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MODELLING FOR TIME OVERRUN PREDICTION DUE TO DISPUTES IN HIGHWAY PROJECTS IN INDIA

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ABSTRACT

Indian infrastructure investment in general and highway construction in particular have seen manifold increase in the recent times. This has brought about a paradigm shift in the way in which the highway construction industry has been conducting its business with increased pressure on its stakeholders, namely the employers, the contractors and the consultants for high quality and timely project delivery. Disputes and arbitration has also seen a dramatic rise in past decade or so. Majority of the projects due to several reasons encounter time overrun. This paper presents the study of multi-level break down structure of the claim-causes and its impact on the project time overrun with multiple claim-causes acting simultaneously. It presents the prediction model for predicting time overrun in highway construction contracts in India. It is proposed to use this model for diagnostic as well as predictive tool to understand and possibly mitigate time overrun.

KEYWORDS: Highway Construction, Claims, Causes of Claims, Time Overrun, Prediction Model

INTRODUCTION

In past decade or so, India have attracted huge investment in development of highways network. This influx of investment and rapid growth has posed challenges for the government as well as to the highway contractors and developers. Tharakan (2008) presented that the road construction industry is faced with many challenges to undertake the huge investment program proposed by the government. As per the official data, about a third of the highway projects involving a sum of US$1.9 billion are stuck in arbitration despite the government's best efforts to speed up road development in the country.

Chawla (2010) reported the categorized constraints affecting the smooth execution of the highways as pre-construction issues, surveying, investigation and design issues, and construction & contract management issues. Rohatgi et. al (2012) carried out an interesting research on the capacity and performance of the road agencies in India under World Bank. As per the published news, as many as 123 highway projects out of a total of 406 awarded so far by the National Highways Authority of India (NHAI) since 2000 are caught in the arbitration tangle. Out of the 123 projects under arbitration, 103 cases are being settled at the dispute review board formed by the NHAI, while the rest are under various courts. As many as 119 projects under dispute are on engineering-procurement-construction (EPC) basis, while the rest are on build-operate-transfer (BOT) annuity basis.

A need is felt to analyze the causes of claims and disputes arising rather regularly in highway construction projects. The scope entails the study of dispute/claims occurring in the highway construction industry in India; derivation of causes of claims from the study of the disputes and the types of claims; identification of causes of claims to arrive at significant causes for time over run; analysis of data by using principal component analysis; and development of regression model to predict the time overrun due to claim/dispute events.

DATA COLLECTION

Exhaustive and comprehensive data collection efforts were put in place to collect recently published Arbitration Awards related to the disputes occurred in highways construction projects in India. A number of Government Departments, agencies (Employers) and Contractors were connected requesting them to part with the copies of the various Arbitration Awards. Besides these, a few of the prominent lawyers and practicing arbitrators were also contacted to supply copies of such awards.

The information of disputes/claims for 77 contracts under the highway construction projects implemented over a period of last 10 years in India has been collected. These are highway construction projects implemented in various states of India. The information collected is in form of claims and disputes and its settlements through arbitration under Indian Arbitration and Reconciliation Act, 1996. The present study includes the analysis and study of a total of 573 claim cases resulted out of the 77 highway construction contracts in India over a period of past 8 years especially with respect to time overrun on the construction contracts. Various statistical analyses are applied to the data thus collected to arrive at their inter-relationship and the cause-effect impact.

