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ANALYZING THE IMPACT OF CONSTRUCTION DELAYS ON DISPUTES IN INDIA: A STATISTICAL AND MACHINE LEARNING APPROACH

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Abstract

In Major construction projects execution and performance were being negatively impacted by claims and disputes in terms of cost overrun, quality, stakeholders relationships, and productivity. Therefore understanding the significance of underlying the claims is essential. In this study, the primary root causes behind delay claims and disputes in construction projects were identified, examined, and rated. The significance of these factors was assessed using Relative Importance Index (RII) values. In addition, a machine learning model employing the Random Forest Genetic Algorithm (RFGA) was implemented to foresee the related risks and ascertain their levels. In a pilot survey, the data were collected across multiple construction projects at different phases such as scrutiny stage, design and planning stage, bidding stage, operation stage, and maintenance or after-construction stage. From Relative Important Index values from the statistical approach, it emerges that delay claims are generally causes from the owner followed by project-specific activities. Delays in processing bill payments, natural disasters, lack of contract awareness, and delay in final bill payment are the top causes of delay claims which converted to conflicts and disputes in mostly operating stage. The Random Forest Genetic Algorithm model predicted that factors like altering the original design, reluctance to cooperate by contractor, and increase of wages have lower risk whereas factors Poor site conditions, delay in approvals of schedules and change orders, natural calamities, late in running bill payment, repetition of work due to error in original work are at higher risk in terms of conflict and dispute. The model gives an accuracy of 0.89 and 0.87 for training data and testing data. The study will highlight possible research avenues and enhance project management strategies so that the project succeeds its goal.

Keywords: Relative Important Index, Construction Delay claims, RFGA, Risk prediction, conflict and dispute

I. Introduction

Construction industries contribute significantly to the GDP of every nation, create jobs, and are regarded to be core of world economy (IV, VIII). However involvement of many participants in the endeavors resulting diversity in opinions and considered as most challenging sector. A construction project is considered to be successful if it is accomplished on time and within budget without compromising the excellence of work. The construction delay leads to conflict between stakeholders of the project which causes increase in project cost. In this industry, a claim is essentially a demand made by a party within an agreement for payment for losses incurred when another is not able to fulfill his or her part of the contract (VI). Several unexpected problems like Liaisoning and permission issues from different departments, incorrect plans, partial specifications, late supply of resources, bad weather, bad site conditions etc. arise during the project and could extend completion time resulting escalation of wages, hike in material and equipment cost, overhead costs and profit loss. (II). Al-Mohsin (2012) analyzed the Oman construction projects and found that there were 2.6 claims per project causing time overrun, delay in payment, and suspension of work. 75% of claims impacted delay in completion, 15% affected payment delays and 10% affected stoppage of construction projects in Oman (I).

It's very important to know the cause of probable delay claims in various stages before beginning any construction projects to avoid disputes. Zhang et al. (2020) has applied using Random forest technique to examine the relative importance of the causes of construction project delay and to examine the modifications of causes in two countries China and the United States (XI). These authors were identified three most important causes for managers to evaluate materials availability, design and working methods and labour in China however topmost three factors were detailed design, method of work management, flow of information and prerequisite preparedness in US using Random Forst (RF) model.

RF model in machine learning is based on various random trees with their limits and proper random variable gives precise classification but Random Forest Genetic Algorithm (RFGA)is the most reliable machine learning technique for prediction of delay in construction (IX) as Genetic algorithm is added to optimize the RF model.

Motivation and Objective:

Construction delays may lead to significant financial losses for all the stakeholders. Recognizing how these delays contribute to conflicts improves in reducing financial risk and enhancing project management procedures. The study focused on the identification and analysis of major causes of delay claims in numerous phases that lead to disputes in construction projects. The prediction of the riskiness level was analyzed with the Random Forest Genetic Algorithm (RFGA) model. The level was ranked and validated considering its severity level calculated from traditional statistics.

II. Framework

Identification of causes of construction delays lead to disputes

The causes of delay claims at different stages of the project, such as surveying and scrutiny, design and planning, bidding , operation and maintenance or after-construction stage were determined following a review of literature and consultations with qualified professionals.

A well-defined questionnaire was prepared with consultation of stakeholders of construction projects. The questionnaire had two sections. The first section included the details of the project having time overrun and claims and the second part sought information for causes of delay claims and respondents were requested to provide the riskiness with respect to 5-point Likert scale (Very rare, Rare, Moderate, High Extreme weighing 1 to 5) concerning its occurrence of conversion to conflict between parties and disputes. Data were collected in a pilot survey for different types of construction projects at different stages of construction in India. The questionnaire was sent to more than 100 people including contractors, owners, consultants, field engineers, material suppliers, project managers, surveyors, etc.

