Risk Identification and Assessment as Well as Mitigation Strategies used during the Construction Phase of a Real Estate Project: A Literature Review

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Abstract: Risks and uncertainty are inherent in all phases of Project. This study deals with the various risks encountered during the construction phase of a real estate project and methods used in assessment and mitigation strategies used to reduce risks by means of literature review. The literature studies papers related to cost, quality, time, safety and communication and procurement risks during the construction phase and measures taken to mitigate the risks. The results presents a general review of risks encountered during the construction phase of a real estate project from the aspect of publication name, country, research level, type of risk and risk mitigation. The trends can serve as motivation for researchers as well as practioners for future effective measures for effective project execution.

Key Words: Cost, Quality, Safety, Procurement, Communication and Time Risks.

INTRODUCTION

Ling, Wayne, & Archer has defined real estate as property. The term property refers to assets that are physical things such as automobiles, clothing, land, or buildings. Intangible assets are non physical and include contractual rights (eg mortgage and lease agreements), financial claims (eg stocks and Bonds), interests, patents or trademarks (2012). Grasskemp describes real estate cycle having three major groups, the consumer group, production group and infrastructure group. Unlike many mass production industries, each real estate project is unique and the development process is so creative that the society has new opportunity to negotiate and debate (1992).

As per the guidelines of Report, Construction project Management Guidelines IS15883 part 1, Bureau of Indian Standards, a real estate project whether big or small involves following stages i. e. project appraisal

stage, preconstruction Phase, construction phase and finally the commissioning and handing over stage. This study deals with understanding the risks encountered during the construction stage of a real estate project and through literature identifies the various advanced techniques used to mitigate these risks. Construction project management consists of a number of processes which are scope management, Procurement management, time management, cost management, quality management, risk management, communication management, human resource management, safety health and environment management, integration management and other management processes (2009). Wells described construction as informal sector in developing countries. In India, it recognises that it comprises of two large groups of people, one low capital enterprises run by self employed people and second contains causal daily wage worker available at street groups. Informality also means the absence of regulation in terms of enterprises involved in production, notably contractors, subcontractors and material suppliers, the other aspect of regulation refers to the terms and conditions of employment (2007).

METHODS

Literature Search

Relevant papers on the topic were obtained through searching the relevant databases till July 2016 namely (EBSCO Host, Science Direct, Taylor and Francis) which cover the main peered journals in the selected field. A systematic search was done with regards to the keywords scope, procurement, time, cost, quality, communication, human resource management, safety health and environment management and integration management risks in construction sector. In the preliminary review of relevant papers some keywords pertaining to use of risk assessment were found like target value design, integration of design and safety, advanced technology to improve safety, data mining to deal construction costs, development of purchasing portfolio model, E procurement perspectives in construction, use of ICT in construction. Finally a total of 30 papers, 2 reports and 1 book review, totalling to 33 for the study were obtained.

Literature Selection

The literature has been selected based on the publications which are relevant to the subject matter. The literature review aimed to study the recent trends in the construction phase of the project. The parts of publication which did not match the research topic but matched research terms were included in the study. A preliminary review was undertaken by reading the abstract / keywords of the papers.

The Keywords in search items included risks in construction, risk assessment framework, cost risk, quality risk, time risk, communication risk, safety risk and design risk. The full list is shown in the appendix.

Literature Coding

The coding of research paper was done based on the information stored in the database in the below mentioned order. Title, keywords and abstract were the main sources for coding the paper. In the process of coding the papers, the following information was stored in form a database

1) Author of paper.

2) The title of each paper.

3) Publication year of each paper.

4) Publication type namely journal paper (J) and report (R).

5) Database.

6) Country or region (this information refers to where the studies were conducted, rather than where the authors were from).

7) Research level namely Industry level(I), Company level(C), Project level (P)

8) Project Risk namely Cost (CO), Quality(Q), Procurement(PM), Safety(S), Communication (CM), Time (T), Project (P), Construction (C) and Design (D).

9) Project type namely Building (BU), Infrastructure (I).

