RISK BASED INTEGRATED PROJECT DELIVERY MODEL FOR METRO RAIL STATION BOX

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Abstract: In the modern changing world, infrastructure sector has also shown potential growth i.e., development of highway, metro rail projects etc. along with the others sectors. Even though having good potential growth, this industry still lacks proper growth due to lack of adoption of new technologies. Most of the infrastructure and even small construction projects has no proper information management platform. This will lead to lack of collaboration among stakeholders, lack of safety and lack of traceability of projects and its assets during its lifecycle. This will lead to increase in errors, interruptions and delays during construction which will increases the project cost and decreases its efficiency. Complex mega infrastructure projects are subjected to greater risks due to its unique features in various phases like feasibility, design, development, implementation and execution. These risks, if not carefully handled, treated and controlled can affect the project performance significantly. So, a systematic process of risk analysis is required to classify, identify, and analyses these risks, and to formulate risk response strategies. The main purpose of this work was to identify major activities of an elevated metro rail corridor project and associated risks. Success of any infrastructure projects is influenced by proper management of the risks associated with the project. Large infrastructure projects suffer from significant poor risk management in practically all stages and throughout the life cycle of a project. Risk management helps to identify, analyses, mitigate and control risks associated with project cost, schedule, quality, health and safety aspects, environmental aspects. Over the last 25 years, the construction industry has become less efficient disdain having traditional project delivery systems like IPD, DB, CMR & DBB. the amount of waste (man, money, material, time) in construction activity is not properly reducing due to the complexity of infrastructure projects. For waste reduction proper optimizes solution and interdisciplinary teams are required. Integrated project delivery (IPD) is to improve project outcomes through a collaborative approach by early involvement of all parties.

KEY WORDS:Risk Management; Project Management; Factor Analysis; Fuzzy Topsis; Integrated Project Delivery; Statistical Package for the Social Sciences (SPSS)

1. INTRODUCTION

The problems of Multi-Criteria Decision Making (MCDM) appear and are intensely applied in many domains, such as Economics, Social Sciences, Medical Sciences etc. Sometimes, MCDM problems are mentioned as Multiple-Criteria Decision Analysis (MCDA) or Multi-Attribute Decision-Making (MADM). In spite of their diversity, the MCDM have as common characteristic multiple objectives and multiple criteria which usually are in conflict with each other.

The project delivery method integrated project delivery is about integrating the elements in construction industry such as architect, owner, designer, contractor, project manager sub-contractor, suppliers, etc. who are involve in the erection of the structure from design phase to construction phase so that the project execution is swift, with in project duration, minimum cost over runs, minimum wastage on site, execution, developing human value, efficient project management. For developing Integrated project delivery (IPD) method with Indian context, it becomes necessary to understand the construction industry organization structure which includes from owner to project manager to suppliers and other important personnel providing services to part of construction. Also, the material procurement, design alteration and new construction technologies which can be incorporated with proper integration of upper authorities to the construction industry personnel. The binding and integrating of IPD model can only be done by project team empowerment, mutual understanding and interaction at all points of project.[1] IPD is a growing construction project delivery system that collaboratively involves key participants from the beginning of the project timeline, often before the design is started. It is renowned by a multiparty agreement that typically allows sharing of risks and rewards among project participants. Because IPD is becoming progressively popular, various organizations are expressing interest in its benefits to the architecture/engineering/construction (AEC) industry.

2. LITERATURE REVIEW

2.1. INTEGRATED PROJECT DELIVERY (IPD)

The [7] defines IPD as, “A project delivery approach that combines organization, people, occupation, practices and structures into a process that cooperatively controls the talents and insights of all participants to increase project results & value to the owner, decrease waste, and enlarge efficiency by all phases of construction".

According to [7] there are several characteristically deferent between Traditional Project Delivery and IPD which is shown in *Table-2.1.*

2.2. PRINCIPLES OF IPD

According to [7] mainly there are 9 key Principles are there for IPD, 1) Trust & shared respect, 2) Reward & mutual advantage, 3) joint innovation & judgment making, 4) Early engagement of essential participants, 5) premature goal definition, 6) increased planning, 7) free communication, 8) Proper technology, 9) leadership & Organization. But different organizations approach Integrated Project Delivery (IPD) differently also the level of experience varies thus there is no accepted standard definition of IPD. however, consistent equalities which have been identified through most of IPD projects and definitions. Still (Azhar *et al.s*, 2014) *and* [7]have enlisted some Key IPD Principles and descriptions for them which are as follow,[9]

1. Early involvement of key participants (EIKP)
Involving the all teams right from the beginning of the project to help the owners to crystallize the project's goals and objectives from very early on and collaborate throughout the project. According to [10], one in all the foremost basic benefits that IPD affords is that the ability for all parties to be present and involved a project from the earliest design phase.

2. Shared risk and reward (SRR)
All team members jointly share the benefit of achieving project targets and concurrently bears the risk of missing the targeted cost (schedule and quality). According to [10], like historic projects where each party usually takes steps carefully to reduce their risk, IPD contracts collaborate the risks & rewards of each group members and compensate collaboration to reach project goals. these risks are divided into 5 major components as follow,

1) Based on value: to encourage the project team by offering a bonus linked to adding value to the project.
2) Incentive pool: reserves some of the project team's fees into a pool that may increase/decrease supported varied agreed-upon criteria before being shared and distributed to the team.
3) Innovation and outstanding performance: in which the team is allotted for hard work and creativity.
4) Performance bonuses: provides rewards based on quality.
5) Profit sharing: in which each party's profit is determined collectively rather than individually.