Ranking of causes concerning Relative Important Index (RII)

The ranking of the causes of delay in construction projects was done concerning its RII value in conventional statistical method. Similar methods also adopted by Gunduz et al (2013), Sambasivan and Soon (2007), and Kometa et al. (1994) for analysis of causes of delay in construction sectors (III, VII, V).

Relative Important Index (RII) is based on the severity

$$\text{RII } (\%) = \sum a \left(\frac{n}{N}\right) * 100/5$$

a -weightage given to each response (from 1 for very little to 5 for extreme),
n -frequency of the responses and
N- total number of responses

Prediction of risk level of dispute using Random Forest Genetic Algorithm (RFGA) model

RFGA model was used to anticipate the causes of delays in claims that were later disputed. The RFGA model is coded using the Jupytor Notebook. The input variables were all the delay causes due to which conflict between stakeholders arises. The model used the severity of causes' data set at different levels of delay. The severity data ranges from 1 to 5 scale. The total data was catagorised in to two sections: less than 50% delay and greater than 50% delay in delay level and also two phases: training data 30% and testing data 70% in the model and genetic algorithm is applied for optimization. Figure 1 shows the prediction model using RFGA. A similar model was adopted by Yaseen et al (2020) to forecast the of risk in construction delays (IX).

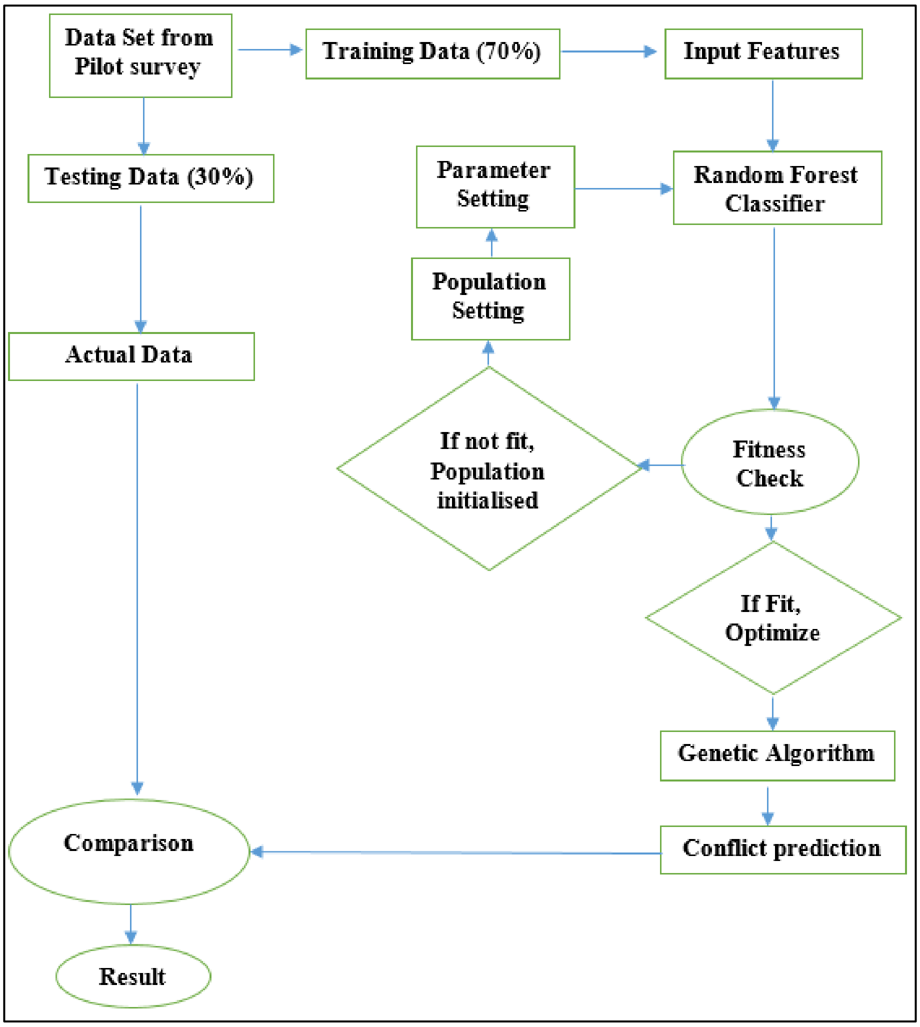

Fig.1. Flow Chart showing RFGA model for prediction of conflict due to delayed claims

III. Results and Discussions

Compressive Strength Test

The causes of delay claims are mentioned in Table 1 and categorized as per their occurrence at various stages of the project and related to the factors such as owner, contractor, project, material, labour, and external factors.