CLAIM-CAUSE BREAKDOWN

The literature study revealed that several researchers have attempted creation of the claim-cause break down structure for construction contracts. Merani (1998) categorized the types of disputes in two categories; (1) Claims by the Contractor, and (2) Claims by the Employers. As study methodology, O'Connor et. al. (1993) screened the claims based on the compensation awarded towards the same. They were grouped under two categories, Damage Type and Highway Element. Further break up of each of these categories was carried out by them. Scott (1997) grouped the delay events based on its origin, Employer (E), Contractor (C) and Third Party (N) and further classified as Compensable, Non-excusable and excusable events, respectively. Kartam (1999) classified the Project Delays into 3 main categories, namely, (1) By their Origin (owner, contractor, third party), (2) By their Timing (Concurrent, Non-concurrent), (3) By their Compensability (Excusable, Non-excusable). He classified the impact of the delay in 2 categories, namely, Direct Impact, Non-direct or ripple impact. Zameldin (2006) collected the data on claims related to different construction projects in Abu Dhabi and Dubai analysed them to discover the rankings of variety of claim types, and claim causes and their frequencies. Kumarswamy (1997) tabulated the findings of his research with respect to sources and causes of claims and disputes. These researchers' works provide basis for developing the claim-cause break down for this research. The extracted claim-causes of the types of claims/disputes under study are then grouped under following major categories. These categories are devised based on the explanation provided against each of them. At the beginning of this classification, it is assumed that these claim-cause categories are mutually independent of each other. They are termed as First Level (Level-1) claim-causes. For purposes of referencing throughout the research it is decided to annotate them with F1, F2.. etc. Henceforth, they are referenced as;

F1: Change in Law

F2: Delay in Site handing over

F3: Improper Contract Management

F4: Improper study prior to tendering the contract

F5: Legal Costs

F6: Beyond the control of the parties

While segregating and grouping 77 contracts using the First Level claim-causes, it is felt that these claim-causes are of broad nature. Further differentiation and drilling down of these broad claim-causes is carried out, again by using the information available from 573 claim and dispute events from 77 contracts.

The First Level claim-causes presented above are henceforth referred as Level-1 claim-causes. The further classification of the claim-causes, since they are the subsets of the First Level claim-causes (Level-1 claim causes), is defined as Second Level (Level-2) claim-causes. The Level-2 claim-causes are given the annotations S1, S2,…etc. Level-1 and Level-2 claim-causes are presented in Table-1.

Table 1: Grouping of Claim-Causes for Level-1 and Level-2

Claim-Cause	Description
F1	**Change in Law**
S1	Imposition of New Taxes
S2	Revision in Entry Tax
S3	Revision in Excise Duty
S4	Revision in Royalty Charges on Material
F2	**Delay in Site Handing Over**
S5	Delay in Land Acquisition
S6	Delay in Removal of Encroachments
S7	Delay in Environmental/Forest Clearance
S8	Delay in Compensation Payments (RAP)
S9	Employer Default
S10	Losses due to EOT
S11	Increased guarantee charges
S12	Idling of tools, plants, manpower
F3	**Improper Contract Management**
S13	Derived BOQ item rate and Payment
S14	Non-BOQ item rate and Payment
S15	Delayed / Reduced Payment
S16	escalation/price adjustment
S17	Poor quality construction
S18	Poor planning of activities by the Contractor
S19	Non granting of Completion
S20	Loss of Interest
S21	Stoppage of Work by Employer
F4	**Improper Study Prior to Tendering the Contract**
S22	Improper study by the client
S23	Improper study by the contractor
S24	Change in scope by the client
S25	Ambiguous Contract Clause
F5	**Legal Costs**
S26	Lawyer fees
S27	Cost of Arbitration
F6	**Beyond the Control of the Parties**
S28	Natural Calamity
S29	Increase in Material / Fuel Cost
S30	Strike, agitation, etc.
S31	Court intervention
S32	Terrorism risk
S33	Statutory Charges

EFFECT OF DISPUTES ON THE COMPLETION PERIOD

At first, the analysis was carried out to find the effect of disputes and claims on the overall performance of the contract timelines. As suspected, and found in various literatures, almost all contracts were running late and stipulated period of completion was surpassed by a decent period. The delays up to 200% of the original period of completion were also observed in some cases.

The values of % Increase in original contract period is termed as Percentage Delay (or % Delay) and were used as the dependent variable in the development of multivariate regression model. To develop better understanding of the delay in completion period, the observed percentage delay was categorized into various groups and the contracts were grouped under each of these delay categories. The following Table-2 depicts these data.

Table 2: Percentage Increase in Original Contract Time Frequency

% Increase	No. of Contracts
≤ 0	9 nos.
> 0 and ≤ 40%	12 nos.
> 40% and ≤ 80%	26 nos.
> 80% and ≤ 120%	14 nos.
> 120%	16 nos.