1. Multi-party contract (MPC)
The parties sign a single combined agreement that distinctly defines the role and responsibilities of all team members. According to [10] in MPC there is one contract for the complete project that is enrolled by the owner and all another party who may have a role in the project.

2. Collaborative decision-making and control (CDMC)
The parties need to agree upon a clear and specific set of criteria for decision-making and control of the project, which can be established according to owner's goal for the project.

3. Liability waivers among key participants (LWKP)
Contracted parties waive any claim amongst themselves except for in the instance of a willful default to reinforce the sense of unity and a collaborative environment.

4. Jointly developed and validated project goals (JDVG)
The owner, with the help of the project team, clearly defines achievable goals and benchmarks for measuring them. Risk and rewards are associated with achieving the set targets.

2.3. RISK MANAGEMENT

Risk management in construction is designed to plan, monitor and control those measures needed to prevent exposure to risk. To do this it is necessary to identify the hazard, assess the extent of the risk, provide measures to control the risk and manage any residual risks. Risks and uncertainties are always occurred in all construction development projects, particularly in the complicated real estate project.[11] said risks can strongly influence each project stage from the project conceptual design, project feasibility analysis, bidding and tendering, design and planning, construction and execution, and handover stage. The risk management process is generally an ongoing and iterative process, even each construction project is unique and different. The typical approach of project risk management consists of three basic steps, which are; Risk Identification and Initial Assessment, Response and Mitigation, and Risk Analysis.

Risks in construction have been considered, in relation to lack of integration, separation of design from construction, poor communication, uncertainty, increasing project complexity changing environment and regional economic crisis including greater competition in this business economic changes such as inflation and deflation. Risks can be defined as an event that negatively affects the project objectives, which are:

1) Time and Schedule
2) Cost
3) Quality of work

Mismanagement is one of the various sources of risk. Risk is indirectly proportional to co-ordination. More the co-ordination of work between different people on the project less is the risk of failure of the project. So naturally, more the number of people working on a project, more is the chance of the risk-taking place. Thus, if a greater number of agencies are working in the project, more powerful management team should be organized to handle the risks. Nowadays, risk mitigation and assessment has become more and more difficult as almost all of the big scale projects are sublet to sub-contractors. As a developing country, India has not focused on risk management. Thus, it is necessary to understand the risk identification process and other risk processes. It has already been recognized that dividing risks

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properly among each participant, impact of risk can be reduced. Proper risk allocation must be done for reducing risk, born by a single agency.

3. METHODOLOGY

3.1. IDENTIFICATION OF FACTOR

Risk factors were identified using a two-step approach where a factor identification from literature review of existing risk research and was supplemented with interviews from the metro rail project.

Industry to ensure a comprehensive and representative risk register for risk assessment and model development.Interviews were conducted with experienced experts, who working in construction of metro rail project, to solicit relevant risk factors, as reported by Mazher et al. (2017). In line with the objectives of this paper, a survey strategy was selected. Following construction companies working in Ahmedabad metro rail project, i.e., (1) Ranjeet buildcon limited, (2) Simplex Infrastructure Ltd, (3) L&T Ltd., (4) Tata Projects Limited, and (5) Afcons Infrastructure Limited. These companies were the top five contractors among Metro rail project in Ahmedabad. Some unusual variables were suggested to clarify in the questionnaires. The survey questionnaire was refined based on the pilot survey feedbacks. Based on the survey feedbacks, 20 variables contributing to IPD and 37 risk factor affecting the metro rail project. A Likert five-point scale (with 1 being the least important and 5 being the most important) was used to elicit respondents' opinions about the importance of each variable. Respondents were encouraged to cite additional variables that were not mentioned in the potential list according to their experience.A brief introduction to IPD & Risk Management and descriptions of some unusual variables were also attached to the questionnaire to ensure that all the respondents were clear about and using the same definition/description for each variable.The factor identified for IPD, Factors which are responsible for successful completion of the project on schedule with design cost (1)Project delivery/implementation speed (2) Lost time injuries (3) Construction speed (4) Amount of re-work in project (5) Waste recycling rate (6) The requirement of extra labor then schedule (7) Working in different teams (8) No blame Culture (9) Trust on team members during the project (10) Communication between team members (11) Conflict resolution between teammates (12) Continuous improvement in work performance project by project (13) Amount of design change during the project (14) System quality throughout the project (15) RFI response time. Factors which are responsible for successful completion of the project on time including (1) Achievement of the project objective (2) Construction schedule growth (3) PPC (% plan complete) (4) Re-submission of change in design (5) The response to a request for information. In Risk management there are 7 factors like, (1) Political Related Risk (2) Contractual Related Risk (3) Construction Related Risk Related Risk (4) Consultant Related Risk Related Risk (5) Consultant Related Risk Related Risk (6) Design Related Risk Related Risk (7) Environment Related Risk Related Risk .Factors those are identified was below:

Table 1 Factor identification table

(1) Political Related Risk Factor
Delay in project approvals and permits
Change in law
Poor public decision-making process
Inconsistences in government polices
Unstable government
Increase in new taxes
Strong political opposition
(2) Contractual Related Risk Factor
Conflict in contract document
Original contract document is rigid and has no scope to accommodate any changes
poorly tailored contract forms
contract clause being one sided
(3) Construction Related Risk Related Risk Factor
Construction cost overrun
Construction time overrun
Change in scope of work
Poor quality workmanship
Poor site management
Disputes between contractor and sub-contractor
Improper construction method
Technology Changes
(4) Consultant Related Risk Related Risk Factor
Design deficiency
Inflexibility of consultant
Unclear and inadequate details in drawings
Non-use of advance engineering design software
Delay in performing inspection and testing by consultant
Insufficient data collection and survey before design
Inadequate experience related project
(5) Project Management Related Risk Related Risk Factor
Project team conflicts
Scheduling error
Failure of comply with contractual quality requirement

absence of safety management
(6) Design Related Risk Related Risk Factor
Design errors and omissions
Design process takes longer than anticipated
Stakeholders request late changes
Failure to carry out the works in accordance with the contract
(7) Environment Related Risk Related Risk Factor
Environmental analysis incomplete
New alternatives required to avoid, mitigate or minimize environmental impact
Obstruction to surrounding business

3.2 QUESTIONNAIRE SURVEY

The questionnaire had three sections with section one targeted at collecting background information on the respondent and parent organization, whereas, section two is question related to IPD. The third section is question related to Risk Management. The survey effort produced 64 valid responses from the industry. A majority of the practitioners have more than 10 years of experience in the construction industry and international construction.A Likert nine-point scale (with 1 being the least important and 9 being the most important) was used to elicit respondents' opinions about the importance of each variable.

For the interpretation of data collected we use two methods to summarize the data and model preparation.

1) Factor Analysis.
2) Fuzzy Topsis Method

3.2.1. FACTOR ANALYSIS

According to[17], [18] factor analysis (FA) is an exploratory data analysis method used to search influential underlying factors or latent variables from a set of observed variables. It helps in data interpretations by reducing the number of variables. It extracts maximum common variance from all variables and puts them into a common score.Factor analysis is widely utilized in market research, advertising, psychology, finance, and operation research. Market researchers use factor analysis to identify price-sensitive customers, identify brand features that influence consumer choice, and helps in understanding channel selection criteria for the distribution channel.

According to [19]Factor analysis is a linear statistical model. It is used to explain the variance among the observed variable and condense a set of the observed variable into the unobserved variable called factors. Observed variables are modelled as a linear combination of factors and error terms. Factor or latent variable is associated with multiple observed variables, who have common patterns of responses. Each factor explains a particular amount of variance in the observed variables. It helps in data interpretations by reducing the number of variables.

3.2.2. FUZZY TOPSIS METHOD

Step 1: ALTERNATIVES RATINGS BY DECISION MAKERS
Step 2: CRITERIA WEIGHTAGE BY DECISION MAKERS
Step 3: APPLY FUZZY NUMBERS
Step 4: AGGREGATED ALTERNATIVE AND CRITERIA WEIGHTAGE FUZZY DECISION MATIX

$$x^{k}{}_{ij} = (a^{k}{}_{ij} , b^{k}{}_{ij} , c^{k}{}_{ij})$$

$$w^{k}{}_{j} = (w^{k}{}_{j1}, w^{k}{}_{j2}, w^{k}{}_{j3})$$

$a_{ij} = \min \{a^{k}{}_{ij}\}$, $b_{ij} = 1/K \sum b^{k}{}_{ij}$, $c_{ij} = \max\{c^{k}{}_{ij}\}$ …..(3)

$w_{j1} = \min \{w_{jk1}\}$, $w_{j2} = 1/K \sum w_{jk2}$, $w_{j3} = \max \{w_{jk3}\}$ ….(4)

Step 5: FUZZY MULTI CRITERIA GROUP DECISION MAKING (GDM) AND PROCESS OF NORMALIZING
As we are working on various criteria for decision making, some might be benefit criteria and some might Becostcriteria.Aimistomaximizebenefitandminimizethe cost. A fuzzy multi criteria Group Decision Making (GDM) problemwhichcanbeconciselyexpressedinmatrixformat as:
$R = [r_{ij}]_{m\times n}$, i = 1, 2, . . ., m; j = 1, 2, . . .,n…... (5)

$r_{ij}= (a_{ij}/ c^{*}_{j}, b_{ij} / c^{*}_{j}, c_{ij}/c^{*}_{j})$ and

$c^{*}_{j} = \max c_{ij}$(benefitcriteria) …. (6)

$r_{ij} = (a_{j}/ c_{ij}, a_{j} / b_{ij}, a_{j}/ a_{ij})$ and

$a_{j} = \min a_{ij}$(costcriteria) …. (7)

Step 6: FPIS AND FNIS

$A^{+} = (p^{+}1, p^{+}2, . . ., p^{+}n)$ where

$p^{+}j = \max \{p_{ij3}\}$, i = 1, 2 . . ., m; j = 1, 2, . . ., n …. (8)
$A^{-} = (p^{-}1, p^{-}2, . . ., p^{-}n)$ where

$p^{-}j = \min \{p_{ij1}\}$, i = 1, 2 . . ., m; j = 1, 2, . . ., n …. (9)
Select the maximum value from each row as p^{+} and select the minimum value from each row as p^{-}.

