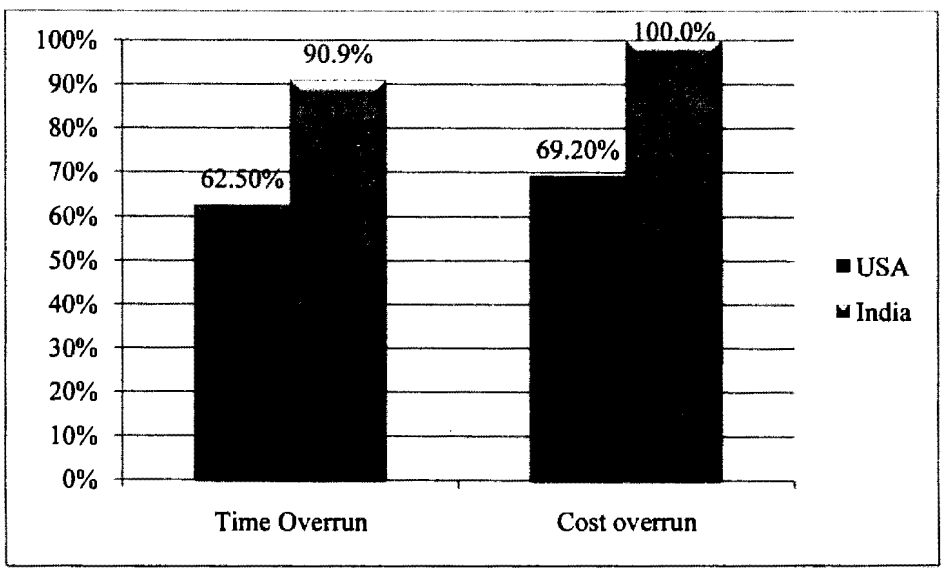

Figure 6: Relationship between time and cost overrun for the projects involved in the survey

However, there is an extensive difference observed between American and Indian projects in the case of average high rise projects' time delay experience. These statistical values are obtained based upon previous construction experience of respondent companies. The average time overrun experience of high rise building projects in the USA is 23.2%, whereas the Indian projects experience is 65.75%. Hence, there are more chances for Indian high rise projects to experience delays.

The respondents from both the USA and India indicated that overall time and cost overruns are the most severe effects of construction delays. But, the cost overrun is less severe than time overrun for the USA, whereas the two effects are equally important for India. It is also evident that there are more disputes and litigations for the Indian projects. The results show that most of the American projects use arbitration to resolve disputes, and the chances for litigations (trying cases in courts) are very low, whereas the scenario for Indian projects is quite the opposite. All the respondents agreed that the chance for the total abandonment of projects is very poor as the effect of construction delays. The results for severe effects of construction delays are shown in Figure 7.

5.1.1. General Delays

The general delays category shows a difference between the opinions of participants from the two nations. The results of general delays are more severe for India compared to the USA since the relative importance indexes for most of the causes are high (four of six causes are ranked more than 70%) for India. The average severity of these delays for the USA is 62.6% compared with 72.39% for India. These delays are 9.79% more severe for India than the USA. The analysis shows that a major difference is

observed in the opinions of respondents in the case of unavailability of project management crew (51.43% -USA, 72.73% - India), which has a 21.3% relative importance index. The only cause that is ranked more severe for the USA than India is changes in contract, the second most severe cause of delay for the USA in the general delay category. It is also observed that the lack of communication and coordination among all the parties (75.71% - USA, 85.45% -India) is a very severe cause, and LEED certification procedure and requirements is the least severe cause (47.14% - USA, 58.18% India) for the two nations in this category. Figure 8 shows the comparative analysis of the general delay causes.

