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Research paper



Validation of Impacts of Widely Acknowledged Human Factors in Risk Management of Residential Construction Projects

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Abstract

In the countries like India where one has to still handle a unique blend of operational diversities like human operated traditional construction practices and modern construction technologies, in all construction projects that are highly vulnerable to socio-economic, political, technical and business risks. The involvement of the people with diverse educational, technical, economical and experience backgrounds is an unavoidable fact of the construction industry in India and hence the human factors are going to play a key role in the project to be more prone to risks as well as to mitigate the likely projects risks. Due to lack of robust risk management system, many prestigious construction projects in India have suffered failures and have impacted the country's GDP and growth because of the gigantic share of the construction industry in the country's economy. Hence, the risk management in the construction industry has become the subject of concern for the industry practitioners and so the analysis of operational difficulties for the identification and management of construction related risks to minimize the cost overruns, quality deviations and uncertain delays, is remained to be the main objective of the research by the domain experts and engineers for so long. In this paper, an attempt has been made to review all such papers with a specific aim to identify and analyze the human factors that, are highly acknowledged by experts in their works and, can influence / impact the project parameters namely cost, time and quality and validate the results by tracking a real time construction project to draw conclusions.

Keywords: *Risk management, Residential projects, Factors influencing human factors, Akaike information criterion, Primavera*.

1. Introduction

As is defined by ISO 31000, risk is "the effect of uncertainty of objectives". In the highly uncertain and high probable risk environment of construction industry, some of the risks can be predicted and identified at the initial stage itself to develop an effective management system to plan and mitigate those risks. The essential purpose of risk management is to improve project performance via systematic identification, appraisal and management of project related risks. It is undisputable that the construction industry is one of the prominent sectors in India as it contributes a lot to the economic growth of the nation next to the agricultural and its allied industries. Construction sector involves not only the huge amount of capital but also consumes the wide employment circle of labour force in the country as this industry is still depends on the manual operations on certain activities like making concrete where mixing, placing and finishing is done manually. Involvement of more human with diverse backgrounds, has made this industry a 2nd highest employment generating industry in India but on the negative side, it has made the industry more prone to human factor influenced project risks to record failures of the most prestigious projects that impacted the GDP and growth rate of the country because of this industry's gigantic share in the country's economy growth. And also due to the involvement of several stake holders, the human factors, that influence the key parameters of the project to be more prone to risks, are the key to understand, identify and analyse for a project to be successful and helpful to the industry practitioners to design, plan and implement a robust risk management system.

2. Objectives

The objectives of the study are

- To identify the various most likely human risk factors in the residential construction projects.
- To evaluate the impact of the identified human risk factors on a residential projects through the questionnaire survey conducted on the field experts from across the industry.
- To identify the most influencing human risk factors by the statistical analysis (by AIC method) of the responses obtained from the field experts through questionnaire survey.

3. Literature Review

The project risks have been the culprit for the failure of many construction projects not only in India but also across the globe. Following few of the many such research works on risk management in construction industry with a special emphasis on a subject of concern, human factors involved in risks, from literature survey are discussed.

3.1 Desai Madhura .c and Prof.s.v.desale (2013) says that the project is said to be successful only when the project is completed in time with a budgeted cost.

The problems arising out of the project risks are likely to occur at any time of project or during the life cycle of the project leading to

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litigations and disputes. Subsequently a questionnaire was prepared and survey conducted with various stake holders like the owner, engineer and analysed by using frequency index and importance index to identify the major factors.

3.2 Dr. Patrick, Dr. Guomin zhang and Jia-yuan Wang (2014) says that the management of risks, in the construction projects, is recognized as an important process in order to achieve the objectives the project in terms of the three main aspects of construction projects namely cost, time and quality. This work is also based on the questionnaire survey conducted on risks and data analysis method is used to analyze the responses to conclude on risk management measures.

3.3 A. Suchit Reddy (2015) had conducted survey to identify, characterize the risks involved in construction projects and also to identify the ways to reduce the risks. The main conclusion of this project is that the risk management can mainly be linked to the production phase (construction phase) as majority of the risk processes are executed during the construction phase only.