Table 1: Causes of delay claims in different stages of construction project

Project phase	Cause of Delay claims	Related to	Symbol of claim
Surveying and scrutiny stage	land dispute	Owner	CL-1
	Local people interference	External	CL-2
	Different Site Conditions Claims	Owner	CL-3
	Poor site conditions	Project	CL-4
	Failure to obtain permits	Owner	CL-5
Bidding stage	Terms of a contract	Project	CL-6
	Poorly written contracts	Project	CL-7
	Power of individual stakeholders vaguely specified	Project	CL-8
	Nonadherence to site instructions	Contractor	CL-9
Design and planning stage	Fault in design and drawings	Consultant	CL-10
	Incorrect plans, partial specifications	Consultant	CL-11
	Inadequate record-keeping by consultant	Consultant	CL-12
Operation stage	Difficult to reach the site etc. arise during the construction	Project	CL-13
	Liaisoning and obtaining permissions across departments	Owner	CL-14
	Late supply of resources	Material	CL-15
	Escalation of material/equipment cost the project has began.	Material	CL-16
	Late in running bill payment	Owner	CL-17
	Escalation of wages	Labour	CL-18
	Material and equipment costs, overhead costs, and profit loss	Material	CL-19
	Breaches by the Employer or his agents	Owner	CL-20
	Poor documentation.	Project	CL-21
	Change in orders after the start of work	Owner	CL-22
	Lack of contract awareness of the site team	Project	CL-23
	Lack of management or financial capability, sub-contractor issues	Contractor	CL-24
	Changing in original design.	Owner	CL-25
	Non-cooperation by Owner	Owner	CL-26
	Needs special material/equipment to operate	Material	CL-27
	Delayed approvals of schedules and change orders	Project	CL-28

	Inadequate scheduling clauses	Contractor	CL-29
	Nonadherence to site instructions	Contractor	CL-30
	Non updating of schedules	Contractor	CL-31
	Contractors unwillingness to comply	Contractor	CL-32
	Adoption of the incorrect construction method	Contractor	CL-33
	Financial difficulty of contactor	Contractor	CL-34
	Natural calamities	External	CL-35
	Labour shortage and strike	Labour	CL-36
	Repetition of work due to error in original work	Contractor	CL-37
Maintenance or after-construction stage	Quality control	Project	CL-38
	Noncompliance with specifications.	Project	CL-39
	Delay in final bill processing and payment	Owner	CL-40

General Profile of Responses

The data retrieved from the survey shows different types of construction projects built around five years from 2015 to 2019. The categories included housing projects, power plants, roadways, Industrial buildings, multistoried buildings, sewage lines, water lines, railway projects, bridges, water resource projects, and other various projects. The responses consisted of 46% Owners, 38% contractors, and 16% related to the consultants. The respondents have given data for delay claims in different stages of the project, their causes, and the status of claims.

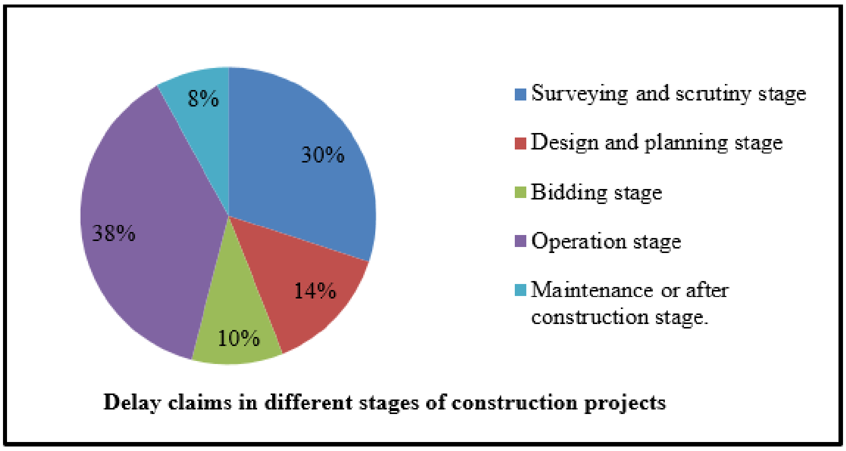

Fig. 2. A pie chart showing the no. and percentages of delay claims in various stages of the construction project

Figure 2 shows the percentages of claims in different stages of construction projects. The maximum numbers of delay claims were found in operation stage followed by the scrutiny and surveying stage. The stages were the surveying and scrutiny stage, design and planning stage, bidding stage, operation stage, and maintenance or after-construction stage.