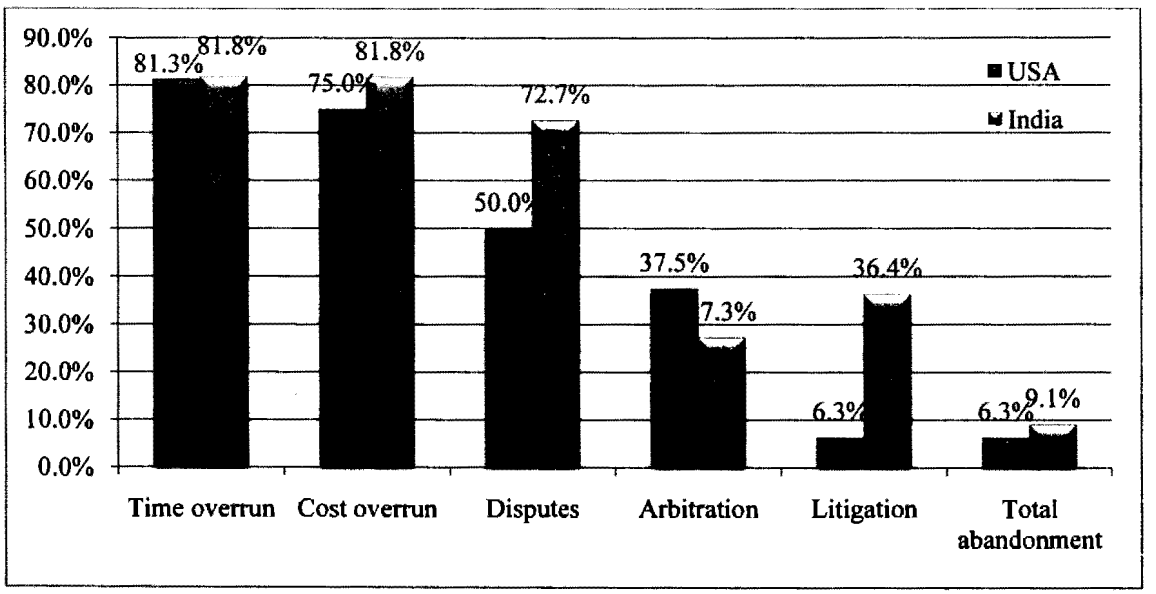

Figure 7: Severe effects of construction delays

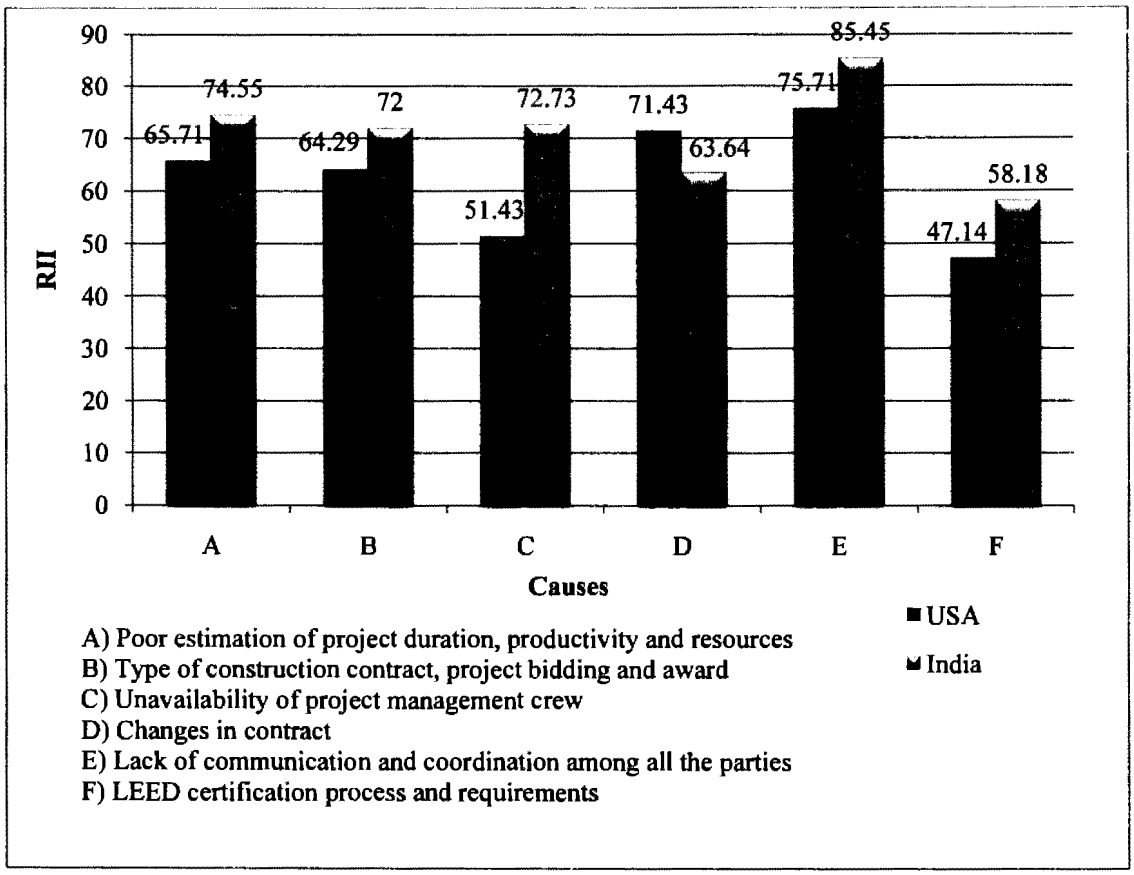

Figure 8: Comparative analysis of general delays

5.1.2. Owner Related Delays

The analysis of the owner related delays shows that these delays are also more severe for India than the USA. However, the difference between averages of relative importance indexes is not very big. The average value of severity of all the causes in this category for the USA is 68.9%, whereas, India is 76%. The comparative analysis of the study shows that five of seven delay causes are ranked more severe for India than the USA, but only one cause is ranked more severe for the USA than India. The results are identical for the remaining one cause. For India, all the causes are ranked 70% and more except the delay in site preparation and delivery to contractor, whereas only two causes

are ranked more than 70% for the USA. However, the difference between the opinions of respondents is huge in the case of the delay in progress payments by the owner to the contractor, which has an RII of 20%. This particular cause is remarkable since it is ranked very severe for India and second least severe for the USA. The only cause that is ranked more severe for the USA than India is change orders during construction by the owner (77.33%) with 7.33% difference in RII. It is also the most severe cause among all the delays for the USA. The only cause with identical severity ranks by the respondents is delay in site preparation and delivery to the contractor (68%), and it is also the least severe cause for India in this category. The least severe cause for the USA is the delay in settlement of contractor's claims (62.67%). Figure 9 shows the comparative analysis of owner related causes.

5.1.3. Contractor Related Delays

The analysis of this category shows considerable differences between the results. These delays are more critical for the Indian construction projects than the USA projects. All the delays in this category are more severe for India than the USA, except for delays by sub-contractors where the difference is not remarkable. The average value of severity of all the delay causes for the USA is 64.56%, whereas it is 72.63% for India. The difference in RII is 8.07%. The most severe delays for India in this category are ineffective planning and scheduling by the contractor (80.0%), poor performance in monitoring and tracking of work performed (82.22%), inexperienced technical and administrative staff (82.22%), and improper construction methods and rework due to errors during construction (85.0%); these are ranked more severe and equal to 80%, and

none of the delays are ranked more than 80% for the USA. It is observed that four of twelve delays are ranked more than 70% for the USA, whereas seven delays are ranked more than 70% for India. The study shows that the causes with major differences in the results are improper construction methods and rework due to errors during construction (66.67% - USA, 85% - India), inexperienced technical and administrative staff (68% - USA, 82.22% - India), and financial difficulties experienced by the contractor (52% - USA, 64.4% - India). The differences in RII values are 18.33%, 14.22%, 12.44%, respectively. The least severe cause for the USA is financial difficulties experienced by the contractor (52%), while India's contractor's inexperience ranks least (62.22%). Figure 10 shows the comparative analysis of contractor related delays.