Step 7: THE DISTANCE OF EACH WEIGHTED ALTERNATIVE

$d_i^{+}=\sum^{n}{}_{j=1} d (p_{ij},p_j^{+})$ …. (10)

$d_i^{-}=\sum^{n}{}_{j=1} d(p_{ij},p_j^{-})$ …. (11)

Step 8: CLOSENESS COEFFICIENT OF EACH ALTERNATIVE

$CCi= d^-i/ (d^-i+ d^+i), i = 1, 2 . . ., m$ …. (12)

4. RESULTS

The data were analyzed using the Statistical Package for the Social Sciences (SPSS). Also, SPSS Statistics is a software package used for statistical analysis. It was acquired by IBM in 2009. It is also used majorly by Health researchers, market researchers, Education Researchers, Survey companies, Marketing organizations, Data miners, Government, Construction researcher. It is one of the most extensively used software programs for analyzing data in construction management and the most essential factors affecting in Ahmedabad-Gandhinagar metro rail project identified.

4.1. DESCRIPTIVE STATISTICS ANALYSIS

The descriptive statistical analysis is executed to attain the mean value, standard deviation and coefficient of variation for 20 foremost key factors which are given in the table. The frequency analysis method was performed for descriptive statistical analysis. Also, in descriptive statistics, the frequency analysis is based upon the number of occurrences selected by the respondents and then followed by measure of central tendency and dispersion analysis.

The first analysis involved the ranking of the 15-cost base factors and 5-time based factors on the mean values of the 64 responses. In cases wherein multiple practices had the same mean value, a lower standard deviation was assigned a higher ranking.The factor with means 4.39 as the best practices 15factorswere identified as the best factors that could lead to the successful completion of infrastructure projects. Table lists the rankings of the best factors according to the value of their means.

Table 2 Descriptive statistics analysis of factors which are responsible for successful completion of the project on schedule with design cost

Factor	Mean	Std. Deviation	Analysis N	Rank
Project delivery/implementation speed	4.39	.809	64	1
lost time injuries	2.50	.735	64	12
Construction speed	4.34	.946	64	2
Amount of re-work in project	1.94	1.139	64	15
Waste recycling rate	2.50	.797	64	13
The requirement of extra labor then schedule	2.61	.902	64	11
Working in different teams	3.05	.575	64	9
No blame Culture	2.50	.976	64	14
Trust on team members during the project	3.09	.750	64	8
Communication between team members	3.13	.630	64	7
Conflict resolution between teammates	3.14	.753	64	6
Continuous improvement in work performance project by project	3.64	.743	64	4
Amount of design change during the	3.02	.630	64	10

project				
System quality throughout the project	3.67	.778	64	3
RFI response time	3.14	.639	64	5

Table 3 Descriptive statistics analysis of factors which are responsible for successful completion of the project on schedule with design time

Factor	Mean	Std. Deviation	Analysis N	Rank
Achievement of the project objective	3.72	.745	64	2
Construction schedule growth	3.66	.623	64	3
PPC (% plan complete)	4.36	.949	64	1
Re-submission of change in design	3.00	.436	64	4
The response to a request for information	2.64	.932	64	5

4.2. FACTOR ANALYSIS

In this study, factor analysis was used to explore the underlying constructs in the identified factors for infrastructure projects like metro rail Ahmedabad. In this study, 20factors were subjected to factor analysis using principal components analysis.Factor Analysis (FA) is an exploratory technique applied to a set of observed variables that seeks to find underlying factors (subsets of variables) from which the observed variables were generated. For example, an individual's response to the questions on a college entrance test is influenced by underlying variables such as Intelligence, years in school, age, emotional state on the day of the test, amount of practice taking tests, and so on. table 3 and table 4 shows the communalities of the study. A communality is the extent to which an item correlates with all other items. Higher communalities are better. If communalities for a particular variable are low (between 0.0-0.4), then that variable may struggle to load significantly on any factor. In the table below, you should identify low values in the "Extraction" column. Low values indicate candidates for removal after you examine the pattern matrix.

Table 4 Communalities of factors which are responsible for successful completion of the project on schedule with design cost

Communalities		
Factor	Initial	Extraction
Project delivery /implementation speed	1.000	.528
Lost time injuries	1.000	.641
Construction speed	1.000	.678
Amount of re-work in project	1.000	.888
Waste recycling rate	1.000	.820
The requirement of extra labor then schedule	1.000	.720
Working in different teams	1.000	.646
No blame Culture	1.000	.866
Trust on team members during the project	1.000	.772
Communication between team members	1.000	.584
Conflict resolution between teammates	1.000	.683
Continuous improvement in work performance project by project	1.000	.536

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Amount of design change during the project	1.000	.818
System quality throughout the project	1.000	.799
RFI response time	1.000	.782

Table 5 Communalities of factors which are responsible for successful completion of the project on schedule with design time

Communalities		
Factor	Initial	Extraction
Achievement of the project objective	1.000	.761
Construction schedule growth	1.000	.787
PPC (% plan complete)	1.000	.838
Re-submission of change in design	1.000	.692
The response to a request for information	1.000	.646

Table 5 and 6 shows Total variance explained for factors which are responsible for successful completion of the project on schedule with design cost and time. The Total column gives the eigenvalue, or amount of variance in the original variables accounted for by each component. The % of Variance column gives the ratio, expressed as a percentage, of the variance accounted for by each component to the total variance in all of the variables. The Cumulative % column gives the percentage of variance accounted for by the first *n* components.