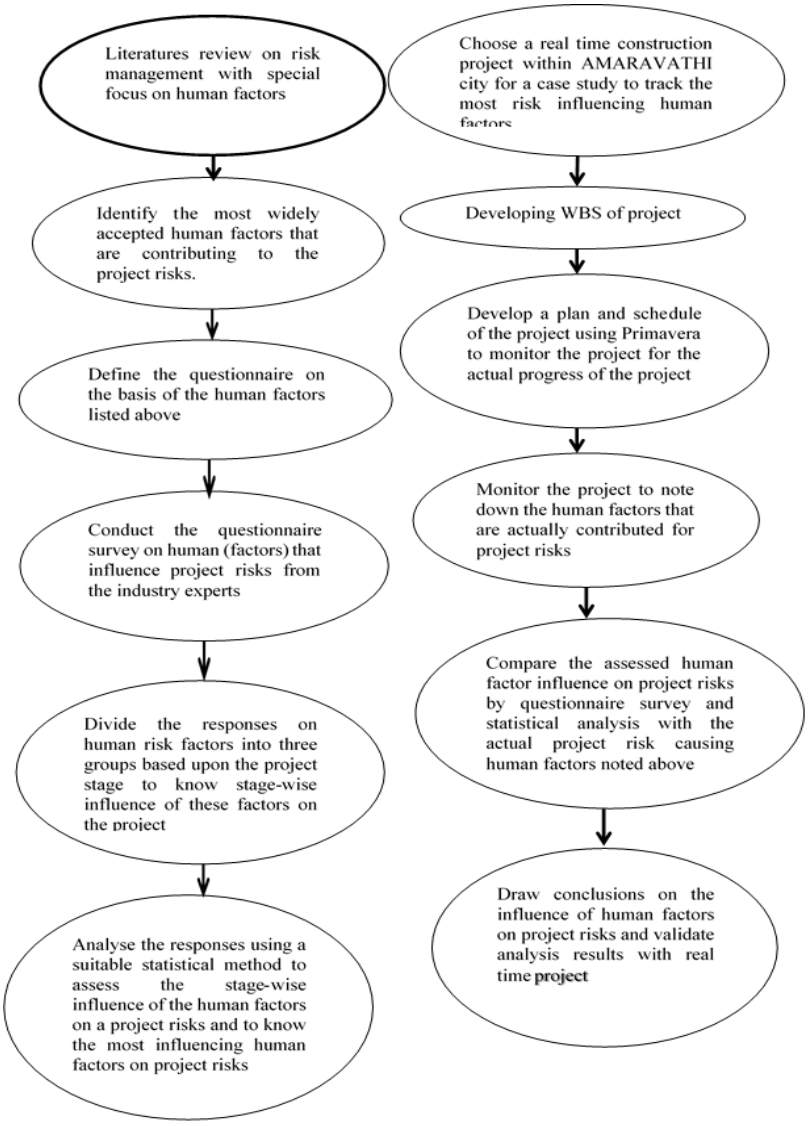
3.4 Divya guitar, Manoj Sharma, Dr, Ash tosh and Shankar Trivedi (2015) says that managing the risks in the construction projects has been recognized as a very important management process to realize the undertaken goals of the construction project aspects such as time, cost, quality, safety and environment. Questionnaire survey was conducted to understand the risks involved in such projects and to plan better for the mitigation of the same. It was found, through this study that the financial risk is occurring in every project phase. All the stake holders have to work closely to mitigate the risks in the construction projects.

3.5 Patel Kishan, Rajiv Bhatt and Prof. J. J. Bhavsar (2014) says that every construction project has unique characteristics and factors of controlling such as a time limit, financial constraints, specific objects, legal conditions. Many construction companies often establish a risk management system in their construction projects for improving their performances, minimizing the losses and gaining the profits. In this work also the authors have conducted a survey based on literature review, and are analysed according to the factor-wise influence / importance associated with the project risks

4. Research Methodology

The methodology adopted / involved in this research work is comprised of the two processes of sequential steps, as per the objectives set for this study, that runs parallel throughout the research until the analysis and comparison of the outcomes of the both the processes are done to conclude on the research work as shown in the detailed flow chart given below.

Methodology Flow Chart



4.1 Literature Review

A total of nearly 40 journals have been studied to identify the human risk factors that influence the residential construction projects. Some of those reviewed journal details are given in the above section of literature review. As a result of which we were able to identify the 40 most common and most likely human risk factors that affect the residential construction projects.