10) Methodology used

11) Risk Mitigation measures

Publication Type and Publication Name

Journals belong to the top construction journals including Journal of Business Economics and Management (JBEM), Journal of Construction Management and Economics(JCME), Journal of Production, Planning and Control (JPPC), Journal of Total quality Management and Business (JTQMB), Journal of Construction Engineering and Management (JCEM) Journal of Risk Management(JRM), Journal of Architecture, Engineering and Management(JAEM), International Journal of Project Management (IJPM), Journal of Procedia Engineering(JOPE), Journal of Building and Environment (JBE), Journal of civil engineering and management (JOCEM), Journal of technological and economic development of economy (JTEDE), Journal of total quality management and business excellence (JTQMBE) and Journal of total quality management. The 13 papers were studied in context of Europe, 9 for Asia, 3 for Africa and 5 for USA.
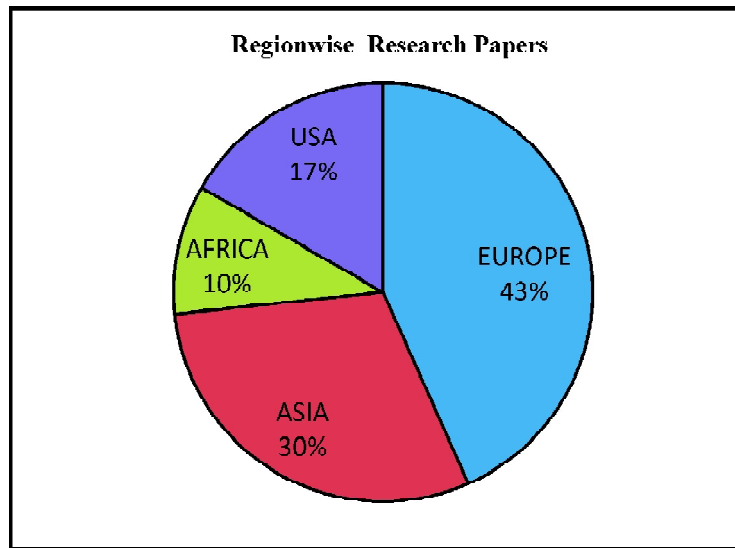

Figure 1: The number of relevant papers by Region

Source: Research papers studied for this study

Identified Risks

There are very few papers for discussion on real estate and at construction stage of Project. Existing literature on the subject risk assessment and mitigation measures during the construction phase of a real estate projects was studied with a view to leverage from research outcomes, experience and observations of various researchers. The relevant papers from some experienced industry leaders and research agencies also have been considered for study to find out their observations. As per the construction project management guidelines Report, IS 15883 PART 8, risk is considered as an exposure to a danger or hazard and is viewed as negative. However, risk could be both, a mix of danger and opportunity. Project risk management is the art and science of identifying, assessing and responding to project risks throughout the life cycle of the project and is in best interests of its objectives namely project completion within estimated time and cost and to the required specifications and quality standards. The constant goal of project risk management should be to minimize the uncertainties and move towards opportunities. The goal of risk management, therefore are to identify project risks and to develop strategies which either reduce them or attempt to avoid them so as to achieve project objectives (2013). Going through the literature, Iqbal, Choudhry, Ali, & Tamo studied risk management in construction projects. Construction projects face lot of risks which have negative impacts on time, cost and quality. The study reports that contractor is responsible for risks related to site execution and client is responsible for risks related to financial issues, design related issues and scope of work. Payment delay is on top of the list, followed by defective design, inaccurate schedule, poor performance of subcontractors, exchange rate fluctuations, improper scope of work, poor quality of materials and shortage and delay of materials (2015). Schieg studied the six process steps for integration of risk management system in construction projects. Construction Projects are risky in nature and costs of risks are not allowed for beforehand and thus reduce its profit margin. The task of risk management is to cover the risks as completely as possible (2006).
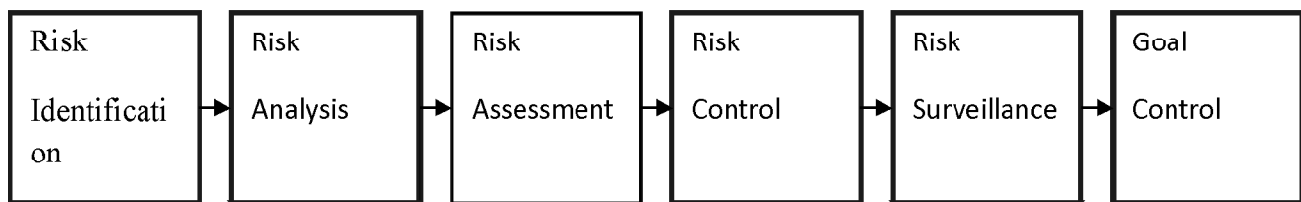
Risk Identification		Risk Analysis		Risk Assessment		Risk Control		Risk Surveillance		Goal Control

Figure 2 : Steps for integration of risk management in construction projects

Source: Risk Management in construction project management (Schieg, 2006)

Scheig studied post-mortem analysis and evaluation of risks in construction project management. This tool is used nowadays for reduction of risks. The analysis of processes, the assessment of projects, and the discovery of need for improvement are tasks of Management. The post mortem analysis takes place at defined project milestone or at the end of the project. The methodology used is root cause analysis or Fishbone diagram is used for systematic identification of problem causes (2007). Wang, Dulami, & Aguria studied risk management framework for construction projects in developing countries. The research aim was to identify the risks which foreign firms may face in operation in developing countries and to develop risk mitigation plans to mitigate such risks. It was found from the study that the top 11 critical risks

are approval and permit, change in law, justice reinforcement, local partners creditworthiness, political instability, cost overrun, corruption, inflation and interest rates, government policies, government influence on disputes and termination of JV(2010).