Table 6 Total variance explained for factors which are responsible for successful completion of the project on schedule with design cost

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	4.867	32.446	32.446
2	2.845	18.968	51.414
3	1.859	12.397	63.811
4	1.191	7.940	71.751
5	.838	5.587	77.338
6	.807	5.379	82.717
7	.600	3.999	86.716
8	.529	3.527	90.243
9	.374	2.490	92.733
10	.341	2.274	95.006
11	.262	1.748	96.754
12	.167	1.115	97.869
13	.146	.970	98.840
14	.122	.814	99.654
15	.052	.346	100.000

Table 7 Total variance explained for factors which are responsible for successful completion of the project on schedule with design time

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.510	50.204	50.204
2	1.212	24.250	74.454
3	.731	14.618	89.072
4	.306	6.123	95.195
5	.240	4.805	100.000

4.3. COMPONENT MATRIX

The underlying, influential variables are the factors. Factor analysis is carried out on the correlation matrix of the observed variables. A factor is a weighted average of the original variables. The factor analyst hopes to find a few factors from which the original correlation matrix may be generated.

Principal components analysis is one of the variable reduction techniques that share many similarities to exploratory factor analysis KMO determination. Its aim is to lessen a larger set of variables into a smaller set of variables called 'Principal Components', which account for most of the variance in the original variables. The outcome obtained from the principle component analysis is given in table 7 and table 8.

Table 8 Component matrix for factors which are responsible for successful completion of the project on schedule with design cost

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Correlation	Project delivery/implementation speed	1.000	-.174	.547	-.490	-.259	-.418	-.006	-.452	-.114	-.066	-.092	.264	.237	.283	.076
	lost time injuries	-.174	1.000	-.342	.721	.515	.611	.282	.399	.173	.171	.072	-.131	-.017	-.181	.287
	Construction speed	.547	-.342	1.000	-.495	-.210	-.454	.116	-.430	-.136	-.020	-.091	.246	.177	.522	.076
	Amount of re-work in project	-.490	.721	-.495	1.000	.752	.609	.247	.614	.174	.277	.195	-.327	-.131	-.239	.208
	Waste recycling rate	-.259	.515	-.210	.752	1.000	.497	.364	.551	.319	.474	.436	-.174	-.111	.141	.234
	The requirement of extra labor then schedule	-.418	.611	-.454	.609	.497	1.000	.342	.622	.407	.367	.293	-.118	-.017	-.367	.097
	Working in different teams	-.006	.282	.116	.247	.364	.342	1.000	.438	.652	.334	.314	.114	.305	.141	.198
	No blame Culture	-.452	.399	-.430	.614	.551	.622	.438	1.000	.586	.594	.637	.011	-.194	.010	-.038
	Trust on team members during the project	-.114	.173	-.136	.174	.319	.407	.652	.586	1.000	.311	.566	.175	.131	.135	.071
	Communication between team members	-.066	.171	-.020	.277	.474	.367	.334	.594	.311	1.000	.431	.301	-.005	.279	.113
	Conflict resolution between teammates	-.092	.072	-.091	.195	.436	.293	.314	.637	.566	.431	1.000	.319	-.005	.324	-.042
	Continuous improvement in work performance project by project	.264	-.131	.246	-.327	-.174	-.118	.114	.011	.175	.301	.319	1.000	.148	.452	-.126
	Amount of design change during the project	.237	-.017	.177	-.131	-.111	-.017	.305	-.194	.131	-.005	-.005	.148	1.000	.043	.625
	System quality throughout the project	.283	-.181	.522	-.239	.141	-.367	.141	.010	.135	.279	.324	.452	.043	1.000	.158
	RFI response time	.076	.287	.076	.208	.234	.097	.198	-.038	.071	.113	-.042	-.126	.625	.158	1.000

Table 9 Component matrix for factors which are responsible for successful completion of the project on schedule with design time

		Achievement of the project objective	Construction schedule growth	PPC (% plan complete)	Re-submission of change in design	The response to a request for information
Correlation	Achievement of the project objective	1.000	.644	.684	.147	-.079
	Construction schedule growth	.644	1.000	.723	.000	-.326
	PPC (% plan complete)	.684	.723	1.000	.115	-.372
	Re-submission of change in design	.147	.000	.115	1.000	.195
	The response to a request for information	-.079	-.326	-.372	.195	1.000

Analysis whether the selection of evaluation indicator in metro rail project construction is appropriate for the factor analysis. Bartlett's test of sphericity and KMO detection are used for detection and SPSS software is used for the calculation to obtain the raw data correlation examination, as shown in Table 9 and 10.

KMO detection value ranges from 0 to 1, the more KMO value indicates that there are more communities among variables and it is more appropriate for factor analysis. Generally, when the detection value is more than 0.5, factor analysis is appropriate, whole not appropriate when less than 0.5. The result in Table 1 sows that the KMO value is 0.624 and0.681, Bartlett examination value is 0.00, less than 1%, indicating that the evaluation indicator is appropriate for the factor analysis, but there is a correlation among the variables.

Table 10 KMO and Bartlett's Test result matrix for factors which are responsible for successful completion of the project on schedule with design cost

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.624
Bartlett's Test of Sphericity	Approx. Chi-Square	588.305
	df	105
	Sig.	.000

Table 11 KMO and Bartlett 's Test result matrix for factors which are responsible for successful completion of the project on schedule with design time.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.681
Bartlett's Test of Sphericity	Approx. Chi-Square	109.518
	df	10
	Sig.	.000

4.4. FUZZY TOPSIS METHOD

The technique called fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) can be used to evaluate multiple alternatives against the selected criteria. In the TOPSIS approach an alternative that is nearest to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is chosen as optimal. An FPIS is composed of the best performance values for each alternative whereas the FNIS consists of the worst performance values. Here, we have presented relevant steps of fuzzy TOPSIS as below.