4.2 List of Most Widely Accepted 40 Human Factors That Influence the Project Risks

The most likely 40 Human factors that influence the residential construction project risks with categorization under three 3 stages of construction project cycle, namely Feasibility Stage (FS), Pre-construction or Engineering Stage (PS) and Construction (CS) are given in the table-1 below:

Table 1: Most widely accepted 40 human factors that influence the project risks

Q. No	Most widely accepted 40 Human factors that influence the construction project risks	FS	PS	CS
1	Delayed decision making by stake holders	√		√
2	Financial capabilities of investors / management	√		√
3	Intervention of stake holders into the technical aspects of a project	√		√
4	Stake holder's technical knowledge	√		√
5	Inappropriate planning by contractor			√
6	Financial capabilities of a contractor			√
7	Bad / inappropriate engineering practices / construction methods by contractor			√
8	Inexperience of the contractor			√
9	Rework due to errors by contractor			√
10	Improper site management by contractor			√
11	Delays in preparation of plans and drawings by architects / consultant	√		√
12	Lack of coordination of Architect	√		√
13	Delays in conducting inspections / tests by consultant			√
14	Consultant’s reluctance / unwillingness to adapt to change management decision by investors / builders	√	√	√
15	Inexperienced consultant	√	√	√
16	In-efficient labour and Low output			√
17	Labour quarrels and strikes			√
18	Non-attendance of labour			√
19	Legal disputes among stake holders and negotiations	√	√	√
20	Contractor's inappropriate forecasting of the project time lines during bidding stage		√	√
21	Unexpected project Claims by stake holders / individuals	√	√	√
22	No communication / Miscommunication among stake holders	√	√	√
23	Negligence to work hazards and accidents and injuries at site			√
24	Delay in decision of plans / design by owner / investor	√		√
25	Payment delays by owner / investors			√
26	Abrupt work termination of employees	√		
27	High expectation of owner / investor	√		
28	Inability to identify critical activities of a project		√	√
29	Changes made by owner during construction			
30	Delay's in subcontractor's work			
31	Abrupt exit of a consultant from the project	√		
32	Project manager’s technical capabilities		√	√
33	Usage of inappropriate planning tools and techniques in project		√	√
34	Temporarily pausing key decisions PM and management		√	√
35	Negative attitude of project manager		√	√
36	Project manager's lack of communication and leadership quality		√	√
37	Not maintaining target schedule by top management			√
38	Project manager's sudden exit from the project		√	√
39	Selection of inappropriate equipment		√	√
40	Lack of co-ordination between project participants		√	√

4.3 The Template for the Questionnaire Survey

Based on the identified human risk factors that influence the residential construction projects, a template to conduct the literature survey to identify the most influencing or to rate the human risk factors out of the identified risk factors by the statistical analysis, is designed to track OR record the responses as obtained from the

field experts through the online questionnaire survey. A snap shot of the designed template is given below and to access the complete survey template, follow the link given below.

URL:

https://docs.google.com/forms/d/1MfhFtcTSFxShZnP_JiyEETYMa94YOp24vye6jK0Vm0U/edit

4.4 Stage Wise Division of the Responses Received Through Questionnaire Survey

A total number of 100 responses are received, by the time the research work has reached to the stage of conducting analysis, through the template of the above questionnaire survey from the Project Managers, Construction engineers, builders, investors and contractors. These 100 responses received are divided into three groups that belongs to the 3 stages of construction project cycle as defined in the section 4.1 above, namely Feasibility, Pre-constriction OR Engineering and Construction stage for the analysis of the responses to evaluate the stage-wise influence of these human factors on residential construction projects.

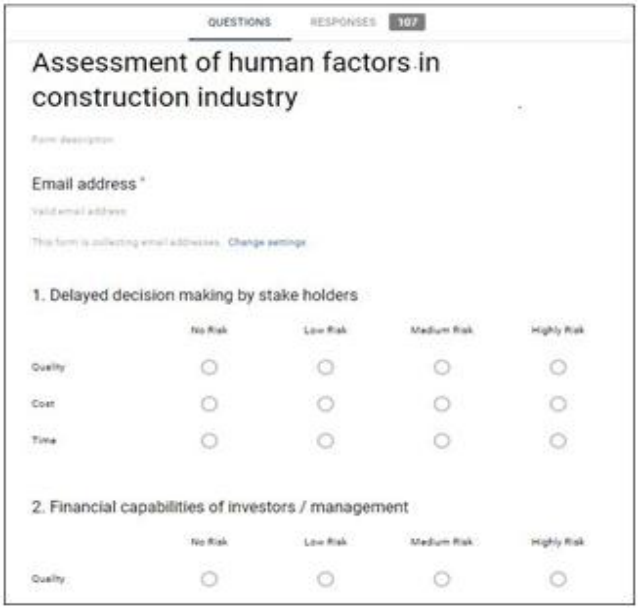


Fig. 1: Template of Questionnaire Survey

4.4 Analysis of the Responses by a Suitable Statistical Method

The most critical and important part of this research work is the analysis of the responses received from the field experts by a suitable statistical method to evaluate the stage-wise impact / influence of these human factors on the three key parameters of the construction projects namely project cost, project schedule time and project quality. The method chosen for statistical analysis is the Akaike Information Criterion (AIC).