Tah & Carr studied the relationships between the risk factors, risks and their relationships on cause and effect diagrams. Methodology to evaluate risks considering the consequences in terms of cost, quality, time and safety performance of project based on fuzzy estimates of risk components is presented. Some common risks are labour, plant, materials, subcontractors, design or client. They concluded that by implementing the fuzzy logic allows the use of descriptive linguistic variables in the definition of risks and consequences (2000). Odimabo & Oduoza studied building construction in developing countries and observed that output of Construction Company is characterised by poor quality work, cost and time overruns. The management of project risks starts with the management of uncertainty such as errors, imprecision, vagueness, variability, ignorance and ambiguity (2013). Kazimieras, Turskis, & Tamosaitiene studied risk assessment of construction projects. The assessment is based on the multi attribute decision making methods. The attributes are taken into consideration keeping the goals of stakeholders as well as factors that have influence on construction process efficiency. The project risk can be external, project and internal. External risks can be political risks, economic risks, social risk and weather risks. The project risk can be due to time, cost, work quality, construction and technological risk Internal risks can be resource risk, project member risk, construction site risk and documents and information risk (2010). Doloi, Sawhney, Iyer, & Rentala analysed the factors affecting delays in Indian construction projects. The main objective of the research is to identify the various attributes to construction delay, to identify relationship between these attributes by statistical methods and predict the impact of these attributes on construction delay using regression analysis. They used various techniques to find results like spearman correlation technique, covariance analysis, pareto analysis. The findings from literature were issues related to low productivity, limited mechanisation and lack of professionally qualified employee which are causing problems in industry. Lack of sophistication across the construction supply chain is one of the key issues in industry (2011). Dewlaney & Hallowell, studied the Leadership in Energy and Environmental design (LEED) certified buildings and found that the injury rate was more than of traditional buildings. The researchers aim is to identify and describe risk mitigation strategies that reduce the safety risks associated with design and construction of high performance buildings by conducting extensive interviews with experienced designers and constructors (2012). Gardoni & Murphy proposed a conceptual framework for ranking the relative gravity of risks. A risk is ranked higher on scale the larger the consequences. The information from the proposed comparative evaluation can inform for risk mitigation measures(2014). Ling & Hoi studied the risks faced by Singapore firms when undertaking construction projects in India. The main risks that AEC firms face in India include political and social risks, high cost of financing, fluctuating currency exchange rate and high cultural difference between foreigners and Indians. There were also risks related to design and construction related risks (2006). Iyer, Doloi, & Sawhney studied the use of structural equation modelling for investigating factors affecting delays Indian construction projects. He found that clients influence is key factor, lack of efficient planning, lack of commitment by contractor are the root causes of delays(2012). Based on the above, a risk matrix was prepared to identify various risks during the construction phase of a real estate project.

Table 1
Risk Matrix

Risks encountered during the Construction Phase of Real Estate Project

Cost of Construction	Cost overruns in projects	**Lack of clarity on building Bye laws**	Type of building to be constructed
	Effective estimation of costs		Changes in Floor Area Ratio
	Quality of Construction		Changes in ventilation requirement
	Change in scope	**Bidding**	Short Bid preparation Time
	Non availability of information at start of project		Aggressive competition at construction stage
Shortage of Labour	Workforce Unavailable		Project Documents Contract Clauses
Contract Duration	Delay in payment	**Site Management**	Inefficient site management.
	Inaccurate Schedule		Lack of clarity of scope.
Quality	Quality of GFC drawings		Inexperienced contractors
	Approach of Project Manager and project participants		Slow decision from owner
	Poor work environment		Errors in Execution
	Harsh climatic conditions		Poor labour productivity
	Aggressive Bidding to quote low		Lack of communication
	Inferior quality material		Improper planning
	Bad Technical practices		Ignoring contract provisions
	Management Commitment		
	Customer Focus	**Safety**	Poor interface of design and safety
	Team work		Poor Supervision
	Employee Empowerment		Cost and time pressures
	Loss of Customer		Uncontrolled changes
	Increased overheads		Poor Communication
	Delay in projects		Lack of use of technology
	Poor communication among participants		Management commitment

contd. table 1

	Conflict between PM and Project Participants		Employee Involvement
	Proper analysis at the start of job		Training and Audits
	Monitoring of quality with check sheets		Organizational Culture
	Compromising quality to meet schedule and cost objectives		Greater degree of housekeeping
			Safety reviews in early design
Design	Delay in decision making by client		Clause for safety Mgmt in tender document
	Defective design		Remoteness of responsibility
	Discrepancy in tender document	**Environmental**	Pollution during the development of Project
	Designed concepts mismatch with customers requirements		Degree of the difficulties in site preparation
	Frequent changes in design		Delay in Approval from Authorities
Procurement of materials	Variation of construction material price		Environmental Impact
	Inappropriate scheduling of materials	**Financial**	Risk caused by large project values
	Right material at right time for project completion		Funding problem
	Demand Forecasting	**Manpower**	Lack of professionally qualified manpower
	Lack of sophistication across supply chain		Lack of Knowledge
	Delay in delivery of material		Non Existence of cooperation
	Improper handling of materials		Reluctance in timely decisions
	Price escalation of materials		Lack of commitment
	Classification of critical items		Poor Labour Productivity
Regulatory and Urban Planning	Lengthy Approval Process	**Technological**	Difficulties in Design
	Conversion of Land use		Difficulty in delivery
	Change in law		Difficult execution