Relative Important Index (RII) of causes of delay claims causing dispute

The RII value was calculated in percentage and the higher the RII percentage indicates the importance of delay claim causes towards dispute and conflicts concerning its occurrence. The ranking of each cause is mentioned in Table 2.

Table 2: Predicted Ranking of causes of delay claims that lead to dispute as per RII (%) value

Cause of delay claim	Causes	RII (%)	RII Rank	Associated to
Late in running bill payment	CL-17	60.4	1	Owner
Natural calamities	CL-35	54	2	External
Lack of contract awareness of the site team	CL-23	52.8	3	Owner
Delay in final bill processing and payment	CL-40	52.4	4	Project
Poor site conditions	CL-4	51.2	5	Owner
Escalation of material/equipment cost after the start of the project	CL-16	50.4	6	Project
Quality control	CL-38	50	7	Project
Failure to obtain permits	CL-5	48.8	8	Project
Liaisoning and obtaining permissions across departments	CL-14	47.6	9	Contractor
Financial difficulty of contactor	CL-34	47.2	10	Consultant
Non-cooperation by Owner	CL-26	46.8	11	Consultant
Inadequate scheduling clauses	CL-29	46.4	12	Consultant
Repetition of work due to error in original work	CL-37	46	13	Project
Terms of a contract	CL-6	45.6	14	Owner
Lack of management or financial capability, sub-contractor issues	CL-24	45.2	15	Material
Delayed approvals of schedules and change orders	CL-28	44.8	16	Material
Labour shortage and labour strike	CL-36	44.4	17	Owner
Non updating of schedules	CL-31	44	18	Labour
Non adherence to site instructions	CL-30	43.6	19	Material
Different Site Conditions Claims	CL-3	43.2	20	Owner
Difficult to reach the site etc. arise during the construction	CL-13	43.2	21	Project

Nonadherence to site instructions	CL-9	42.8	22	Owner
Adoption of the incorrect construction method	CL-33	42.4	23	Project
Poor documentation.	CL-21	42	24	Contractor
Change in orders after the start of work	CL-22	41.6	25	Owner
Noncompliance with specifications.	CL-39	41.6	26	Owner
land dispute	CL-1	41.2	27	Material
Contractors unwillingness to comply	CL-32	41.2	28	Project
Breaches by the Employer or his agents	CL-20	40.8	29	Contractor
late supply of resources	CL-15	40.4	30	Contractor
Needs special material/equipment to operate	CL-27	40.4	31	Contractor
Incorrect plans, partial specifications	CL-11	40	32	Contractor
Inadequate record-keeping by consultant	CL-12	39.6	33	Contractor
Power of individual stakeholders vaguely specified	CL-8	39.2	34	Contractor
Local people interference	CL-2	38.8	35	External
Fault in design and drawings	CL-10	38	36	Labour
Material and equipment costs, overhead costs, and profit loss	CL-19	37.6	37	Contractor
Poorly written contracts	CL-7	37.2	38	Project
Escalation of wages	CL-18	36.8	39	Project
Changing in original design.	CL-25	36	40	Owner

The table shows Owners and project-related factors are mostly sources of claims. According to Al-Mohsin (2012), Owners are the first party “as sources of claims” with 42% over other sources like consultants, contractors, and contract documents (I). Contract clauses addressing disputes, change orders, extra work conditions, and delays should be carefully reviewed (X). Delay claim causes like delay in running bill payments, natural disasters, lack of contract awareness, and delay in final bill payment were the most occurred claims by one of the parties.

Conflict prediction and management of claim

Figure 3 revels the risk level for each claim cause derived from the RFGA model. It illustrates that factors such as non-adherence to the site, changes made to the original design, contractor refusal to assist, and wage escalation have low risk associated with disputes, whereas elements like unfavourable site circumstances, a delay in scheduling and change order approvals, delay claims due to natural disasters, late running bill payments, and the need to repeat work because of an error in the original work are at higher risk in terms of becoming conflict.