Akaike Information Criterion

The Akaike information criterion, AIC, was basically developed, to estimate the expected Kullback-Leibler information between the models generating the data and a fitted candidate model by Akaike. It is simply a measure of relative quality of a statistical model for a given set of data and it is the measure of the relative quality of a statistical model for a given set of data. As such, AIC provides a means for model selection. AIC will have to deal with the trade-off between the goodness of fit of the model and complexity of the model. It is founded on information theory and offers a relative estimate of the information lost when a given model is used to represent the process that generates the data. The Akaike Information Criterion (AIC) is widely used in model selection because it is an estimate of the expected Kullback-Leibler information of a fitted Model.

Hence it is understand to be the best fit method to evaluate the relative importance / influence of the human factors in the scenario of involvement of multiple factors of the three different parameters namely cost, quality and time to deal with.

If all the models in the set assume normally distributed errors with a constant variance, then AIC can be easily computed from least squares regression statistics as

AIC is given by,

$AIC = N*\log(RSS/N) + 2K$

RSS is the Residual Sum of Squares and K is the number of model parameters, it is 3 in our case (cost, quality and time), N is the number of samples, it is 40 in our case.

4.5 Selection of a Residential Construction Project to Track the Impact of Risk Influencing Human Factors on the Project Parameters

A 16 storey residential building located in Bhavanipuram of Vijayawada is selected. This residential project consists of 2 podium level car parking and G+13 floors of residential apartments.

Details of the project

Cost of the project	= 99.96 Crores
Total area of the project	= 1.5 Acres
Floor area	= 19500 sqft
Total no: of units	= 234 units
Built up area for 2 BHK	= 10000sqft – 1294sqft.
Built up area for 3 BHK	= 1332sqft – 1976sqft
Each floor consists of	= 17 flats
Unit 1, 2,4,12 consists of	= 3 BHK
Unit 16, 17 consists of	= 2.5 BHK
Remaining	= 2 BHK
Start date of the project	= October 2013
Progress of the project	= 25th September 2017



Fig. 2: Taken live project

4.6 Project Management using PRIMAVERA SOFTWARE to plan, Schedule, Monitor and Update the progress of the project

A project management tool for the delivering the project efficiently in terms of project cost, time and quality. This software is useful to complete the project in specified time and cost by creating strategies to control the delay, to minimize the cost and to optimize the resource. Primavera is project management software used to plan, Schedule, Monitor and Update the progress of the project activities.

Steps involved in implementing a project in primavera

Enterprise Project Structure (EPS): EPS represents the hierarchical structure of all projects in the database.

Organizational Breakdown Structure: After the EPS, the main step involved in primavera is to create OBS which shows the persons responsible for the project in the enterprise.

Interlinking: both enterprise project structure EPS and organizational breakdown structure OBS.

Create a Project: After interlinking both OBS and EPS, a project has to be created. A project is a collection of tasks or activities that all together results in the creation of the product / Structure

Creating Calendar: A calendar has to be created to calculate the start and finish dates of a project. These project calendars form a part of the project schedules.