Risk Mitigation Strategies

Going through the risk matrix, we have found that there are number of risks encountered during the construction phase of a real estate project. These risks lead to increase in construction cost, delay in achieving project timelines, procurement delays, improper safety practices followed during project execution, frequent design change, bad project quality and lack of communication between the project stakeholders. Going through the literature, research papers were studied to find out the risk mitigation strategies. Wong & Norman studied the problems related to delay in the supply of construction materials and inappropriate scheduling of materials in construction projects. The study illustrates the use of materials planning system (MPS). The objective of construction materials planning system (CMPS) is to have right material in right quantity and at right time to complete the project. Better handling of materials helps in proper planning and prevents delays. The MPS requires massive data storage, retrieval and computational capabilities which can only be achieved by using the computers. CMPS is used to determine what to order, order quantity, ordering time and when to schedule the delivery. CMPS is driven by the MCS (Material Construction Schedule), which is statement of which construction activities are completed and the dates by when they are completed. CMPS needs to show how much is on hand, how much is allocated and how much is available for forecast demand.
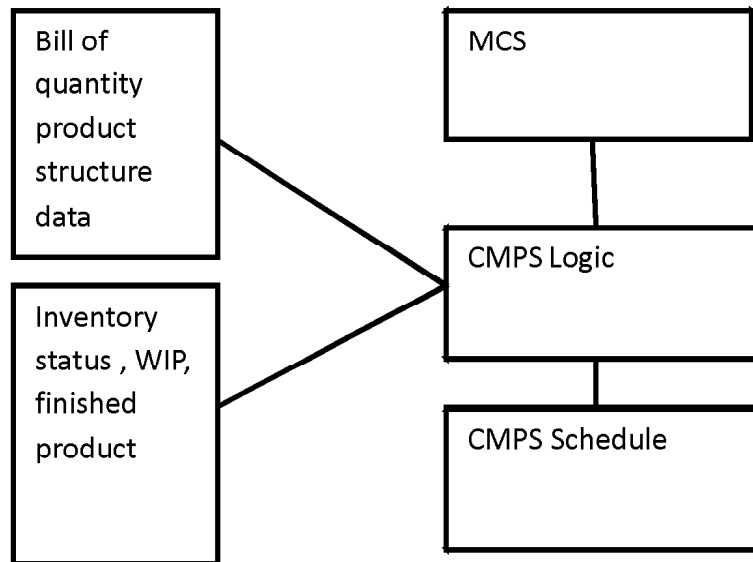

Figure 3: Input requirement of a CMPS

Source: Economic Evaluation of Materials Planning System for Construction (Wong&Norman, 1996)

This technique was used in local construction projects in Hongkong and was found to be be positive throughout the project. This has helped in better handling of materials and components and eliminates project delays resulting in a better service (1996).

Osipova & Eriksson studied the procurement variables that influence the risk management. The focus of the study is on three variables which have been identified as project delivery method (design responsibility), form of payment (how contract price was formed) and use of any additional collaboration arrangements. From the discussion we find that the competent clients will go for general contracts so that

they can influence in the decision making of project. The architects and design managers involvement is important from risk management view point as design is the source of considerable risk in the project (2011).

Ferreira, Arantes, &Kharlamov developed the purchasing portfolio model for construction industry. They used Analytical Hierarchical Process for prioritization of construction item classes. The selection of the right purchasing strategy is important and need for an improved approach to purchasing is evident and impacts company performance. Based on this it was found that out of 28 items, five items are in bottle neck category and represent 17. 9% of the total amount purchased. One item is of strategic importance and comprises 3. 6% of amount purchased. Five items are in leverage category and represent 17. 9% of total amount purchased. And 17 items are non critical and comprise 60. 7% of total amount purchased. This research helped the company in outsourcing of non critical activities and and keeping in house strategic and bottleneck activities (2014).

