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Delay Factor Analysis for Indian HAM Highway Construction Projects

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Abstract: ***Government has approved the hybrid annuity model (HAM) for building National Highways (NH) to speed up the construction of roads in the country by renewing interest of private developers in highway projects. 40% the Project Cost is to be provided by the Government as Construction Support during the construction period and the balance 60% as annuity payments over the operations period along with interest thereon to the concessionaire. Execution of hybrid annuity model (HAM) projects, which is the preferred mode of awarding by the National Highways Authority of India (NHAI), is largely on schedule with about 60% of projects, covering 3,200 km of roads, completed on time. The rest of the projects, however, are delayed largely due to various reasons. In order to identify and analysis of delay causes in highway projects of HAM model, this study provides a questionnaire survey-based study. Land acquisition delay is found as the most severe delay cause of highway projects of HAM model. Waste of time in controlling the traffic is found as the least severe delay cause of highway projects of HAM model. The study is supposed as useful to HAM construction managers for delay analysis of highway projects.***
Keywords: Hybrid annuity model, Highway projects, Delay analysis, Questionnaire survey.

I. INTRODUCTION

Government has approved the hybrid annuity model (HAM) for building National Highways (NH) to speed up the construction of roads in the country by renewing interest of private developers in highway projects. 40% the Project Cost is to be provided by the Government as Construction Support during the construction period and the balance 60% as annuity payments over the operations period along with interest thereon to the concessionaire. National Highway projects worth approximately Rs 10,000 crore have been approved in this financial year (till 31.10.2019) under the hybrid annuity mode. The objective is to maximize the quantum of implemented projects within the available financial resources of the Government and to revive private sector participation in the sector. Toll fee collection from the highway projects developed under the hybrid annuity model is the responsibility of the Government/Authority. In order to tap the benefit of long-term funds like pension fund, insurance fund, wealth fund etc into road construction sector, MoRTH has introduced models like HAM and TOT (Toll-Operate-Transfer). The government has argued that as many as 210 national highway projects are delayed due to various reasons such as poor performance by developers and problems in land acquisition besides regulatory hurdles. It also said there are some hybrid annuity model (HAM) projects which are yet to secure financial closure.

"210 nos. of National Highway projects are delayed under NHAI due to various reasons. The delays are due to multiple reasons, such as poor performance of Contractors/Concessionaires, delays in various activities and clearances such as utility shifting, environment/forest clearance, land acquisition and law & order problems etc," Minister of State for Road Transport and Highways V K Singh told the Rajya Sabha in a written reply.

The steps include constitution of High-Powered Committee under Chief Secretary to monitor the pre-construction activities, strengthening of Land Acquisition Units by way of providing manpower and resources and effective formal public consultations at the time of project preparation to address the concerns of public, he added. The minister added that there are some HAM projects which are yet to secure financial closure.

II. OBJECTIVES OF THE STUDY

The objectives of the study are given as follows:

1) To identify the delay causing factors of the HAM highway projects.
2) To conduct a questionnaire survey for severity ranking of the identified delay causing factors of the HAM highway projects.
3) To determine the most severe delay causing factors of the HAM highway projects.
4) To propose recommendations in order to reduce the delay phenomenon in HAM highway projects.