Step 1: ALTERNATIVES RATINGS BY DECISION MAKERS

Here, we have two alternatives such as A1 and A2 also we have two decision makers namely DM1 and DM2. Now, decision makers rate the alternatives as shown below:

Table 12 Alternative ratings (A1) by decision makers for Political related risk

Factors	Alternative 1	
	DM 1	DM 2
Delay in project approvals and permits	7	7
Change in law	5	5
Poor public decision-making process	3	3

Inconsistences in government polices	5	5
Unstable government	7	7
Increase in new taxes	5	5
Strong political opposition	7	7

Table 13 Alternative ratings (A2) by decision makers for Political related risk

Factors	Alternative 2	
	DM 1	DM 2
Delay in project approvals and permits	5	7
Change in law	7	5
Poor public decision-making process	3	5
Inconsistences in government polices	5	5
Unstable government	9	7
Increase in new taxes	3	5
Strong political opposition	7	7

Step 2: Criteria Weightage by Decision Makers

Table 14 Criteria Weightage by Decision Makers (1 & 2)

Factors	**CRITERIA WEIGHTAGE BY DECISION MAKERS**	
	A1	A2
Delay in project approvals and permits	7	7
Change in law	5	5
Poor public decision-making process	3	5
Inconsistences in government polices	5	5
Unstable government	7	7
Increase in new taxes	5	5
Strong political opposition	7	7

Step 3: APPLY FUZZY NUMBERS

Table 15 Fuzzy number for Alternative A1, A2 and Criteria Weightage

Factors	**APPLY FUZZY NUMBERS**					
	DM1	DM2	DM1	DM 2	A1	A2
Delay in project approvals and permits	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)
Change in law	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)
Poor public decision-making process	(1,3,5)	(1,3,5)	(1,3,5)	(3,5,7)	(1,3,5)	(3,5,7)
Inconsistences in government polices	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
Unstable government	(5,7,9)	(5,7,9)	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)
Increase in new taxes	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)
Strong political opposition	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)

STEP 4: AGGREGATED ALTERNATIVE AND CRITERIA WEIGHTAGE FUZZY DECISION MATRIX AND AGGREGATED FUZZY WEIGHTAGE MATRIX

1. $a_{ij} = min\{a_{kij}\}$ = 3.000 [i.e. minimum value of first place k (3,5,7 & 3,5,7)]

2. $b_{ij} = 1/K \sum b_{kij}$ = 5.000 [i.e. average of values at middle k=1 place (3,5,7 & 3,5,7)]

3. $c_{ij} = max\{c_{kij}\}$ = 7.000 [i.e. maximum value of last place k (3,5,7 & 3,5,7)]

Table 16 Aggregated Alternative and Criteria Weightage Fuzzy Decision Matrix and Aggregated Fuzzy Weightage Matrix

Factors	**Aggregated Fuzzy Weightage Matrix**		
	Alternative 1	Alternative 2	C.W
Delay in project approvals and permits	(5,7,9)	(3,6,9)	(5,7,9)
Change in law	(3,5,7)	(3,6,9)	(3,5,7)
Poor public decision-making process	(1,3,5)	(1,4,7)	(1,4,7)
Inconsistences in government polices	(3,5,7)	(3,5,7)	(3,5,7)
Unstable government	(5,7,9)	(7,8,9)	(5,7,9)

Increase in new taxes	(3,5,7)	(1,4,7)	(3,5,7)
Strong political opposition	(5,7,9)	(5,7,9)	(5,7,9)

Step 5: FUZZY MULTI CRITERIA GROUP DECISION MAKING (GDM) AND PROCESS OF NORMALIZING

As we are working on various criteria for decision making, some might be benefit criteria and some might Becostcriteria.Aimistomaximizebenefitandminimizethe cost. A fuzzy multi criteria Group Decision Making (GDM) problemwhichcanbeconciselyexpressedinmatrixformat as:

R = $[rij]_{mxn}$, i = 1, 2, . . ., m; j = 1, 2, . . .,n…... (3)

$rij = (a_{ij}/ c^*j, b_{ij} / c^*_j, c_{ij}/c^*_j)$ and

c^*j = max cij(benefitcriteria) …. (4)

rij = $(a_j/ c_{ij}, aj / b_{ij}, a_j/ a_{ij})$ and

aj = min aij(costcriteria) …. (5)

Example:

For Benefit Criteria A1

$$C * j\ maximum = 9$$

$$\left(\frac{5}{9}, \frac{7}{9}, \frac{9}{9}\right) = (0.56,0.78,1)$$

For Cost Criteria A2

$$aj\ minimum = 1$$

$$\left(\frac{1}{9}, \frac{1}{6}, \frac{1}{3}\right) = (0.11,0.17,0.3$$

Table 17 Normalized aggregated fuzzy decision matrix for alternative A1 & A2

Factors	FUZZY MULTI CRITERIA GROUP DECISION MAKING (GDM) AND PROCESS OF NORMALIZING	
	Alternative 1	Alternative 2
Delay in project approvals and permits	(0.56,0.78,1)	(0.11,0.16,0.33)
Change in law	(0.43,0.71,1)	(0.11,0.16,0.33)
Poor public decision-making process	(0.2,0.6,1)	(0.14,0.25,1)
Inconsistences in government polices	(0.43,0.71,1)	(0.14,0.2,0.33)
Unstable government	(0.56,0.78,1)	(0.11.0.13,0.14)
Increase in new taxes	(0.43,0.71,1)	(0.14,0.25,1)
Strong political opposition	(0.56,0.78,1)	(0.11,0.0.14,0.2)