From above Table-2, it can be observed that a little more than 1/3rd (26 nos. out of 77 nos) of contract have percentage increase range between 40% and 80%.

While percentage increase in original contract time up to 40% and between 80% to 120% have 12 nos. and 14 nos. of contracts, respectively, in each of these categories.

16 nos. of contract from this data set have percentage increase in original contract time beyond 120%, while 9 nos. of contract showed no delay in the original completion period. The data set for this research is considered quite diverse and the regression model developed through this data set is assumed to be applicable in predicting all ranges of delay in construction period.

DEVELOPMENT OF TOPHIP MODELS

This step of the research was planned to establish relationship between the claim-causes and the time overrun in the highway construction projects. It was decided to use the multivariate regression technique to develop the required models not only to establish the relationship between the claim-causes and time overrun, but also to develop prediction model(s) for the time overrun.

Linear regression models are generated, and are annotated as Time Overrun Prediction in HIghway Projects (TOPHIP). The regression models generation are attempted using SPSS software with the dependent variable as percentage Time Overrun. The stage wise procedure adopted to arrive at the best fit regression model is presented in the following Figure-1.

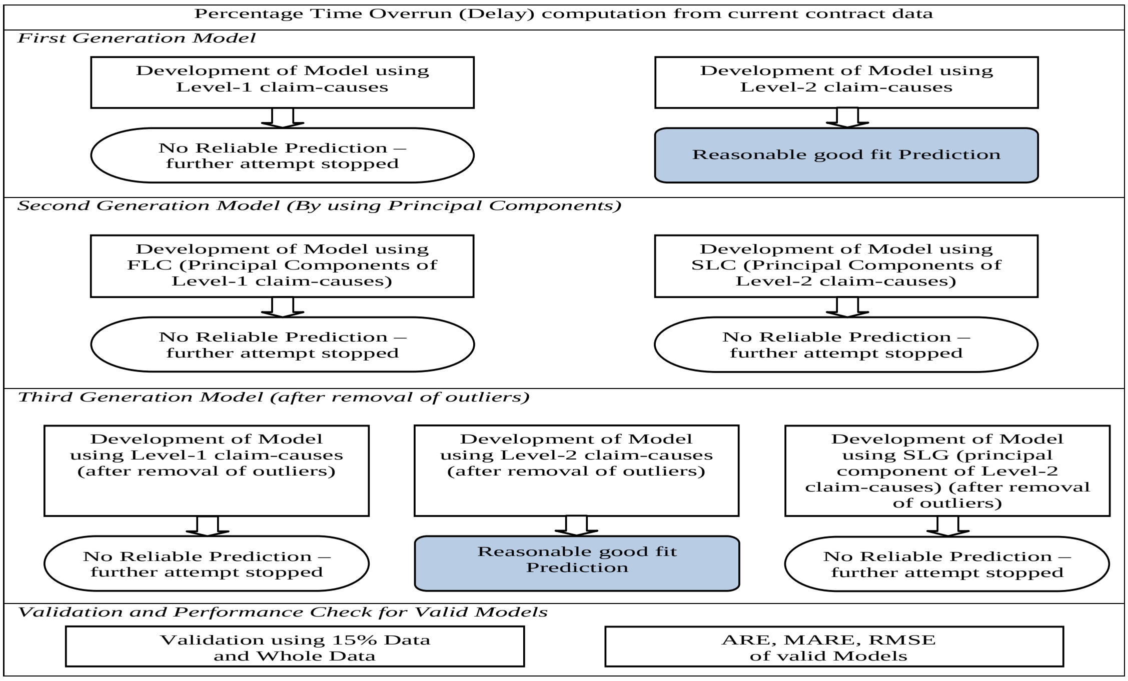

Figure 1: Flow Chart of the Model Development for Time Overrun

First Generation TOPHIP Models

The first generation TOPHIP models are developed using two sets of predictors are used; the first one using the Level-1 claim-causes and the second using the Level-2 claim-causes. The TOPHIP model between Level-1 claim-causes and percentage Time Overrun showed that the regression model thus developed would not give reliable predictions. The multiple correlation coefficient (R) value is 0.372 (less than 0.5), and R^2 value of 0.138. This regression has p-value of 0.097 which is greater than significant value of 0.05. The model is found to be not appropriate. The TOPHIP model using the Level-2 claim-causes and percentage delay time, however, gives reliable results. While deriving at the most appropriate regression model several iterations are carried out to achieve the maximum R-value and the p-value less than 0.05. However, as can be seen from the details given in Table-3, the lowest p-value that can be achieved from the iterative process was 0.057, which near to upper limit of 0.05. The other details of the model are as follows:

Table 3: TOPHIP-1 Model Summary (Predictor: Level-2 Claim-Causes)

R	R^2	Adjusted R^2	Std. Error of the Estimate	Significance (p)
0.685	0.469	0.176	54.08897	.057

From the above table, it is observed that the multiple correlation coefficient between percentage Time Overrun (Delay) and Level-2 claim-causes is 0.685 with p-value 0.057, which indicated that it is near significant. With the knowledge that the p-value is more than 0.05, further study of this model is carried out to check the significance of the regressions equation that can be generated from this model. Study of the results revealed that only one claim-cause **S3:** Revision in Excise Duty has p-value less than 0.05 (significant value). Rest all the Level-2 claim-causes are having p-value more than 0.05. Therefore, no further attempts are made to generate the model using this analysis. It is concluded that TOPHIP-1 model may not give valid predictions.

Second Generation TOPHIP Models

At this stage, an attempt is made to determine the possible reduction in the dimension of data set and then using the components as predictors to arrive at better fit prediction models. This application is made on the claim-causes for both

Level-1 and Level-2. To achieve this Principal Component Analysis for Level-1 and Level-2 claim-causes is performed. It is derived from the analysis that six Level-1 claim-causes can be converted into 3 components covering 77.6% of the data. The components for Level-1 claim-causes are annotated as First Level Components (FLC). Similarly, 33 nos. of Level-2 claim-causes can be converted into 13 nos of components that can explain 78.9% variance in the dataset. The components for Level-2 claim-causes are annotated as Second Level Components (SLC).

The second generation TOPHIP models are developed using the newly formed 3 FLC and 13 SLC in separate attempts. The TOPHIP model using FLC as predictors shows R-value as 0.372, which is less than 0.05 and p-value of 0.097 which is greater than 0.05. Thus, a valid model could not be generated. TOPHIP model using SLC as predictor shows R-value as 0.529 and p-value of 0.019, even though better than those of model using FLC as predictor; a valid model could not be generated.

Third Generation TOPHIP Models

The development of TOPHIP models using Level-1 claim-causes, and using the 3 components derived during PC method analysis as predictors, respectively has failed thus far. As regards to Level-2 claim-causes as predictors, even though a valid TOPHIP model could be generated, it is felt that the fitment of the regression model generated using the secondary causes (S1 to S33) could be improved by using the 13 Groups arrived at using the PC method analysis. However, TOPHIP model attempted using the 13 groups formed using PC analysis gave very poor fit.

In order to achieve a better fit between the claim-causes and percentage Time Overrun (Delay), i.e. arrive at a regression model with R value > 0.7, an attempt was made to generate the regression model by removing the outliers. The outliers are removed from the data using ± 1.5 x IQR, where IQR=inter quartile range. Using this equation, the contracts with outlier values are removed from the model generation attempt. Accordingly, Contract nos. 16, 34, 35, 53 and 70 qualified as contract with outlier’s values, and removed from the development of TOPHIP models. Further, in order to validate the TOPHIP model arrived after removal of outliers, it is decided to set aside randomly selected 12 nos. of contracts to validate the TOPHIP model created using the remaining 60 contracts.

After removal of outliers, three alternative attempts are made to arrive at the best fit TOPHIP model, viz; 1) TOPHIP model using the Level-1 claim-causes; 2) TOPHIP model using the Level-2 claim-causes; and, 3) TOPHIP model using 13 Components of Level-2 claim-causes.