Vitkauskaite & Gatautis studied the internal processes of construction SME and evaluate possibilities to use ICT to optimise those processes. The research was carried out within e – NVISION project which aims at providing insight into some of the areas like e procurement. The procurement process of acquiring products and services for the construction takes following aspects. Look for suppliers offering whole products like house /part of construction /installations. Look for suppliers offering specific services like designers to make plans, engineers to make calculations. Choosing of PMC the most appropriate supplier to buy some building products that construction company will use to build. Findings of the article show that a successful implementation of procurement configuration will increase the speed and initial selection of suppliers. Integration services will improve analysis of offers / quotations received in order to select the best possible supplier (2008).
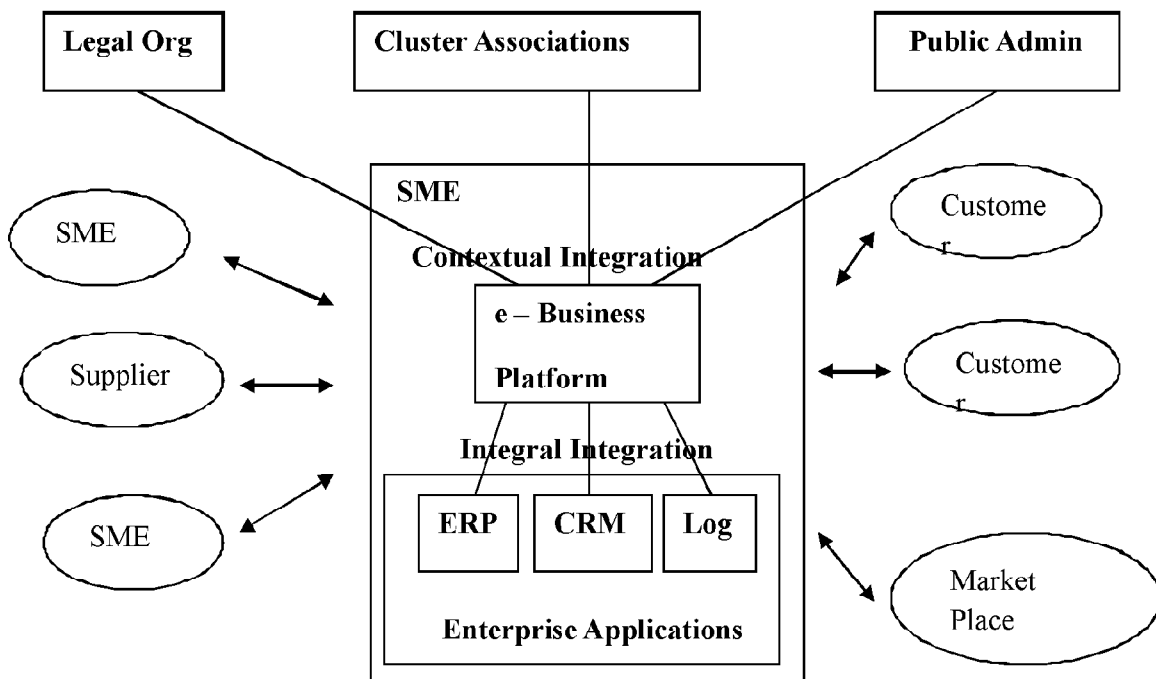

Figure 4 : ICT implementation for procurement in construction Sector

Source: E Procurement perspectives in construction SME s (Vitkauskaite & Gatautis, 2008)
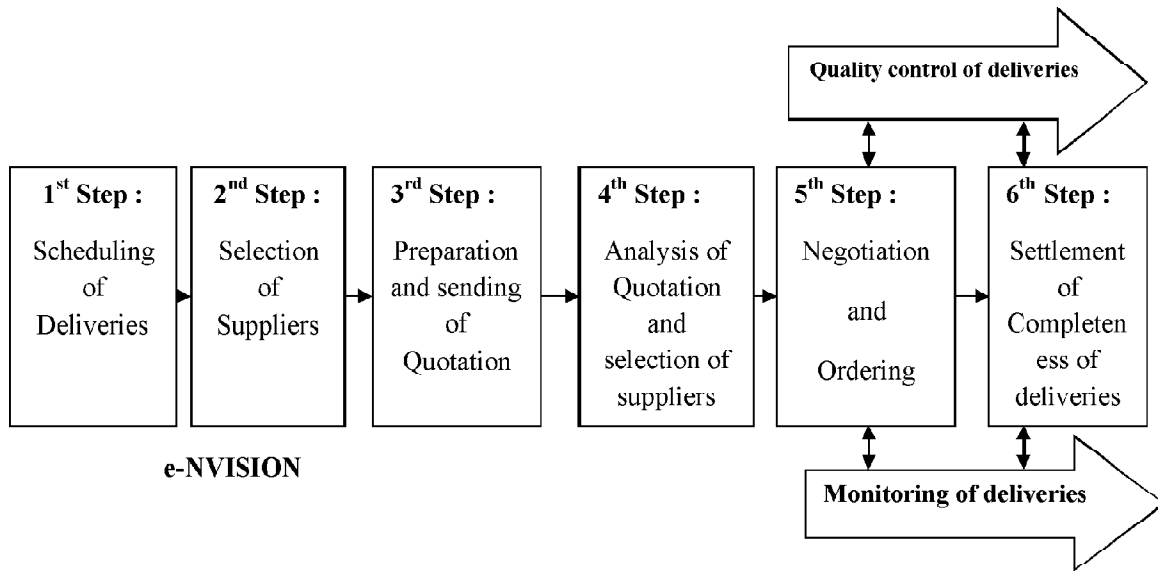
1st Step : Scheduling of Deliveries	2nd Step : Selection of Suppliers	3rd Step : Preparation and sending of Quotation	4th Step : Analysis of Quotation and selection of suppliers	5th Step : Negotiation and Ordering	6th Step : Settlement of Completeness of deliveries