The statistical performance of the training and testing data sets of the RFGA were assessed using the model performance measures derived from the confusion matrix shown in Table 3 and Table 4. The Mean square error was found to be 0.1778253 for the model which indicates closer predicted values.

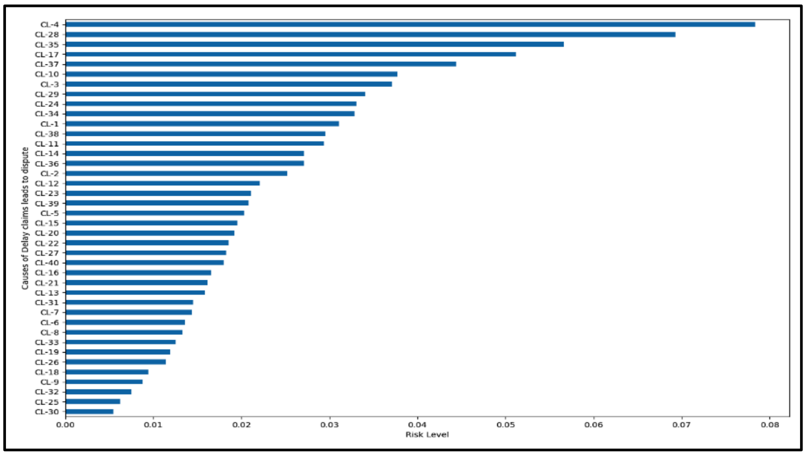

Fig. 3. Barchart showing risk level of causes of delay claims using RFGA model

Table 3: Confusion matrix of RFGA classifier (Training data)

Predicted Class	Actual Class		
	<50%	≥50%	Total
<50%	1	1	2
≥50%	1	12	13
Total	2	13	

Table 4: Confusion matrix of RFGA classifier (Testing Data)

Predicted Class	Actual Class		
	<50%	≥50%	Total
<50%	9	4	13
≥50%	0	22	22
Total	9	26	

Table 5: Performance measures in RFGA classifier for Training data and Testing Data

Predicted Class	Training Data		Testing Data	
	<50%	≥50%	<50%	≥50%
Precision	1	0.85	0.5	0.92
Recall	0.69	1	0.5	0.92
Accuracy	0.89		0.87	

In Table 5 performance of training and test data is predicted using precision recall and accuracy. The accuracy of the RFGA classifier in training data is 0.89 and the weighted precision in the category of <50% delay is 1 whereas in ≥ 50% group is 0.85 similarly recall values are found to be 0.69 and 1 respectively. The accuracy of the testing data is 0.87, weighted precision and recall values are 0.5 and 0.92 in both categories of <50% delay and ≥50% delay respectively. Yaseen et al. (2020) did a similar investigation utilising Random Forest (RF) and RFGA, and discovered more accuracy in RFGA than RF (IX).

IV. Conclusion

A detailed analysis of the gathered data on 50 construction projects was conducted to determine the actual reason of delay claims in the construction industry, as well as their relative important index in terms of incidence, using a statistical method and the RFGA machine learning model. The data were accumulated on a 1 to 5 scale for causes of delay claims concerning their occurrence throughout the project. Additionally, the responders were asked to mention the percentage of time overrun. The RII value was calculated for each cause. The cause with greater RII value indicates more frequency of occurrence of delay claims in the project. Frequency of factors like delay in running bill payments, natural disasters, lack of contract awareness, and delay in final bill payment are the top causes of delay claims which converted to conflicts and disputes in mostly operating stage in comparison to elements such as contract writing pattern, wage escalation and change in design. To predict the dispute from delay claims RFGA approach was used to catogorise project delays in two groups as <50% and ≥50% based on respondent data and schedule overrun percentage. The model had accuracy of 0.87 and 0.89 for testing and training data respectively.

For training data, the weighted precision and recall value in the category of <50% delay are 1 and 0.69 respectively and for the ≥ 50% group the values are 0.85 and 1 respectively. For testing data the weighted precision and recall are 0.5 and 0.92 in both categories of <50% delay and ≥50%. The model predicted that factors like nonadherence to the construction site, modification of original design, reluctance to cooperate by the contractors and increase in wages have lower risk towards dispute whereas factors Poor site conditions, delay in approvals of schedules, and change orders, natural calamities, late in running bill payment, repetition of work due to error in original work are at higher risk in terms of conflict and dispute. The current study will improve economic impact, construction industrial reputation, and project management.

Conflicts of interest

All authors declare that they have no conflicts of interest.

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