TOPHIP Model Using Level-1 Claim-Causes (After Removal of Outliers)

After removal of the outliers as described above, the first attempt is carried out to establish a model between Level-1 claim-causes and percentage Time Overrun (Delay). However, the model thus developed would not give reliable predictions. It is found that, even after several attempts, the model has multiple correlation coefficient (R) less than 0.5 with R^2 value more than 0.05, which indicate that the model is not significant.

TOPHIP Model Using Level-2 Claim-Causes (After Removal of Outliers)

After removal of outliers, the second attempt is carried using the Level-2 claim-causes and percentage Time Overrun (Delay). This model gives reliable results. Several attempts are also made to make the model best fit for the data set, viz. achieve the highest R value with minimum p-value. The best fit model as derived after these iterations is annotated as TOPHIP-2 model and is presented in Table-4 below:

Table 4: TOPHIP-2 Model Summary (Predictor: Level-2 Claim-Causes after Removal of Outliers)

R	R^2	Adjusted R^2	Std. Error of the Estimate	Significance (p)
0.757	0.573	0.337	36.35872	0.009

It is observed that the Level-2 claim-causes **S1:** Imposition of New Taxes, **S2:** Revision in Entry Tax, **S3:** Revision in Excise Duty, **S4:** Revision in Royalty Charges on Material, **S21:** Stoppage of Work by Employer, **S22:** Improper Study by the Client, **S23**: Improper Study by the Contractor, **S25:** Ambiguous Contract Clauses, **S26:** Lawyer Fees, **S28:** Natural Calamity, **S31:** Court Intervention and **S33:** Statutory Charges have no effect on percentage Time Overrun (Delay). The most significant claim-causes with p-value ≤ 0.05 are, **S5:** Delay in Land Acquisition, **S7:** Delay in Environmental/Forest Clearance, **S9:** Employer's Default, **S11:** Increased Guarantee Charges, and **S18:** Poor Planning of Activities by the Contractor. The significant claim-causes are grouped under 4 categories based on their p-value. The Table-5 shows the claim-causes distributed by their level of significance in terms of their influence in arriving at the prediction of percentage Time Overrun (Delay).

Table 5: Significant Claim-Causes (Predictor: Level-2 Claim-Causes after Removal of Outliers)

	Significance (p-Value)	No. of Claim-Causes	Claim-Causes
Most Significant	≤ 0.05	5 nos.	S5: Delay in Land Acquisition S7: Delay in Environmental/Forest Clearance S9: Employer's Default, S11: Increased Guarantee Charges, and S18: Poor Planning of Activities by the Contractor
Moderately Significant	> 0.05 and ≤ 0.20	9 nos.	S6: Delay in Removal of Encroachments S8: Delay in Compensation Payments (RAP) S12: Idling of tools, plants, manpower S14: Non-BOQ item rate and Payment S16: escalation/price adjustment S17: Poor quality construction S20: Loss of Interest S30: Strike, agitation, etc. S32: Terrorism risk
Less Significant	> 0.20 and ≤ 0.70	7 nos.	S10: Losses due to EOT S13: Derived BOQ item rate and Payment S15: Delayed / Reduced Payment S19: Non granting of Completion S24: Change in scope by the client S27: Cost of Arbitration S29: Increase in Material / Fuel Cost
Non Significant	> 0.70	0 nos.	

The TOPHIP-2 model can be written as follows. The S values are the frequency of occurrence of claim-cause in the contract.

Percentage Time Overrun (Delay) = 71.425 – 40.731(S5) + 31.828(S6) + 40.926(S7) + 26.672(S8) – 85.586(S9) – 9.258(S10) + 47.556(S11) – 24.083(S12) + 7.022 (S13) – 4.780(S14) – 4.425(S15) – 13.107(S16) + 28.679(S17) – 24.557(S18) + 22.652(S19) + 13.629(S20) – 6.763(S24) + 30.804(S27) + 19.513(S29) + 76.454(S30) + 30.235(S32) …(1)

TOPHIP Model Using Groups (Components) of Level-2 Claim-Causes (After Removal of Outliers)