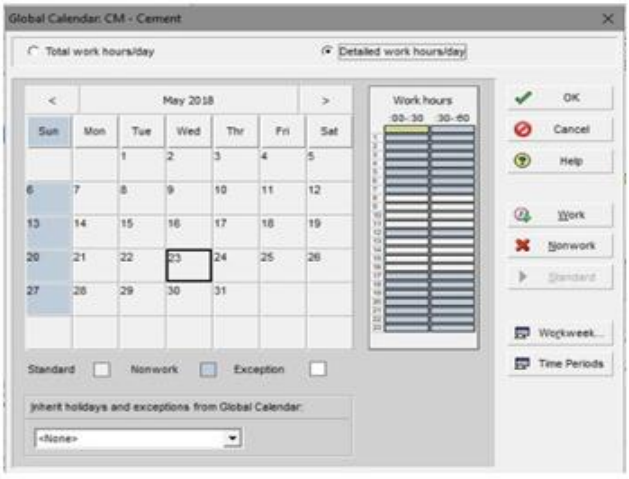


Fig. 2: Project calendar

4.6.1 Creating a Work Break Structure (WBS)

One of the first steps in planning a project is to break down the project into its major deliverables i.e. major products or project components, and is called a WBS. WBS helps to maintain a focus on the product. Focus on the breaking the deliverables down into component product elements that are small enough so that work activities can be clearly defined and assigned to these elements.
The breaking down of a project into component elements requires a study of methodology of execution. In construction projects, this execution methodology, generally known by the term method statement, is evolved by concerned planning engineer using his construction experience and through discussions with the particular functional managers and project engineers.
The work breakdown structure of our project comprises of 13 stages, namely 1) Finalization and approvals 2) Engineering and design approvals 3) Planning, Mobilization and ground work 4) Sub structure 5) Super structure 6) Brick work 7) MEP works 8) Plastering works 9) Tiles work 10) Wood works 11) Painting Works 12) UPVC windows 13) Finishing with a total activities of 345.

WBS Code	WBS Name	Total Activities
1-14	G+16 Residential Building Reflection Ref	345
1-14.F&A	Finalization & Approvals	5
1-14.EDA	Engineering Design Approvals	7
1-14.M&GW	Mobilization & Ground Work	10
1-14.SS	Sub Structure	66
1-14.Sup	Super Structure	183
1-14.BW	Brick Work	1
1-14.MEP	MEP Works	60
1-14.PW	Plastering Work	3
1-14.TW	Tiles Work	1
1-14.WW	Wood Works	1
1-14.PW1	Painting Works	3
1-14.UPVC	UPVC Windows	1
1-14.1	Finishing	4

Fig. 3: Work breakdown structure of the project

4.6.2 Listing the Project Activities

After creating the Work Breakdown Structure, it is time to define the activity i.e., breakdown of components into sub components. Activity is deliberated as a task or an event which helps in finishing the undertaken project. Each activity has its own duration, start and finish dates and logical relationships which help in scheduling the project. And all these stages consist of 345 activities

4.6.3 Assigning Relationships among Activities

After entering all the tasks, the next step is to assign the relationships like finish to start (FS), start to finish (SF), finish to finish (FF) and start to start (SS) among the activities. These relationships play an important role for scheduling.

4.6.4 Assigning the Resources

Resources like men, machinery and material are to be assigned to activities as needed by them. The project success depends upon the proper utilization of resources which in turn will be resulting to the cost optimization of the project.
Some of the resources assigned for this project are
Material: Cement, sand, coarse aggregate bricks, steel, fencing material, shuttering material, tiles, wood, ceiling material, UPVC windows, wall putty and painting etc.
Machinery: Roller machinery, dozer, grader, pile driving excavator, excavator, dewatering pump.
Manpower: Mason, brickwork mason, brickwork labour, fencing labour, shuttering labour, bar bending labour, bar bending mason, concrete mason, concrete labour, ceiling mason, ceiling labour, painter, painting labour, roller operator, dozer operator, grader operator, pile driving excavator operator, excavator operator, flooring labour, helper male, carpenter and carpenter labour.

4.6.5 Project Scheduling

The main step to analyse the project is to schedule the overall project. Project scheduling is useful to know the total duration and cost of the project from the base line. If any changes are made in the project during the execution, the PRIMAVERA enables us to reschedule the project for cost and other parameters.
Bar Chart/Gantt Chart: Gantt chart was originally developed by Henry Gantt in 1917 used in project management which helps in how the project will run. It provides a graphical illustration of schedule which has start and finish dates of the project. They are helpful for managing the relationships between tasks.
Network Diagram: The network diagram portrays the succession of activities by indicating activities as components and their relationships as connecting arrows. It clearly defines the relationship between the tasks or events when compared to the Gantt chart.