Table 18 Weighted normalized fuzzy decision matrix

Factors	Weighted normalized fuzzy decision matrix	
	Alternative 1	Alternative 2
Delay in project approvals and permits	(2.8,5.46,9)	(0.55,1.12,2.97)
Change in law	(1.29,3.55,7)	(0.33,0.80,2.31)
Poor public decision-making process	(0.2,2.4,7)	(0.14,1,7)
Inconsistences in government polices	(1.29,3.55,7)	(0.42,1,2.31)
Unstable government	(2.8,5.46,9)	(0.55,0.91,1.26)
Increase in new taxes	(1.29,3.55,7)	(0.42,1.25,7)
Strong political opposition	(2.8,5.46,9)	(0.55,0.98,1.8)

Step 6: FPIS AND FNIS

$A^+ = (p^+1, p^+2, . . ., p^+n)$ where

p^+j = max {$pij3$}, i = 1, 2 . . ., m; j = 1, 2, . . ., n …. (6)

$A^- = (p^-1, p^-2, . . ., p^-n)$ where

p^-j = min {$pij1$}, i = 1, 2 . . ., m; j = 1, 2, . . ., n …. (7)

Select the maximum value from each row as p^+ and select the minimum value from each row as p^-.

Step 7: FPIS AND FNIS FOR EACH CRITERIA

Table 19 FPIS AND FNIS FOR EACH CRITERIA

(1) POLITICAL RELATED RISK FACTOR	FPIS		FNIS	
	A1	A2	A1	A2
Delay in project approvals and permits	4.12	7.52	5.79	1.44
Change in law	3.85	5.91	4.31	1.18
Poor public decision-making process	4.74	5.26	4.17	3.99
Inconsistences in government polices	3.85	5.81	4.24	1.14
Unstable government	4.12	8.1	5.79	0.46
Increase in new taxes	3.85	5.04	3.94	3.83
Strong political opposition	4.12	7.91	5.79	0.76
SUM	28.65	45.55	34.03	12.8
	CC1=0.54292		CC2=0.219366	
(2) CONTRACTUAL RELATED RISK FACTOR	FPIS		FNIS	
	A1	A2	A1	A2
Conflict in contract document	4.06	5.81	4.17	1.14
Original contract document is rigid and has no scope to accommodate any changes	3.33	3.61	2.92	2.81
poorly tailored contract forms	5.45	7.66	5.45	1.57
contract clause being one sided	4.92	7.91	5.47	0.76
SUM	17.76	19.18	18.01	6.28
			CC1	CC2
			0.503495	0.246661
(3) CONSTRUCTION RELATED RISK RELATED RISK FACTOR	FPIS		FNIS	
	A1	A2	A1	A2
Construction cost overrun	3.74	7.89	6.31	0.78
Construction time overrun	3.74	7.89	6.31	0.78
Change in scope of work	4.65	6.8	4.76	1.14
Poor quality workmanship	4.92	7.52	5.47	1.44

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Poor site management	4.92	7.52	5.47	1.44
Disputes between contractor and sub-contractor	0.63	0.54	0.46	0.49
Improper construction method	3.33	3.61	2.92	2.81
Technology Changes	3.33	3.61	2.92	2.81
SUM	29.26	37.49	34.62	11.69
			CC1	CC2
			0.541954	0.237698
(4) CONSULTANT RELATED RISK RELATED RISK FACTOR	FPIS		FNIS	
	A1	A2	A1	A2
Design deficiency	3.85	5.81	4.24	1.14
Inflexibility of consultant	3.06	7.91	6.3	0.76
Unclear and inadequate details in drawings	4.49	5.81	4.05	1.14
Nonuse of advance engineering design software	4.49	5.81	4.05	1.14
Delay in performing inspection and testing by consultant	3.85	5.81	4.24	1.14
Insufficient data collection and survey before design	4.12	7.91	5.79	0.76
Inadequate experience related project	4.12	7.91	5.79	0.76
SUM	27.98	41.16	34.46	6.84
			CC1	CC2
			0.55189	0.1425
(5) PROJECT MANAGEMENT RELATED RISK RELATED RISK FACTOR	FPIS		FNIS	
	A1	A2	A1	A2
Project team conflicts	4.06	5.81	4.17	1.14
Scheduling error	4.81	5.99	4.15	1.31
Failure of comply with contractual quality requirement	3.92	7.91	6.02	0.76
absence of safety management	4.06	5.81	4.17	1.14
SUM	16.85	19.71	18.51	4.35
			CC1	CC2
			0.523473	0.180798
(6) DESIGN RELATED RISK RELATED RISK FACTOR	FPIS		FNIS	