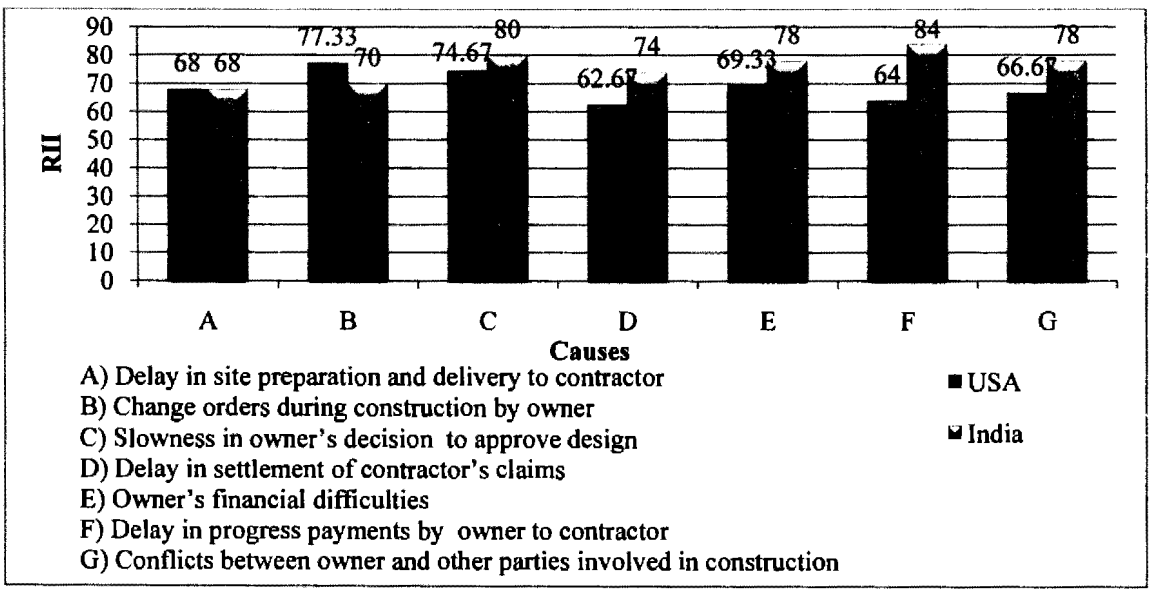

Figure 9: Comparative analysis of owner related delays

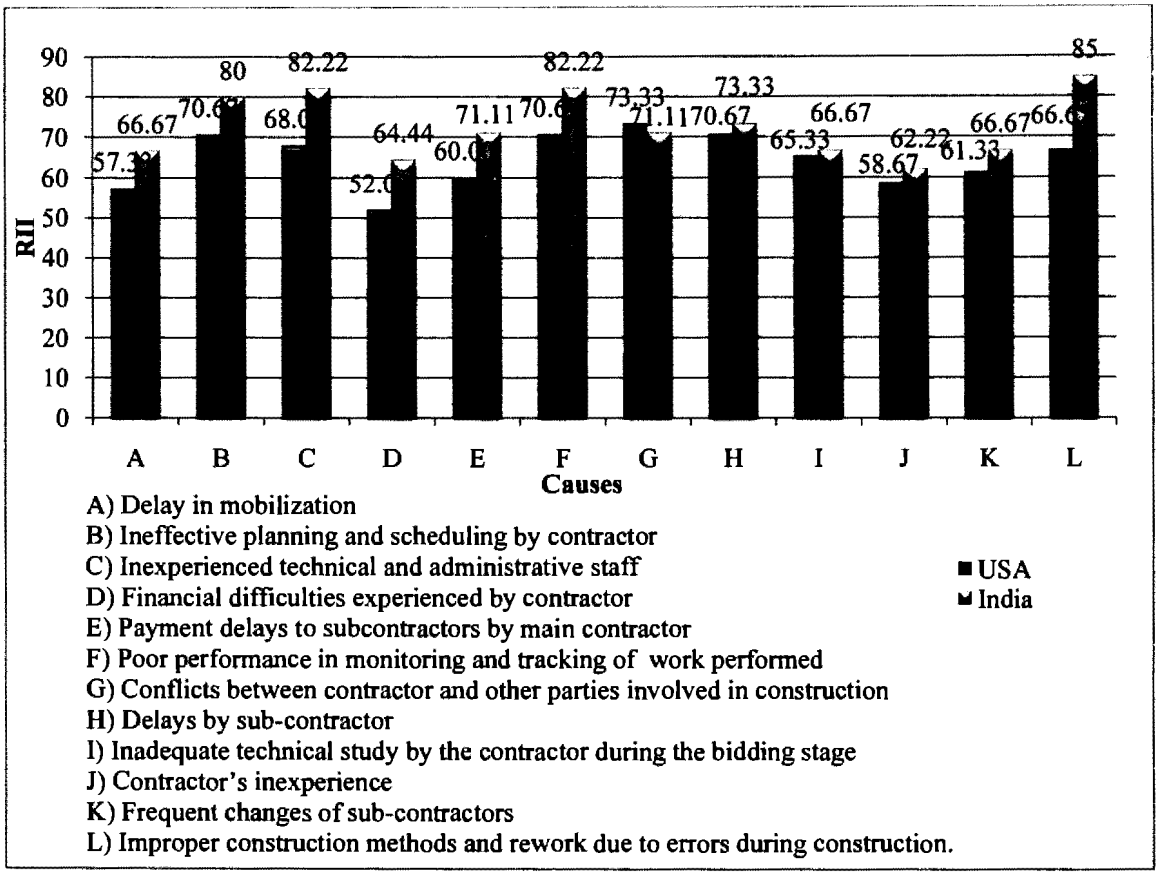

Figure 10: Comparative analysis of contractor related delays

5.1.4. Consultant Related Delays

The analysis of consultant related delays reveals that these delays are more severe for the USA than India. Four of the six delay causes are ranked more severe for the USA than India, while the remaining two causes are ranked less severe. However, the results for these two less severe causes are very close and can be considered identical results. The average severity of all the causes in this category for the USA is 70.9%, whereas India is 65.9%. The severity difference between the RIIs is 5%, which is not very significant when compared with the severity differences of the other categories. The study shows that poor performance of the consultant (69.33% - USA, 57.78% - India) as

well as conflicts between the consultants and other parties involved in the project (72% - USA, 60% - India) are the two causes which exhibit major differences in the results, with 11.55%, and 12% in RII respectively. The two causes with close results are delay in the approval of design and drawings (73.33% - USA, 75.56 - India) and too many change orders by consultant (73.33% - USA, 75.56 - India). These causes are also the most severe causes for India, whereas mistakes and errors in design and drawing documents (76%) is the most severe cause for the USA. The least severe cause for the two countries is inadequate experience of the consultant and design team (61.33% - USA, 55.56% - India). Figure 11shows the comparative analysis of consultant related delays.

5.1.5. Resource Related Delays

In this category, the comparative analysis shows that the results of all the causes of delays are very close to each other. The resource related delays category is the only one where the opinions of respondents are identical. However, the statistical figures of the results show that these delays are less severe for India than the USA, since the average value of severity indexes of all the causes in this category for the USA is 61.3%, whereas India is 63.6%. The difference is just 2.3%, which can be considered identical or negligible. The only cause where there is a major difference between the results is shortage of equipment (51.43% - USA, 57.78% - India), with 6.35% of difference in RII. The results are similar for the rest of the causes. The study observed that shortage of equipment (51.43% - USA, 57.78% - India) and delays in material delivery (72% - USA, 71.11% -India) are the least and most severe delays, respectively, for the two nations. In

addition, causes due to equipment failures (57.78%) are also the least severe cause for India, which is ranked same with shortage of equipment. Figure 12 shows the comparative analysis of resource related delays.