Quality control of deliveries

Monitoring of deliveries

e-NVISION

Figure 5 : Schematic representation of procurement process

Source: E Procurement perspectives in construction SME s (Vitkauskaite & Gatautis, 2008)

Research papers were studied on design and following were the learning's from the papers. Larsen & Whyte, studied how the work of designers impacts the safety of construction site. The interface between design and safety is misunderstood. This study aims to understand how the team executing the project find problems in construction design and their response to the problems. After analysing the interviews it is revealed the priority of designers is aesthetics which leads to difficulty in construction process. Due to complexity of projects, this has led to extensive design changes. The design freeze was mentioned by interviewees but it has become challenging to manage the design changes (2013).

Zimina, Ballard, & Pasquire described target value design as the management approach that takes target value costing and applies to the construction projects. The target value costing includes several phases ie work scope brief by client, budgeting and Pain / gain share mechanism is the distinguishing feature of these contracts, if the contractor completes job below target cost he is awarded for efficient management. As per the study done for 12 projects it has been found on a average have under run market costs by 15%. The aim is to define value of the facility and constraints first of all financial what the client is able and willing to pay to get this value. Target costing to design a building based on some budget rather than budgeting the design after it has been executed. Target cost of project gives the figures on the basis of which design team has to work (2012).

Atkinson & Westall studied the integration of designers and constructors for improved safety in construction. According to the literature, there are mixed interpretations. Some researchers say that building designers are influential but they do not know how to design for build ability and safety. Some designers are willing to design for safety but due to limitation of time and cost they do not go ahead for the same. There has to be integrated partnering between the designers, contractors and subcontractors for the better opportunities for safety reviews early in design (2010).

Zhou, Irizarry, & Li studied the application of technology for better construction safety management. A number of technologies have been used in construction safety which includes geographical Information
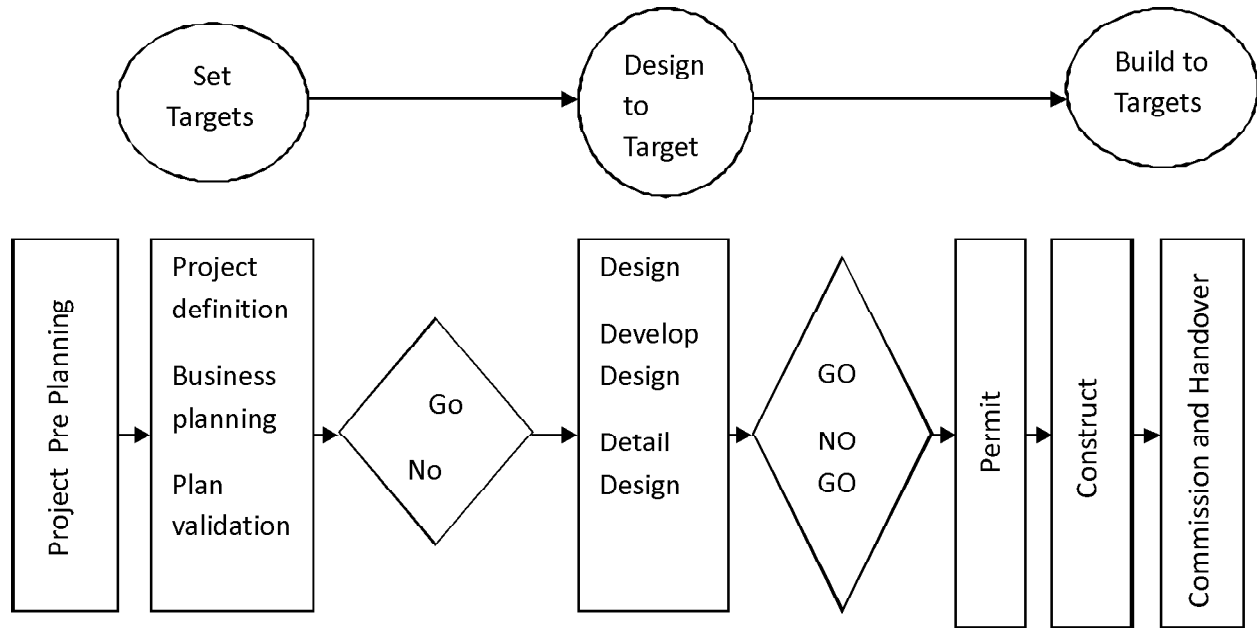
Figure 6: Target value Design Process Scheme

Source: Target Value design: using collaboration and lean method to reduce costs (Zimina, Ballard, & Pasquire, 2012)

System, Information communication technology, radio frequency identification and virtual reality. . The real time tools like Global positioning system, Radio frequency identification, building information modelling are used to store large amount of information for risk evaluation and accident prediction (2013).