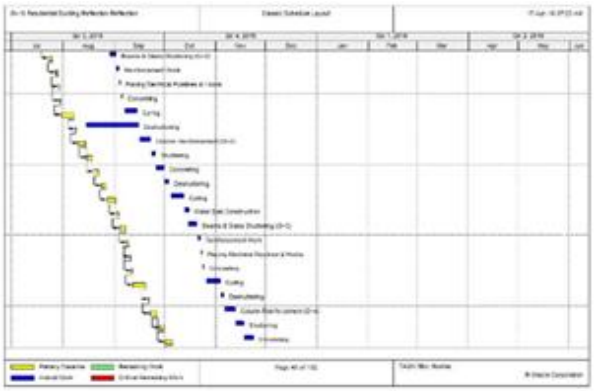


Fig. 4: Gantt chart showing activities of the project

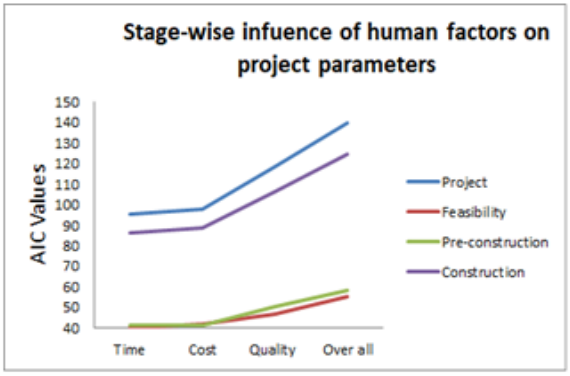
Fixing the baseline: After completing the above steps of the process, it is necessary to make a baseline of the project. The baseline refers to the copy of the original schedule and while updating, as the project progress, it allows you to display where the project is diverting from original plan
Updating the project: After fixing the baseline, again updating the activities as the project progress for analysis with reference to the base line fixed and scheduled at the beginning of the project.

4.7 Tracking the Project Progress

The important step is this project is to track the project against the original schedule by the earned value analysis. Earned value analysis (EVA) is one of the most popular and standard method of measuring the project progress at any given time and also used to analyze variances of the actual cost of the project from the schedule cost during the progress of the project. Earned Value analysis requires three parameters namely Planned value (PV) is referred to the budgeted cost for the work scheduled for a project, Actual cost (AC) is referred to the actual amount spent on the work performed and Earned Value (EV) is referred to the budgeted cost of the work performed for the evaluation of the project progress in terms of cost and time.
Budget at completion (BAC) is referred to the budget scheduled to complete the project. Schedule Performance Index (SPI) is the ratio of earned value to the planned value. Cost performance Index (CPI) is the ratio of earned value to actual cost.

5. Results and Analysis

The total of 100 responses received from the experts of the construction industry from across India for a total of 40 short listed human factors, by a critical literature survey of the journals on the subject, for their influence on the three parameters of the project namely cost, time and quality are categorized under three phases of the project namely Feasibility, Pre-construction and Construction.
The responses are analyzed phase-wise by the AIC for the 3 parameters of quality, Time and Cost of the project. The results are represented fig 5 above.
Since, the lower the values of the AIC, more the influence of the human factors on the parameters of the project at any given stage of the project,
The impact of human factors on the project risks follows the same trend in all phases of the construction project
Project Time is more likely to get affected by the human factors in a project followed by other parameters like cost and quality in any stage of the project, as opined by the experts.

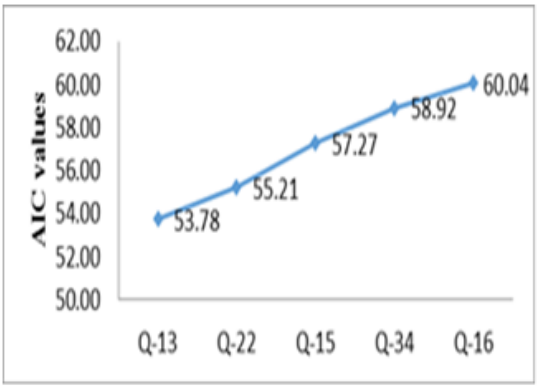


Graph 1: Influence of human-factors on project

5.1 Top 5, project COST influencing human factors (Question No. as per Table -1)

Table 2: Project cost influencing human factors

S No	Human factor as per table 1	AIC values
1	Q-13	53.78
2	Q-22	55.21
3	Q-15	57.27
4	Q-34	58.92
5	Q-16	60.04