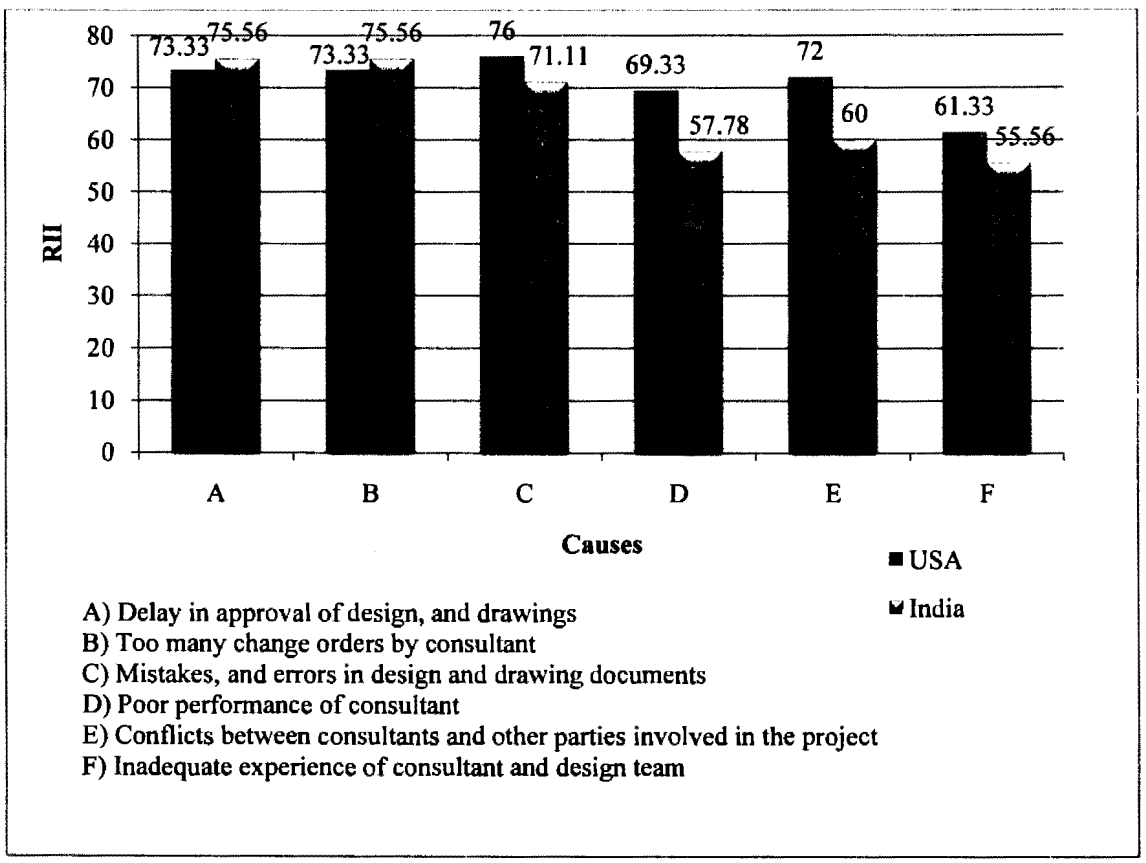

Figure 11: Comparative analysis of consultant related delays

5.1.6. Miscellaneous Delays

The miscellaneous delays category is also the one with minimal difference between the results of both countries. However, the statistical figures show that this category is a little more severe for the USA than India. The average value of severities of all the causes for the USA projects is 68.2%, whereas India is 66.6%, with a difference of 1.6% in RII. The study shows that the only cause that exhibits considerable

difference between the opinions of respondents is severe weather conditions (77.14% - USA, 60% -India), which has a 17.14% difference in RII. This might be due to the different geographic locations, which result in different climatic conditions. India's climate is a mix of dry and tropical conditions, whereas America's climate is mix of dry and continental conditions. The historical data of the climates shows that the presence of natural calamities in the United States is more frequent than India.

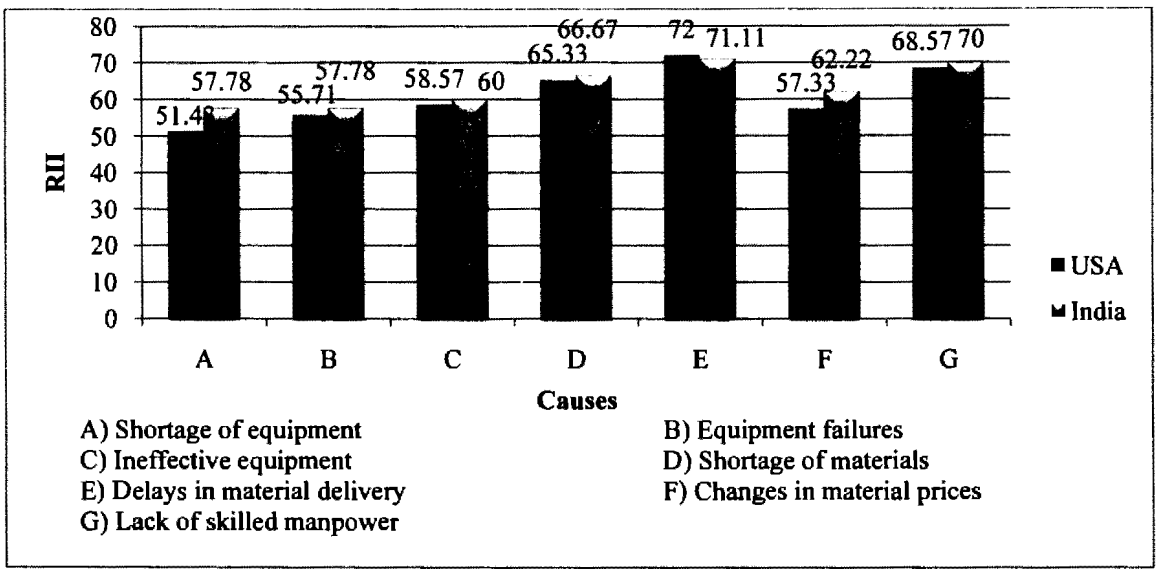

Figure 12: Comparative analysis of resource related delays

The second major difference is in the number of accidents during construction (58.57% - USA, 64.44% India) with a 5.87% difference. There is the presence of a higher number of accidents during the construction of Indian projects than the American projects. For the two remaining factors, the severity ranks are very similar and can be considered identical results. Figure 13 shows the comparative analysis of miscellaneous delays. All the causes of delays, including the RII values and severity ranks for the two countries, are shown in Table 8, which is derived from Table 6 and 7.

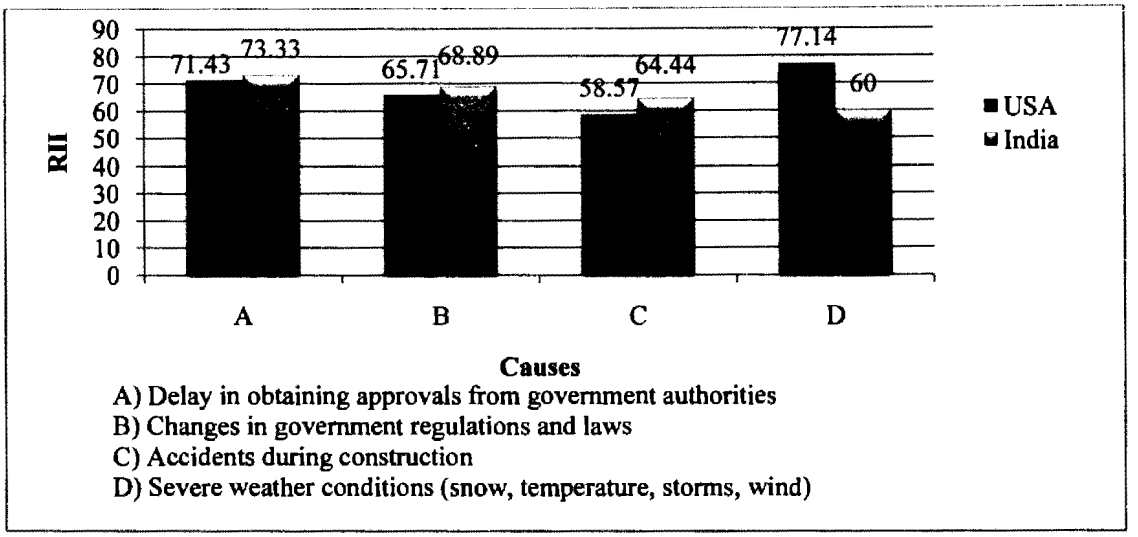

Figure 13: Comparative analysis of miscellaneous delays

Table 8: RII, and severity ranks of all the delay causes for the USA and India sorted in alphabetical order