Dagbui & Smith, studied cost overruns in construction projects and showed how data mining can be effectively used to predict the budgets of projects. Advances in the field of data warehousing, artificial intelligence can be used to develop data as assets for decision making. Data mining process consists of understanding data, preparation of data, proper modelling and deploying the data for using the information for new upcoming projects. This study consisted of 1600 completed projects and data taken from them was used in cost estimation of new projects and it was found that 92% of predictions were within +/- of 10% of actual costs of final projects (2014).

Oztas & Okmen studied risk analysis in fixed price design – build construction projects. The study presents a literature survey on the issues of risk; risk management and design build contract systems. It also proposes a schedule and cost analysis model through a case study. The literature suggests the use of tools like Montecarlo Simulation for evaluating uncertainties on construction projects that are procured through design build construction management. It also suggests that problems faced during execution of design built projects are due to lack of payment, ignoring contract provisions, change in government and politics in general. The study addresses the applicability and necessity of the risk analysis process in examination and evaluation of schedule and cost characteristics of fixed DB projects. Risk analysis process as a step of project risk management system can be performed at tendering and estimating stages of project. Risk analysis techniques are grouped into two parts quantitative and qualitative. Qualitative approach consumes the gathered information through direct judgement, ranking options, comparing options and descriptive analysis. Quantitative risk analysis such as Montecarlo Simulation is used for performing statistical models.

The DB contracts are popular these days because one point responsibility for both design and construction part of project.

The methodology used in this study is Montecarlo simulation using crystal ball program and MS projects for schedule risk analysis. The models consists of schedule risk and cost risk model. The case study taken was from one of the construction projects in Turkey. The findings from the study were in form of bidding and contracting deficiencies. There were 14 risks that were explored from project documents, contract clauses, conversations. The owner finished project with total payment of 130. 6 billion which was 84. 5 billion.

The conclusion of this study is that a design built project has been examined from the builder point of view. Design Built projects are very risky especially for inexperienced contractors. Apart from experience risk analysis should be done during the decision making while quoting the bid price. Client should comprehensively give their requirement in the tender documents to prevent design changes and delay in design (2004).

Jha & Iyer studied the critical factors affecting quality performance in the construction projects in India. In the context of project management, the schedule, cost and quality achievements is referred to as Iron Triangle. In order to achieve schedule and cost objectives, project quality is sometimes overlooked. The most important success attribute for quality compliance of construction projects is the positive approach of Project Manager and Project participants. The quality of project also gets affected by poor work environment, harsh climatic conditions and aggressive bidding to quote low for the project which leads to use of inferior quality materials and bad technical practices (2006).

Rosenfeld studied the cost of quality versus the cost of non quality in construction to determine the optimal level of investment in quality by construction companies. The methodology he adopted was quantifying the four types of quality related costs in residential construction. The first two are called cost of quality and the last two are called cost of non quality. The findings were that internal failures are the most expensive component of the quality related costs and cost of non quality were always higher than cost of quality. Also it was found that investing less than 2% in prevention and appraisal will lead to higher failure cost whereas an investment of over 4% most probably will not pay back itself (2010).

Elbarkouky, Aboushady, & Marzouk studied the fuzzy consensus of qualitative risk analysis framework as is composed of a fuzzy expert system to determine the qualification of experts. The literature suggest the use of techniques like Decision Tree, Montecarlo Simulation, sensitivity analysis, fault tree analysis, fuzzy logic to analyze risks. The statistical analysis of experts determined mean, median, mode, standard deviation and standard error. This has helped in qualitative evaluation of risks (2014).

Aspinwall & Hernandez studied a framework for building quality into construction projects. A total quality management framework has been built to build quality in projects; the framework includes quality policy, product and service quality (2008).

Loushine, Hoonakker, Carayon, & Smith studied the quality and safety management in construction and emphasized that the company ability to deliver a quality product in a safe manner is key to a business success. The study was carried out in US where construction employs less than 7% of work force and accounts for 22% of occupational fatalities. Poor work quality and unsafe conditions cost billions of dollars to the construction company. A common response to the cause of decrease of quality and safety in

construction is the nature of work environment. The nature of construction is a cooperative effort of several participants each with their own perspectives and interests in hand. The nature of construction clearly presents a barrier for successful safety and quality efforts. Poor work quality and unsafe work conditions have cost billions of dollars to the construction companies, owners and their families (2006).

Sawhney, Mukherjee, Rahimian, & Goulding studied the use of Information and communication technology to support in the Indian construction Industry. It also emphasizes the benefits of ICT as means of not only enhancing the existing business but also creating the new innovation opportunities. Construction sector has been referred to as a sector that has missed the ICT revolution, this sector has not fully embraced ICT compared to other sectors due to peculiarities of the sector, operational boundaries and fragmentation. The main incentives behind the adoption of ICT by SME relate to reduced transaction cost, lower risk, information gathering / dissemination, increased inventory control and improved relationship between customers and suppliers (2014).