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	A1	A2	A1	A2
Design errors and omossions	4.06	5.91	4.24	1.17
Design process takes longer than anticipated	4.12	7.93	5.79	0.75
Stakeholders request late changes	4.81	5.26	4.15	3.99
Failure to carry out the works in accordance with the contract	5.6	7.93	5.27	0.75
SUM	18.59	21.12	18.51	4.35
			CC1	CC2
			0.498922	0.170789
(7) ENVIRONMENT RELATED RISK RELATED RISK FACTOR	FPIS		FNIS	
	A1	A2	A1	A2
Environmental analysis incomplete	4.49	5.81	4.05	1.14
New alternatives required to avoid, mitigate or minimize environmental impact	4.92	7.91	5.47	0.76
Obstruction to surrounding business	2.99	8	6.58	0.31
SUM	12.4	15.91	16.1	2.21
			CC1	CC2
			0.564912	0.121965

Step 8: THE DISTANCE OF EACH WEIGHTED ALTERNATIVE

$d_i^+ = \sum_{j=1}^{n} d(p_{ij}, p_j^+)$ .... (8)

$d_i^- = \sum_{j=1}^{n} d(p_{ij}, p_j^-)$ .... (9)

$$\tilde{d}(\tilde{a},\tilde{b}) = \sqrt{1/3\,[(a1-b1)^2+(a2-b2)^2+(a3-b3)^2]}$$

$d_1^+ = 28.65$

$d_2^+ = 45.55$

$d_1^- = 34.03$

$d_2^- = 12.8$

Step 9: CLOSENESS COEFFICIENT OF EACH ALTERNATIVE

CCi = $d_i^-/(d_i^- + d_i^+)$, i= 1,2,3,…..m …..(10)

CC1 (A1)	0.5429164
CC2 (A2)	0.219366

Step 10: RANKING OF EACH ALTERNATIVE

Hence, the ranking order of A1 > A2,

A1 is the Best Choice considering the given criteria.

5. DISCUSSION

In this research work, total 20 numbers of factors related to IPD are identified from related literature review and interview with related field experts. From 64 expert 51.6% are engineer, 17.2% ate project manager,15.6% are contractor, 9.4% are structural designer.12.5% experts have less than 5 years experience, 21.9% experts have less than 5 to 10 years experience, 46.9% experts have less than 10 to 20 years experience, 12.5% experts have more than 20 years experience.12.5% expertsknow IPD concept and work with this concept,54.7 % experts knowIPD concept and not work with this concept, 32.8 % experts don't know IPD concept and not work with this concept, 20.3 % experts know risk management concept and work with this concept, 53.1 % experts knowrisk management concept and not work with this concept, 26.6% experts don't know risk management concept and not work with this concept. Factor analysis method used to find out most critical factor for metro rail station box. Factors which are responsible for successful completion of the project on schedule with design cost (1)Project delivery/implementation speed (2) Construction speed (3) System quality throughout the project Construction speed (4) Continuous improvement in work performance project by project (5) RFI response time (6) Conflict resolution between teammates (7) Communication between team members (8) Trust on team members during the project (9) Working in different teams (10) Amount of design change during the project (11) The requirement of extra labor then schedule (12) Lost time injuries (13) Waste recycling rate (14) No blame Culture (15) Amount of re-work in project. Factors which are responsible for successful completion of the project on time including (1) PPC (% plan complete) (2) Achievement of the project objective (3) Construction schedule growth (4) Re-submission of change in design (5) The response to a request for information.

6. CONCLUSION

From the literature survey done for past decade through the research done by eminent researchers, it is found that the research has been limited to identification of various types of risks involves in various phases of the project. But very nominal work has been done to quantify these risks. There is also no proper integrated project delivery risk model which is directly related to the metro rail station box project**.** Thus, the present research aims to develop risk based integrated project delivery model for metro rail station box. In this research work, total 20 numbers of factors related to IPD and 39 factors related to risk management are identified from related literature review and interview with related field experts. These 39 factors are divided among 7 Parts on the basis of that questionnaires were prepared. The work contains 2 different questionnaires; 1) Factor analysis, 2) Fuzzy topsis. The results of the different analysis are as follow. According to the analysis of data collected it is observed awareness related to project management (PM) tools & software in Indian construction industry is very less. It is concluded this the awareness to Project Risk Management and Integrated Project Delivery is very less which mainly lead to the waste generation during infrastructure construction. The **Factor Analyses** is the KMO measure of sampling adequacy and Bartlett's test of sphericity for the extraction individual factors were check. Value of KMO test is 0.624 and 0.681 and in Bartlett's test chi-square value is 588.305 and 109.518 the associated significance level p-value is 0.000 which show correlation matrix is not an identity matrix. And maximum extraction value for a factor which is 15 and 5. Which concludes that the results of factor analysis are accepted.

7. SCOPE FOR FUTURE RESEARCH

Apply this Integrated project delivery and risk management model to real life project and make necessary modification and develop LIPD model. This research work is restricting to the work of Gujarat state, further, we can go for country level so that we can find more modifications related to work.

8. LIMITATIONS

The level of awareness regarding Risk Management & IPD in India is less. So, it is quite challenging to convince several private organization and government bodies in the construction industry. And further, there is no case study done related to Risk Management and IPD in India. Also, the attitude of people toward research in the construction industry is improper.

9. DECLARATIONS

1. FUNDING INFORMATION

- NOT APPLICABLE

2. CONFLICTS OF INTEREST /COMPETING INTERESTS

- On behalf of all authors, the corresponding author states that there is no conflict of interest.

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