Category	Causes of Delays	USA		India	
		RII	Rank	RII	Rank
General delays	Changes in contract	71.43	11	63.64	32
	Lack of communication and coordination among all the parties	75.71	4	85.45	1
	LEED certification process and requirements	47.14	42	58.18	38
	Poor estimation of project duration, productivity and resources	65.71	23	74.55	12
	Type of construction contract, project bidding and award	64.29	27	72	17
	Unavailability of project management crew	51.43	40	72.73	16
Contractor related delays	Conflicts between contractor and other parties involved in construction	73.33	6	71.11	19
	Contractor's inexperience	58.67	33	62.22	33
	Delay in mobilization	57.33	36	66.67	26
	Delays by sub-contractor	70.67	15	73.33	14
	Financial difficulties experienced by contractor	52	39	64.44	30
	Frequent changes of sub-contractors	61.33	30	66.67	28

Table 8. (Continued)

Category	Causes of Delays	USA		India	
		RII	Rank	RII	Rank
Contractor related delays	Improper construction methods and rework due to errors during construction	66.67	22	85	2
	Inadequate technical study by the contractor during the bidding stage	65.33	25	66.67	27
	Ineffective planning and scheduling by contractor	70.67	13	80	7
	Inexperienced technical and administrative staff	68	20	82.22	4
	Payment delays to subcontractors by main contractor	60	32	71.11	18
	Poor performance in monitoring and tracking of work performed	70.67	14	82.22	5
Consultant related delays	Conflicts between consultants and other parties involved in the project	72	9	60	35
	Delay in approval of design, and drawings	73.33	7	75.56	10
	Inadequate experience of consultant and design team	61.33	31	55.56	42
	Mistakes, and errors in design and drawing documents	76	3	71.11	20
	Poor performance of consultant	69.33	17	57.78	39
	Too many change orders by consultant	73.33	8	75.56	11
Owner related delays	Change orders during construction by owner	77.33	1	70	22
	Conflicts between owner and other parties involved in construction	66.67	21	78	9
	Delay in progress payments by owner to contractor	64	28	84	3
	Delay in settlement of contractor's claims	62.67	29	74	13
	Delay in site preparation and delivery to contractor	68	19	68	25
	Owner's financial difficulties	69.33	16	78	8
	Slowness in owner's decision to approve design	74.67	5	80	6
Resource related delays	Changes in material prices	57.33	37	62.22	34
	Delays in material delivery	72	10	71.11	21

Category	Causes of Delays	USA		India	
		RII	Rank	RII	Rank
Resource related delays	Equipment failures	55.71	38	57.78	41
	Ineffective equipment	58.57	34	60	36
	Lack of skilled manpower	68.57	18	70	23
	Shortage of equipment	51.43	41	57.78	40
	Shortage of materials	65.33	26	66.67	29
Miscellaneous delays	Accidents during construction	58.57	35	64.44	31
	Changes in government regulations and laws	65.71	24	68.89	24
	Delay in obtaining approvals from government authorities	71.43	12	73.33	15
	Severe weather conditions (snow, temperature, storms, wind)	77.14	2	60	37

5.2. Comparative Analysis with Previous Studies

Finally, the study also compares the survey results with the previous studies on construction delay causes in other parts of the globe, apart from the USA and India. The selected studies for comparison are Kaming *et al.*, 1997 (Indonesia), Faridi and El-Sayegh, 2006 (UAE), Murali and Wen, 2007 (Malaysia).

The results of comparative analysis show that the findings of each study are different from the others. Most of the top ten delay causes in Indonesia are related to inaccurate estimation, resources and miscellaneous delays. For UAE, the delay causes are related to resources, contractors, and consultants. For Malaysia, contractor and resource related delays are severe. These dissimilarities prove that the factors affecting the construction delays change based upon geographical locations. The study concludes that these dissimilarities are due to the difference in climatic conditions, construction methods, usage of materials, availability of innovative technology, and contractual

procedures. However, there are some common delay causes observed among the studies, which include: delay in approval of design and drawings, delay in progress payments by owner to contractor, equipment related delays, improper construction methods and rework due to errors during construction, ineffective planning and scheduling by the contractor, labor related delays, lack of communication and coordination among all parties, material related delays, severe weather conditions, and slowness in the owner's decision to approve design. Table 9 lists the top ten delay causes for all the studies.

Table 9: The top ten causes of delays in construction in the USA, India, Indonesia, UAE, and Malaysia

Rank	USA (Present Study)	India (Present Study)	Indonesia (Kaming *et al.*, 1997)	UAE (Faridi and El-Sayegh, 2006)	Malaysia (Murali and Wen, 2007)
1	Change orders during construction by owner	Lack of communication and coordination among all the parties	Unpredictable weather conditions	Preparation and approval of drawings	Improper planning by contractor
2	Severe weather conditions (snow, temperature, storms, wind)	Improper construction methods and rework due to errors during construction	Inaccuracy of materials estimate	Inadequate early planning of the project	Site management by contractor
3	Mistakes, and errors in design and drawing documents	Delay in progress payments by owner to contractor	Inaccurate prediction of craftsmen production rate	Slowness of the owner's decision-making process	Inadequate contractor experience
4	Lack of communication and coordination among all the parties	Inexperienced technical and administrative staff	Inaccurate prediction of equipment production rate	Shortage of manpower	Finance and payments of completed work by client
5	Slowness in owner's decision to approve design	Poor performance in monitoring and tracking of work performed	Material shortage	Poor supervision and poor site management	Subcontractor delays
6	Conflicts between contractor and other parties involved in construction	Slowness in owner's decision to approve design	Equipment shortage	Productivity of manpower	Shortage in material

Table 9. (Continued)