CONCLUSION

The recent papers from different continents have been studied on different kind of risks encountered during the construction phase of real estate project and mitigation strategies used to mitigate those risks. The study also mentions the use of advanced techniques used to reduce risks due to cost, quality, time, safety, communication and procurement risks during the construction phase of a real estate project. Through search and selection a total of 30 papers, 2 reports and 1 book review were obtained. These were compiled in form of a database by literature coding, publication information about title, year, type, region, research level, project phase, project type and methodology used. The results presented a general overview of various risks and tabulated in form of a risk matrix table and then mitigation strategies used to mitigate these risks through literature review. Some of the mitigation strategies used in reducing the risks for procurement are use of Construction Material Planning System (CMPS), the form of payment for contracts, the purchasing portfolio model (PPM), use of information communication technology (ICT) and software's like e-NVISION for procurement. For design use of target value design (TVD) and freezing of design and not allowing any changes helps in mitigating risks. Regarding safety, there has been integrated partnering between designers, contractors and subcontractors for better opportunities for safety reviews in early design. A number of technologies also have been used in construction safety which include geographical information system (GIS), radio frequency identification and building information modelling (BIM) used to store large amount of information. For cost overruns using of data mining process, data warehousing and artificial intelligence can be used to cost estimation, for quantitative risks montecarlo simulation has been used to for evaluating the uncertainties in projects. The quality success of project depends on the positive approach of project manager and project participants. Companies who have invested less than 2% of cost in prevention will lead to higher failure and over 4% will not pay back itself. Decision tree, sensitivity analysis, fault tree analysis and fuzzy logic have been used to analyze qualitative risk analysis. Regarding information and communication technology, it is missed by real estate sector and increasing use of this can help in improved relationship between customers and suppliers, reducing transaction cost and increasing inventory control. Research gap were identified namely studies which have not focussed on preconstruction stage, maintenance stage. Future researchers and practioners can conduct studies to study the gap areas and identify risks during these stages and the strategies adopted to mitigate these risks.

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Appendix
List of Journal with type of risk and risk mitigation strategies

Year	Publication Name	Country	Research Level	Type of Risk	Risk Mitigation
2000	JCME	UK	I	C	FUZZY LOGIC
2004	JBE	TURKEY	C	D	MONTECARLO SIMULATION
2006	IJPM	SINGAPORE	I	P	INTERVIEW
2006	JTQM	INDIA	C	Q	PILOT SURVEYS
2007	JBEM	GERMANY	I	C	POST MOTREM ANALYSIS
2007	JTQMB	USA	I	Q	CUSTOMER FOCUS
2007	JCME	UK	I	C	LITERATURE REVIEW
2008	JTQMB	UK	I	Q	QUALITY IMPROVEMENT TECHNIQUES
2008	JOCEM	EU	I	PM	E- NVISION
2008	JTQMBE	UK	P	Q	TOTAL QUALITY MANAGEMENT
2010	JCME	HONGKONG	C	PM	CONSTRUCTION MTL PLG SYSTEM
2010	JBEM	GERMANY	I	C	LITERATURE REVIEW
2010	JCME	UK	P	S&D	SAFETY SCORES T TEST
2010	JCME	SINGAPORE	C	C	RISK RATING SYSTEM
2010	JCME	ISRAEL	I	Q	LITERATURE REVIEW
2010	JCEM	LITHUANIA	I	C	MULTI ATTRIBUTE DECISION MAKING
2011	JCME	SWEDEN	C	PM	PROJECT DELIVERY METHODS
2011	IJPM	INDIA	I	C	PARETO ANALYSIS COVARIANCE ANALYSIS
2012	JCME	USA	C	D	TARGET VALUE DESIGN
2012	JCME	USA	I	D	INTERVIEWS
2012	JCME	INDIA	I	C	STRUCTURAL EQUATION MODELLING

2013	JCME	UK	I	D	BUILDING INFORMATION MODELLING
2013	JCME	USA	P	S	RFID, GPS GIS, VR
2014	JCME	UK	P	CO	DATA MINING DECISION SUPPORT SYSTEM
2014	JPPC	PORTUGAL	C	P	ANALYTICAL HEIRARICHAL PROCESS
2014	JRM	USA	I	C	SOURCES OF RISK
2014	JAEM	CANADA	I	C	DECISION TREE FAULT TREE ANALYSIS FUZZY LOGIC
2014	JOPE	INDIA	I	CM	INFORMATION COMMUNICATION TECHNOLOGY
2015	JCEM	NIGERIA	I	C	CASE STUDIES QUESTIONNAIRE SURVEY
2015	JTEDE	PAKISTAN	P	C	QUESTIONNAIRE SURVEY

Legends: For Research Level C – Company, I – Industry and P – Project

Project Risk - CO- Cost, Quality – Q, Procurement – PM, Safety – S, Communication – CM, Time –T, Project – P, Construction -C and D- Design