The PC Method analysis is performed to reduce the dataset dimension on S1 to S33 (Level-2 claim-causes) after removal of outliers. From the correlation matrix derived through this analysis, it was observed that the 33 nos. of Level-2 claim-causes (after removal of outliers) can be converted in to 13 nos of components, named as Groups. In the present case Groups (components) are defined as G1 to G13. It is also derived from that analysis that 79.8% of total variance is explained by these thirteen Groups (components). Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy Test and Bartlett's Test of Sphericity tests are also performed on the data and it is observed that the significant value (P-value) is 0.000< 0.05. The development of TOPHIP model is attempted using 13 groups of Level-2 claim-causes as obtained above from the PC method analysis after removal of outliers to arrive at a better fit prediction/estimation model. The model obtained from this analysis is a poor fit with R value 0.559 <0.7 and the p value 0.119 >0.05. Therefore, this model cannot be used to predict the percentage Time Overrun (Delay).

Validation and Performance of TOPHIP Models

Multiple linear regression model generation attempts are made for developing the TOPHIP models. Out of seven attempts, two valid TOPHIP models could be generated. TOPHIP-1 uses Level-2 claim-causes as predictors, and TOPHIP-2 uses Level-2 claim-causes (after removal of outliers) as predictors. Out of these two valid models TOPHIP-2 is found to be a better fit model.

TOPHIP-2 model is showing R-value of 0.757 with p-value of 0.009. The most significant claim-causes are, **S5:** Delay in Land Acquisition, **S7:** Delay in Environmental/Forest Clearance, **S9:** Employer's Default, **S11:** Increased Guarantee Charges, and **S18:** Poor Planning of Activities by the Contractor with p-value ≤ 0.05.

The sensitivity analysis of the most significant claim-causes shows that TOPHIP-2 model is most sensitive to the claim-cause **S11:** Increased Guarantee Charges. Even though this claim-cause may occur less frequently, but when it does occur, it definitely would bring in the claim/dispute occurrence. The second most influential claim-cause is **S18:** Poor Planning of Activities by the Contractor.

TOPHIP-2 model is generated using the data from 60 nos. of contracts. The data from randomly selected 12 nos. of contract is kept aside for its use in validating the accuracy of the model. These data are not used in formulating the model. The results of validation are presented in Figure-2 below. The validation shows very good predictions compared to the actual values with ARE values ranging from 0.20% to 2.94%. MARE and RMSE values are 1.43% and 1.44, respectively.

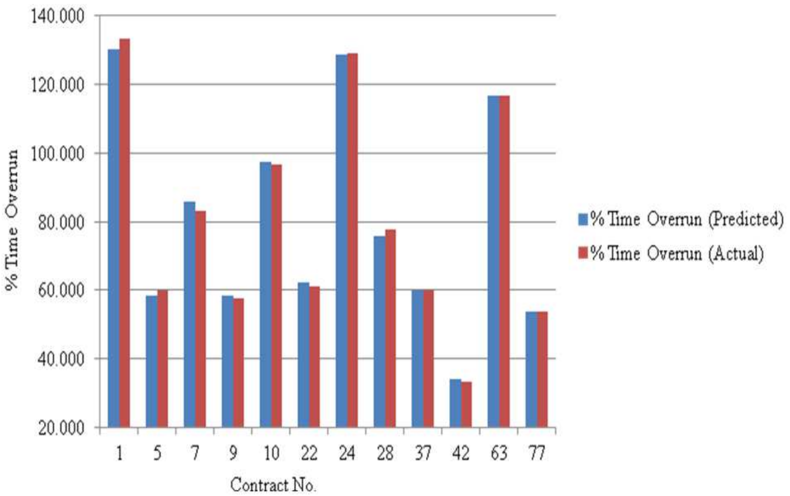

Figure 2: Validation of TOPHIP-2 Model

Further, full data validation is also carried out using the TOPHIP-2 model. The predicted percentage Time Overrun (delay) and actual percentage Time Overrun (Delay) is presented using the scattered plot in Figure-3 below.