Rank	USA (Present Study)	India (Present Study)	Indonesia (Kaming *et al.*, 1997)	UAE (Faridi and El-Sayegh, 2006)	Malaysia (Murali and Wen, 2007)
7	Delay in approval of design, and drawings	Ineffective planning and scheduling by contractor	Skilled labor shortage	Skill of manpower	Labor shortage
8	Too many change orders by consultant	Owner's financial difficulties	Location restriction of the project	Non-availability of materials on time	Equipment availability and failure
9	Conflicts between consultants and other parties involved in the project	Conflicts between owner and other parties involved in construction	Inadequate planning	Obtaining permit/approval from the municipality/different government authorities	Lack of communication between the parties
10	Delays in material delivery	Delay in approval of design, and drawings	Poor labor productivity	Financing by contractor during construction	Mistakes during construction stage

CHAPTER 6. RECOMMENDATIONS

6.1. Recommendations by the Survey Participants

The research study also asked the participants of the survey to recommend possible suggestions to mitigate the construction delays and their severe effects. The possible procedures which could possibly alleviate construction delays in high rise buildings are:

a) Combined efforts of the owner, contractor, and consultant in processing the change orders in time to reduce the delays.

b) Conflicts must be avoided to maintain good communications among all the parties and to improve mutual coordination between the project intra and inter departments involved in the construction.

c) Contractors and consultants should know the owner's expectations to trim down the change orders after the construction phase is started.

d) Contractors should review the detailed scope of work with subcontractors

e) Earliest approvals from the consultants and their mutual co-operation with contractor save a lot of time.

f) Effective pre-construction planning helps to lay out an efficient game plan early in the project life.

g) Efficient planning and scheduling from the contractor avoids unnecessary time overruns, cost overruns, and disputes. Contingencies must be speculated and added to the project schedule.

h) Efficient project management is the key to work faster, reduces costs and requires innovative new processes to deliver value to the owner. It defines and confirms the project goals and objectives, identifies tasks and how goals will be achieved, quantifies the resources needed, and determines budgets and timelines to accomplish a successful project.

i) Extra time should be given to get approvals from municipalities/government authorities.

j) An IPD (Integrated Project Delivery) method is an approach that integrates people, systems, and practices into a collaborative process through all phases of design, fabrication and construction. It makes the people make decisions together and share the problems that occur during the delivery of the project.

k) Selecting available materials for construction reduces the problems with shortages of materials, material handling and sometimes saves transportation costs and time.

l) The owners and consultants must make quick decisions for approvals and to solve any problems during execution.

m) A thorough review of designs prior to final approval minimizes design changes and promotes better design delivery.

n) Using appropriate methods of construction reduce errors during construction and improve efficiency, thus reducing rework.

o) When selecting the contractor, clients should look at previous experience, financial ability, technical capability and the man power of the prospective contractor for better project delivery. Clients and contractors must be careful in selecting the right team.

CHAPTER 7. CONCLUSION

7.1. Conclusion of Research Study

Construction delays are very important since they cause losses to the owners, builders and influence the economics of the construction industry. Prior knowledge of possible delays during construction save money, time, and energy is very essential for the construction of high rise buildings. The investments in these projects are very high and possibilities of delays are relatively common because of the complexity in the construction. This research study is intended to identify the causes of probable delays and their severity for the high rise building construction industry. Additionally, this study investigates all possible delays and their severity through a structured questionnaire survey administered all over the USA and India. The survey results of the two countries were subjected to analysis, and the severities of the delays were calculated using the relative important index.

The research study has collected sixteen (16) responses from the USA and eleven (11) from India. The analysis of the study shows that the results are dissimilar for the USA and India. The top ten severe delay causes for the USA are: change orders during construction by the owner (77.33%), severe weather conditions (77.14%), mistakes and errors in design and drawing documents (76.0%), lack of communication and coordination among all the parties (75.71%), slowness in owner's decision to approve design (74.67%), conflicts between contractor and other parties involved in construction (73.33%), delay in approval of design and drawings by consultants (73.33%), too many change orders by consultants (73.33%), conflicts between consultants and other parties

involved in the project (72.0%), and delays in material delivery (72.0%). For India, the top ten severe delay causes are: lack of communication and coordination among all the parties involved in construction (85.45%), improper construction methods (85.0%), payment delays by the owner (84.0%), inexperienced technical and administrative staff (82.22%), poor performance in tracking performed work (82.22%), slowness in owner's decision to approve design (80.0%), ineffective planning and scheduling by contractors (80.0%), owner's financial difficulties (78.0%), conflicts between owner and other parties (78.0)%, and delays in approval of design and drawing by consultants (75.56%).

The comparative analysis of the study shows that there is a difference between the results of the two countries in many situations. It is clear that the presence of time delays and cost escalations are more severe for India than the USA. The Indian participants indicated that cost escalations are evident every time along with overall time delays, whereas the American participants indicated that 69.2% of the projects experienced cost escalations as the effect of overall time delay. All the participants of the two nations agreed that time and cost overruns are the critical effects of construction delays, followed by disputes and arbitration. The study demonstrates that the delays related to owners, contractors, resources and other general delays are more severe for India than the USA, whereas the miscellaneous and consultant related delays, are more severe for the USA than India. Most of the severe delays are ranked more than 80% for India, and none of the delays are ranked more severe than 80% for the USA. However, the results clearly depict the difference between geographical locations, economy, and the use of project management systems between the USA and India. At the end of this

study, several recommendations are listed by the participants to help minimize the construction delays and their severe effects.

7.2. Future Research

The present research study was limited to the high rise building construction industry in the USA and India only. The future study could be carried out in other parts of the world and could emphasize specific types of building construction including residential, commercial, educational, government buildings, and skyscrapers, and etc. A study similar to the present research is needed for transportation projects and to find delay causes of highway construction, which helps the departments of transportation to minimize unnecessary cost escalations and project schedule delays. The federal and state governments invest significant amounts of capital budget on road construction, and the projects indeed move slowly.

REFERENCES

1. Abd El-Razek, M. E., Bassioni, H. A., and Mobarak, A. M., (2008). "Causes of Delays in Building Construction Projects in Egypt." *Journal of Construction Engineering and Management*, vol. 134, no. 11, pp. 831-841.
2. Abdul-Rahman, H., Berawi, M. A., Berawi, A. R., Mohamed, O., Othman, M., and Yahya, I. A., (2006). "Delay Mitigation in the Malaysian Construction Industry." *Journal of Construction Engineering and Management*, vol. 132, no. 2, pp. 125-133.
3. Aibinu, A. A., and Jagboro, G. O., (2002). "The Effects of Construction Delays on Project Delivery in Nigerian Construction Industry." *International Journal of Project Management*, vol. 20, no. 8, pp. 593-599.
4. Aibinu, A.A., and Odeyinka, H.A., (2006). "Construction Delays and Their Causative Factors in Nigeria." *Journal of Construction Engineering and Management*, vol. 132, no. 7, pp. 667-677.
5. Al-Khalil, M. I., and Al-Ghafly, M. A., (1999). "Delay in public utility projects in Saudi Arabia." *International Journal of Project Management*, vol. 17, no. 2, pp. 101-106.
6. Al-Momani, A.H., (2000). "Construction Delay: a Quantitative Analysis." *International Journal of Project Management*, vol. 18, no. 1, pp. 51-59.
7. Assaf, S.A., Alkhalil, M., and Al-Hazmi, M., (1995). "Causes of delay in large building construction projects." *Journal of Management in Engineering*, vol. 11, no. 2, pp. 45-50.