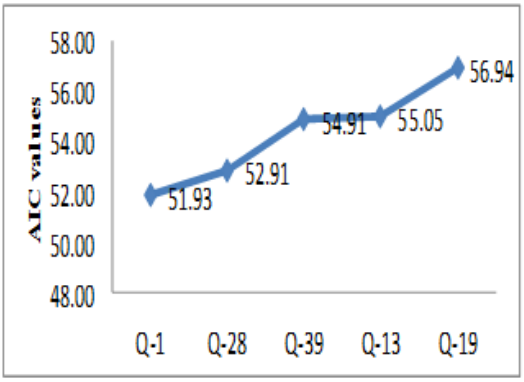


Graph 2: project cost influencing human factors

5.2 Top 5, Project TIME Influencing Human Factors (Question Number as Per Table -1)

Table 3: Project time influencing human factors

S No	Human factor as per table 1	AIC values
1	Q-1	51.93
2	Q-28	52.91
3	Q-39	54.91
4	Q-13	55.05
5	Q-19	56.94

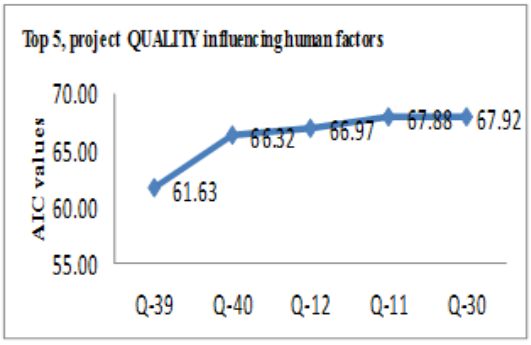


Graph 3: Project time influencing human factors

5.3 Top 5, project QUALITY influencing human factors (Q number as per Table -1)

Table 4: Project quality influencing human factors

S No	Human factor as per table 1	AIC values
1	Q-39	61.63
2	Q-40	66.32
3	Q-12	66.97
4	Q-11	67.88
5	Q-30	67.92



Graph 4: Project quality influencing human factors

5.4 Over All Top 10 Project Risk Influencing Human Factors as Per the Questionnaire Survey and Statistical Analysis by AIC Method

Table 5: Overall tp 10 project influencing human factors

S No	Q No	Human factors	AIC
1	12	Lack of coordination of Architect / Consultant	132.97
2	22	No communication / Miscommunication among stake holders	133.98
3	2	Financial capabilities of investors / management	134.11
4	19	Legal disputes among stake holders and negotiations	135.24
5	11	Delays in preparation of plans and drawings by architects / consultant	135.87
6	1	Delayed decision making by stake holders	140.39
7	30	Delay's in subcontractor's work	141.34
8	13	Delays in conducting inspections / tests by consultant	141.44
9	5	Inappropriate planning by contractor	142.90
10	10	Improper site management by contractor	143.00

5.5 From the Real Project Tracking by the PRIMAVERA Software Using Earned Value (EV) Technique, the Following Activities Identified to be affected by Human Factors.

As opined by the Industry experts in the above analysis, in the real Time project environment also, as observed, TIME is the most likely parameter to get affected by the human factors followed by cost and quality

Table 6: Activities identified by human factors in primavera

Activity number	ACTIVITY	No of days delayed	Cost overrun in Lakhs	Human factors (Q No as per table-1)
10	soil department	0	1.43	13
13	procurement of materials	2	0.10	10
15	labor shed	0	0.04	10
16	storage shed	0	1.08	10
17	Transferring construction tools	0	1.08	10
23	pile marking	2	0.01	5
27	concreting in pile foundation	0	1.00	13
36	earth excavation	1	0.93	5
55	dewatering at pile foundation	0	6.24	5
84	reinforcement placing	9	2.77	13
88	earth fill up to plinth beam	7	0.38	28
90	column reinforcement (p1)	6	1.20	36
96	beams and slab shuttering (p1)	3	0.62	20
109	beams and slab shuttering (p2)	0	0.46	13
115	column reinforcement (G+1)	2	5.40	20
124	concreting (G+1)	2	0.13	36
187	column reinforcement (G+7)	1	101.44	35
193	beams and slab shuttering (G+7)	0	0.44	34
204	waist slab construction (G+8)	0	0.50	28
271	sewage treatment plant	15	20.60	28
272	brick work	60	44.26	34
332	placing water pipelines and installation of faucets	0	4.00	16
333	internal wall plastering	15	0.20	28
335	ceiling plastering	10	0.40	2
336	tiles work	0	1.80	16
338	internal painting works	18	0.33	28
340	ceiling painting	10	0.02	34
341	installation of UPVC windows	30	0.20	34
342	installation of electrical switches, lights	12	0.01	30
344	installation of plumbing items	11	1.11	20