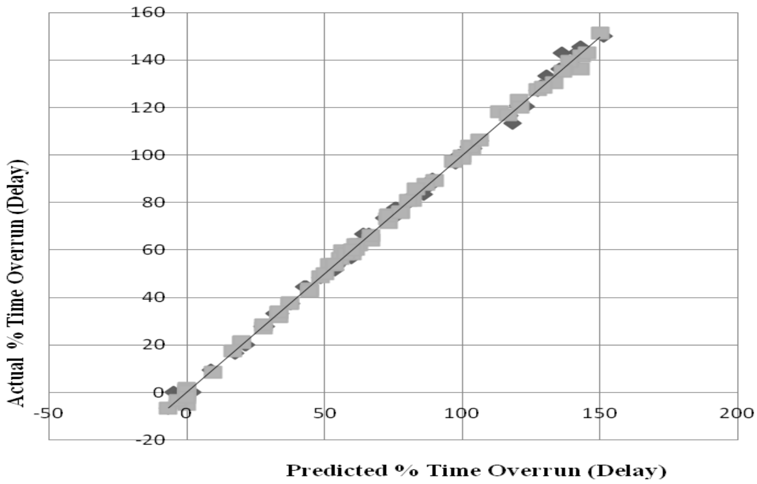

Figure 3: Whole Data Validation Using TOPHIP-2 Model

The scattered plot of full data validation shows very good correlation between the predicted and actual Time Overrun with ARE values ranging from 0.00% to 7.44%. Only about 4% data set having the error value beyond 5%.

Table 6: Error Profile of Whole Data Validation

Percentage ARE	No. of Contracts	% of Total Contracts
Up to 1%	30 nos.	41.7%
> 1 and ≤ 2%	20 nos.	27.8%
> 2% and ≤ 3%	8 nos.	11.1%
> 3% and ≤ 4%	4 nos.	5.6%
> 4% and ≤ 5%	7 nos.	9.7%
> 5%	3 nos.	4.1%

The Table-6 presents the various ranges of percentage ARE and number of contracts showing the ARE in each range. Further, MARE and RMSE values for whole data validation are 1.82% and 2.61, respectively.

FINDINGS

Important findings are as follows

- Two numbers of TOPHIP models could be developed for prediction of Time Overrun (Delay) from the several attempts made. The validity and performance check is performed on TOPHIP-2 model and it shows promising outcomes. The absolute difference between the actual percentage Time Overrun (Delay) and the predicted percentage Time Overrun (Delay) is very minimal.
- The full data validation shows that more than 69% of the contracts are having the error value within 2%. This shows the strength of the model developed and validated in this study. Further, only about 4% of the contracts show the error value beyond 5%.
- Performance evaluation of TOPHIP-2 model using measures such as MARE and RMSE is also performed. The MARE for the partial validation is 1.43%, while for the full data validation is 1.82%. The MARE values are reasonably low and hence, the model demonstrates a high level of validity. Similarly, RMSE for partial validation is 1.44, while for the whole data validation it is 2.61. It is observed that the performance parameter values are within reasonable limits and hence, this model is likely to give valid predictions.
- TOPHIP-2 model can be used for predicting the percentage Time Overrun (Delay) during the currency of the construction contract, where one or more claim-causes appear. This will facilitate early prediction of Time Overrun

(Delay). It will also establish the need to take early action to mitigate the claim-causes to avoid Time Overrun (Delay).

- The TOPHIP models have predictive property. They can be very effectively used for early predictions of dispute/claim scenarios. They can be a very effective tool for early mitigation measures to be applied in the highway construction contracts. The wide and varied base of the data collected in developing these models provides a higher level of reliability and comfort in putting these equations to use in the real world contracts.

CONCLUSIONS

The claim and dispute events in the Indian highway construction projects have become very dominant factor causing the time overrun for majority of the construction projects being undertaken. The classification and grouping of the claim-causes responsible for dispute and claim events help the project stakeholders in developing better understanding of risks and pitfalls during project execution. This understanding provides a useful tool in taking corrective and preventive actions to avoid the circumstances (claim-causes) leading to time overrun.

The models developed using the claim-causes provides the prediction of time overrun by taking into account the multiple claim-causes acting simultaneously. The validation of this model demonstrates a reasonably good "predictive" power and robustness in predicting time overrun in any highway construction project in India. This model can be used as a preventive tool as well as investigating tool for highway construction contracts.

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