8. Assaf, S.A., and Al-Hejji, S., (2006). "Causes of Delay in Large Building Construction Projects." *International Journal of Project Management*, vol. 24, no. 4, pp. 349-357.

9. Chan, A.P.C, Scott, D., and Chan, A.P.L., (2004). "Factors Affecting the Success of a Construction Project." *Journal of Construction Engineering and Management*, vol. 130, no. 1, pp. 153-155.

10. Chan, D.W.M., and Kumaraswamy, M.M., (1996). "An Evaluation of Construction Time Performance in the Building Industry." *Building and Environment*, vol. 31, no. 6, pp. 569-578.

11. Chan, D.W.M., and Kumaraswamy, M.M., (1997). "A Comparative Study of Causes of Time Overruns in Hong Kong Construction Projects." *International Journal of Project Management*, vol. 15, no. 1, pp. 55-63.

12. Chan, D.W.M., and Kumaraswamy, M.M., (2002). "Compressing Construction Durations: Lessons Learned from HongKong Building Projects." *International Journal of Project Management*, vol. 20, pp. 23-35.

13. Faridi, A.S., and El-Sayegh, S.M., (2006). "Significant Factors Causing Delay in the UAE Construction Industry." *Construction Management and Economics,* vol. 24, no. 11, pp. 1167 – 1176.

14. Ireland, V., (1985). "The Role of Managerial Actions in the Cost, Time and Quality Performance of High-Rise Commercial Building Projects." *Journal of Construction Management and Economics,* vol. 3, pp. 59-87.

15. Iyer, K.C., and Jha, K.N., (2005). "Factors Affecting Cost Performance: Evidence from Indian Construction Projects." *International Journal of Project Management*, Vol. 23, no. 4, pp. 283-295.

16. Kaming, P.F., Olomolaiye, P.O., Holt, G.D., and Harris, F.C., (1997). "Factors Influencing Construction Time and Cost Overruns on High-Rise Projects in Indonesia." *Journal of Construction Management and Economics,* vol. 15, no.1, pp. 83-94.

17. Long, N.D., Ogunlana, S.O., Quang, T., and Lam, K.C., (2004). "Large Construction Projects in Developing Countries: a Case Study from Vietnam." *International Journal of Project Management*, vol. 22, no. 7, pp. 553-561.

18. Marzouk, M., El-Dokhmasey, A., and El-Said, M., (2008). "Assessing Construction Engineering-Related Delays: Egyptian Perspective." *Journal of Professional Issues in Engineering Education and Practice*, Vol. 134, no. 3, pp. 315-326.

19. Murali, S., and Wen, Y.S., (2007). "Causes and Effects of Delays in Malaysian Construction Industry." *International Journal of Project Management*, Vol.25, no. 5, pp. 517-526.

20. Nkado, R.N., (1995). "Construction Time-Influencing Factors: the Contractor's Perspective." *Construction Management and Economics*, vol.13, no. 1, pp. 81 – 89.

21. Odeh, A.M., and Battaineh, H.T., (2002). Causes of Construction Delay: Traditional Contracts." *International Journal of Project Management*, vol. 20, no. 1, pp. 67-73.

22. Ogunlana, S.O., Promkuntong, K., and Jearkjirm, V., (1996). "Construction Delays in a Fast-Growing Economy: Comparing Thailand with Other Economies." *International Journal of Project Management*, vol. 14, no.1, pp. 37-45.

23. Sanvido, V., Grobler, F., Parfitt, K., Guvenis, M., and Coyle, M., (1992). "Critical Success Factors for Construction Projects." *Journal of Construction Engineering Management*, vol. 118, no. 1, pp. 94-111.

24. Sweis, G., Sweis, R., Abu Hammad, A., and Shboul, A., (2008). "Delays in Construction Projects: The Case of Jordan." *International Journal of Project Management*, vol. 26, no. 6, pp. 665-674.

25. Yates, J. K., and Epstein, A., (2006). "Avoiding and Minimizing Construction Delay Claim Disputes in Relational Contracting." *Journal of professional issues in engineering education and practice*, vol. 132, no. 2, pp. 168-179.

APPENDIX A. SAMPLE QUESTIONNAIRE

I. Research Intent

This research is conducted by Arun Billa, under the direction of Dr. Eric Asa of the Construction Management and Engineering Department, North Dakota State University, Fargo, North Dakota. High rise buildings are complex, high risk, and multi-contractor projects which make them prone to construction delays. Delays can lead to schedule and cost overrun, effect the project duration and the total budget and can result in litigation. Generally, high rise buildings are expensive undertakings and a schedule overrun could lead to significant losses (time and money). A high rise project manager must therefore be able to estimate the potential delays and eliminate them if possible, in order to reduce their impact on the success of the overall project. This research investigates the probable delays, and their severity.

The purpose of this research survey is to collect information on causes of delays during the construction of high rise buildings, and also the techniques, procedures which could minimize the delays and their effects. It is intended to collect reliable data from contractors, consultants, owners, construction managers and other working professionals of the construction industry.

You are invited to participate in this research study. Your valuable participation will allow the research team to document the causes of construction delays in high rise building projects, and their effects on project completion. We would be grateful if you could participate in this research survey.

It will take about 7 to 10 minutes to complete all the questions. All of the questions ask the participants to check their priority form least to high (1. Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly Agree) except the questions about personal information, project details and recommendations.

We will keep private all research records that identify you, to the extent allowed by law. Your information will be combined with information from other people taking part in the study, we will write about the combined information that we have gathered. You will not be identified in these written materials. We may publish the results of the study; however, we will keep your name and other identifying information private. A project report based on the summary of responses will be available to the public and a free copy of the report will be sent to each respondent.

Please submit your responses by December 30, 2009. We humbly encourage you to participate in this research survey; as a little of your time, knowledge, and experience could have an important and positive impact on the construction industry and its future. Thank you for your time and input.

If you have any questions about this project, feel free to contact us.

Dr. Eric Asa and Mr. Arun Billa (Graduate Student) North Dakota State University Construction Management and Engineering, Dept. 2475 P.O. Box 6050, Fargo, ND 58108 E.mail: Eric.Asa@ndsu.edu, or Arun.Billa@ndsu.edu Phone: 701- 231- 7246 or 701-429 7825, Fax: 701- 231- 7431

If you have questions about your rights or complaints about this research, you may talk to the researcher or contact the NDSU Human Research Protection Program at

701.231.8908, ndsu.irb@ndsu.edu, or by mail at: NDSU HRPP Office, NDSU Dept 4000, P.O. Box 6050, Fargo, ND 58108-6050.