5.6 Top 5 Projects TIME Influencing Human Factors, as Observed are

Table 7: Top 5 time influencing human factors

As table -1	Human factors	Activity got affected	No of days delayed
Q-34	Temporarily pausing key decisions PM and management	193,272,340,341	110= (0+60+10+40)
Q-28	Inability to identify critical activities of a project	338,271,204,333,88	40= (7+0+15+18)
Q-30	Delay's in sub-contractor's work	342	12
Q-20	Contractor's inappropriate forecasting of the project time lines during bidding stage	96,115,344	16=3+2+11
Q-02	Financial capabilities of investors / management	335	10

5.7 Top 5 Project COST Influencing Human Factors, as Observed are

Table 8: Top 5 project cost influencing human factors

As per table-1	Human factors	Activity got affected	Cost escalation in lakhs
Q-35	Negative attitude of project manager	187	101.44
Q-34	Temporarily pausing key decisions PM and management	272	44.26
Q-28	Inability to identify critical activities of a project	271	20.60
Q-05	Inappropriate planning by contractor	55	6.24
Q-20	Contractor's inappropriate forecasting of the project time lines during bidding stage	115	5.40

6. Conclusion

In the scenario of construction projects are vulnerable to the ever increasing project risks, lot of efforts are going, in the direction of identifying, designing and planning of a suitable risk management system for mitigation of construction projects risks, from the industry experts and practitioners.

Our literature survey has revealed that many of such efforts are aimed at identification of factors that influence the construction project risks based on the previous works and papers and by obtaining the responses of the subject experts, practitioners and engineers by conducting the questionnaire survey on the identified factors to rate them to be delivered as conclusions.

Out of the total 40 identified most common and most widely accepted human risk factors that affect the residential construction projects are rated by questionnaire survey & statistical analysis of the responses by AIC method and by a real time project tracking are given in the results section above. The top 5 rated factors from the results by both the methods are tabulated, parameter-wise, in the table given below.

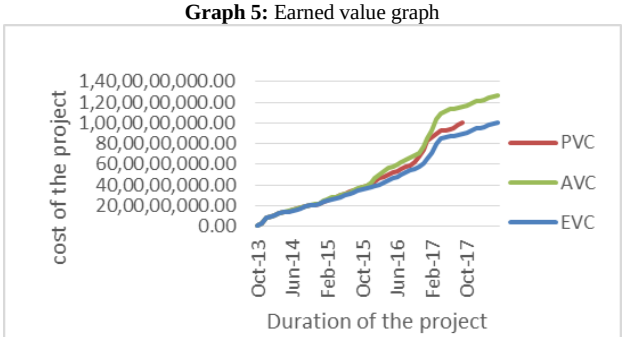
Table 9: Top 5 factors rated parameter wise

TIME		COST		QUALITY	
As observed on real time project	**As per questionnaire survey and AIC analysis**	**As observed on real time project**	**As per questionnaire survey and AIC analysis**	**As observed on real time project**	**As per questionnaire survey and AIC analysis**
Q-34	Q-01	Q-35	Q-13	Not observed	Q-39
Q-28	Q-28	Q-34	Q-22	Not observed	Q-40
Q-30	Q-39	Q-28	Q-15	Not observed	Q-12
Q-20	Q-13	Q-05	Q-34	Not observed	Q-11
Q-02	Q-19	Q-20	Q-16	Not observed	Q-30

It is evident from the above table that the results of both the methods are not matching which indicates that the conclusions arrived, from a questionnaire survey and subsequent analysis by statistical methods, do not have any relevance OR represent the actual human factors that caused project risks as recorded by observing a real time project progress.

Hence, in reality, the construction project risk management *is* so huge to understand and so complex to define as is being proved by this work.

Graph 5: Earned value graph



Moreover, from the EV graph of a real time project observation above, it can be seen that the project cost is escalated from the time of announcement of the de-monetization (Nov'2016). Hence the demonetization is a prime culprit here for the project cost to overrun from 100 crores to 126 crores, which was neither rated nor predicted, rather cannot be predicted by any of the studies. Hence the construction project environment is uncertain and highly vulnerable to socio-economic, political, technical and business risks and

And as indicated above, except a contributing to prediction of a few risk causing factors, construction project environment is uncertain and construction project risk management is so complex and need more efforts from all stakeholders of the sector to build and monitor a robust risk management system, just like Disaster Management**.**

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