II. RESPONDENT'S INFORMATION

1. Please provide the following information

Name:

Company:

Address:

Address 2:

City/Town:

State:

ZIP/Postal Code:

Country:

Email Address:

Phone Number:

2. Respondent's Position/Title

III. PROJECT DETAILS

Please provide information of a high rise project that you involved in its construction

3. Type of the high rise project that you are going to explain

- ○ Residential
- ○ Commercial

4. Did it experience overall time delay

- ○ Yes
- ○ No

5. Did it experience cost overrun

- ○ Yes
- ○ No

6. What percentage of projects that your company constructed experienced time overruns

7. What are the results of construction delays (Please check one or more options)

- ☐ Time overrun
- ☑ Cost overrun
- ☐ Disputes
- ☐ Arbitration
- ☐ Litigation
- ☐ Total abandonment
- ☐ If other (please specify)

8. Who is responsible for most of the time overruns

- ◉ Contractor
- ○ Owner

- ○ Consultant
- ○ Sub Contractors
- ○ If others (please specify)

IV. GENERAL DELAYS RELATED TO PROJECT

9. Please rank the severity of "General Delays" according to their priority (Please check your option)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
A) Poor estimation of project duration, productivity and resources	○	○	◉	○	○
B) Type of construction contract, project bidding and award	○	○	○	○	○
C) Unavailability of project management crew	○	○	○	○	○
D) Changes in contract	○	○	○	○	○
E) Lack of communication and coordination among all the parties	◉	○	○	○	○
F) LEED certification process and requirements	○	○	○	○	○

V. OWNER RELATED DELAYS

10. Please rank the severity of "Owner Related Delays" according to their priority (Please check your option)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
A) Delay in site preparation and delivery to contractor	○	○	○	○	○
B) Change orders during construction by owner	◉	○	○	○	○
C) Slowness in owner's decision to approve design	○	○	○	○	○
D) Delay in settlement of contractor's claims	○	○	○	○	○
E) Owner's financial difficulties	○	○	○	○	○
F) Delay in progress payments by owner to contractor	○	○	○	○	○
G) Conflicts between owner and other parties involved in construction	◉	○	○	○	○

VI. CONTRACTOR RELATED DELAYS

11. Please rank the severity of "Contractor Related Delays" according to their priority (Please check your option)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
A) Delay in mobilization	○	○	○	○	○
B) Ineffective planning and scheduling by contractor	◉	○	○	○	○
C) Inexperienced technical and administrative staff	○	○	○	○	○
D) Financial difficulties experienced by contractor	○	○	○	○	○
E) Payment delays to subcontractors by main contractor	○	○	○	○	○
F) Poor performance in monitoring and tracking of work performed	○	○	○	○	○
G) Conflicts between contractor and other parties involved in construction	○	○	○	○	○
H) Delays by sub-contractor	○	○	○	○	○
I) Inadequate technical study by the contractor during the bidding stage	○	○	○	○	○
J) Contractor's inexperience	○	○	○	○	○
K) Frequent changes of sub-contractor	○	○	○	○	○

L) Improper construction methods and rework due to errors during construction	◉	○	○	○	○

VII. CONSULTANT RELATED DELAYS

12. Please rank the severity of "Consultant Related Delays" according to their priority (Please check your option)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
A) Delay in approval of design, and drawings	○	○	○	○	○
B) Too many change orders by consultant	○	○	○	○	○
C) Mistakes, and errors in design and drawing documents	○	○	○	○	○
D) Poor performance of consultant	○	○	○	○	○
E) Conflicts between consultants and other parties involved in the project	◉	○	○	○	○
F) Inadequate experience of consultant and design team	○	○	○	○	○

VIII. RESOURCES RELATED DELAYS

13. Please rank the severity of "Resource Related Delays" according to their priority (Please check your option)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
A) Shortage of equipment	○	○	○	○	○
B) Equipment failures	○	○	○	○	○
C) Ineffective equipment	○	○	○	○	○
D) Shortage of materials	○	○	○	○	○
E) Delays in material delivery	○	○	○	○	○
F) Changes in material prices	●	○	○	○	○
G) Lack of skilled man power	○	○	○	○	○

IX. MISCELLANEOUS DELAYS

14. Please rank the severity of "Miscellaneous Related Delays" according to their priority (Please check your option)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
A) Delay in obtaining approvals from government authorities	○	○	○	○	○
B) Changes in government regulations	○	○	○	○	○

and laws

C) Accidents during construction	○	○	○	○	○
D) Severe weather conditions (snow, temperature, storms, wind)	○	○	○	○	○

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15. Please recommend some suggestions to minimize the delays

1 [ ]

2 [ ]

3 [ ]

4 [ ]

5 [ ]

APPENDIX B. IRB APPROVAL

NDSU NORTH DAKOTA STATE UNIVERSITY

Institutional Review Board
Office of the Vice President for Research, Creative Activities and Technology Transfer
NDSU Dept. 4000
1735 NDSU Research Park Drive
Research 1, P.O. Box 6050
Fargo, ND 58108-6050

701.231.8995
Fax 701.231.8098

Federalwide Assurance #FWA00002439
Expires April 24, 2011

August 21, 2009

Dr. Eric Asa
Dept. of Construction Management & Engerineering

Re: IRB Certification of Human Research Project:

"Construction Delays for High Rise Buildings"
Protocol **#EN10035**

Co-investigator(s) and research team: **Arun Billa**

Study site(s): **US, India, UAE** Funding: **n/a**

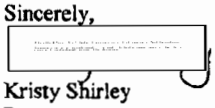
It has been determined that this human subjects research project qualifies for exempt status (category # 2b) in accordance with federal regulations (Code of Federal Regulations, Title 45, Part 46, *Protection of Human Subjects*). This determination is based on the protocol form received 8/20/09 and consent/information sheet received 8/20/09.

Please also note the following:

- This determination of exemption expires 3 years from this date. If you wish to continue the research after 8/20/2012, submit a new protocol several weeks prior to this date.
- The project must be conducted as described in the approved protocol. If you wish to make changes, pre-approval is to be obtained from the IRB, unless the changes are necessary to eliminate an apparent immediate hazard to subjects. A *Protocol Amendment Request Form* is available on the IRB website.
- Prompt, written notification must be made to the IRB of any adverse events, complaints, or unanticipated problems involving risks to subjects or others related to this project.
- Any significant new findings that may affect the risks and benefits to participation will be reported in writing to the participants and the IRB.
- Research records may be subject to a random or directed audit at any time to verify compliance with IRB policies.

Thank you for complying with NDSU IRB procedures; best wishes for success with your project.

Sincerely,



Kristy Shirley
Research Compliance Administrator