III. LITERATURE REVIEW

Prathamesh Brid and Raju Narwade (2017) found that fuzzy logic approach simplize the tough job of project manager to analyze the unclear and vague data and information. They also found that fuzzy logic is useful and satisfactory approach for decision making in construction industry. Hesham Abd El Khalek, Remon Fayek Aziz, Hamada Mohamed Kamel (2016) utilized the fuzzy logic approach to liklihood and impact of risks folllowing the vagueness in the liklihood and impact of risk. They evaluate the risk in construction projects through calculating the R-index of each risk which is function of liklihood and impact of risk. John B. Bowles & C. Enrique Pelaez (1995) have concluded that FMEA & FMECA are the more effective methods than traditional methods to analyze the failures in a product or system. Bowles and Pelaez also found that involvement of fuzzy logic in FMEA technique can give more precise and accurate information about failure status of product or system. To apply fuzzy logic in FMEA, it is required to define linguistic terms, fuzzy numbers and and membership functions of risk occurrence, risk consequences, risk detectability and risk priority number. Bowles and Pelaez also conclude that fuzzy logic with FMEA is also most useful when there is lack of availability of information. Bowles and Pelaez also noted that, if failure modes have multiple dimensions, then calculated RPN might be underestimated. Mohamed Abdelgawad and Aminah Robinson Fayek (2010) found the RPN values of identified risk factors in construction industry using Fuzzy-MATLAB. They used Impact of risk, probability of occurrence of risk and current control on risk as input and RPN as output in Fuzzy-MATLAB. They applied Fuzzy-AHP to count weight of impact of risk on cost, time and quality of construction project. They also concluded that responses should be given to risk events based on RPN values prioritization not on the rules of thumb. Fuzzy and FMEA was concluded as appropriate and satisfactory to calculate RPN values of risk factors. Cheng-Min Feng and Chi-Chun Chung (2013) assessed the the risks in airport airside using fuzzy logic and FMECA. They identified 14 risk factors from the aviation accident database of International Civil Aviation Organization (ICAO). Each risk factor was considered as failure mode. They conduct a case study using questionnaire on Taiwan Taoyuan International Airport. They elicit the information from experts about probability, severity and detectability of risk factors in airport airside. RPN of each risk factor was calculated by making a fuzzy model on MATLAB software. They gave more attention to higher RPN value risk than lower RPN value risks Mohsen Ahmadi, Kouroush Behzadian, Abdollah Ardeshir and Zoran Kapelan (2015) managed the risks in construction of highway projects. They used fuzzy logic in FMEA & MCDA to assess and prioritize the risk factors. Combined fuzzy-AHP was used to compute the impact of risk factors on cost, time and quality of work. They identified 30 risk factors and calculated the RPN values of risks. Risk were prioritized on the basis on RPN value. Higher RPN risk was responded firstly. Lack of fund and time was identified most significant factors. They also conclude that suggested response strategies are sufficient, useful and appropriate to handle the risks in construction of highway projects. Sameh M. El-Sayegh and Mahmoud H. Mansour (2015) assessed and allocated risks in highway construction projects in UAE. They identified 33 risk factors and designed a questionnaire to elicit information from experts about probability of occurrence and impact of risk and risk allocation on highway construction projects. They found Risk occurrence index and Risk Impact index using Relative Importance Index (RII) method to find significant risk factors. They also differentiate the risk factors on the basis of contractors, consultants and owners views. They found strong correlation between all three groups of respondents using spearman rank correlation coefficient. They also analyzed the risk allocation suggested by owner and contractors and recommended the final risk allocation plan. Mahmoud Mohamed Mahmoud Sharaf and Hassan T. Abdelwahab (2015) analyzed the risk factors in Highway Construction Projects in Egyp using risk score. They identified the 73 risk factors and categorized them into 12 risk groups. To elicit the information for occurrence and impact of risk questionnaire method was used. They calculated the Risk Score by multiplying Average Impact and Average Probability of Occurrence, while average probability of occurrence and average impact was calculated by Relative Importance Index (RII) method. Delay in Decision making and land acquisition was found most significant risk factors based on Risk Score value. They also concluded that risk factors having high frequency of occurrence in the life cycle of project and having high impact on project's cost and time are most risky factors in construction of highway projects of Egypt.

In literature, no study related to delay in HAM highway projects was found. Therefore, the presented study provides a detailed questionnaire survey-based delay analysis study for HAM highway projects.

IV. RESEARCH METHODOLOGY

The step-by-step methodology is given as below:

A. Step-1) Delay factors identification

Identified delay factors are shown in Table 1.

B. Step-2) Questionnaire Design

Level of severity was taken on 1-to-5-point scale. Questionnaire survey is conducted among 384 respondents.

C. Step-3) Descriptive Statistics

Relative importance index (RII) is calculated for ranking of delay factors.

$$RI = \frac{\sum W}{A \times N}$$

D. Step-4) Ranking

Ranking is done on the basis of RII value.

Table 1 Delay Factor Table

Delay Factor	Factors under the group
DF1	1. Delay in payment by government
DF2	2. Delay in land acquisition
DF3	3. Modification in scope of work
DF4	4. Delay in issuing various approval/clearance documents
DF5	5. Financial problems of contractor
DF6	6. Rework due to errors during construction
DF7	7. Inefficient planning, scheduling and controlling of project
DF8	8. Lack of adequate and skilled manpower in contractor's team
DF9	9. Lack of adequate quality control measures of contractors
DF10	10. Inflexibility of consultants
DF11	11. Delay in inspection of work by consultant
DF12	12. Lack of qualified consultant team members. adequate inspectors in consultant's team
DF13	13. Awarding the project to lowest bid price
DF14	14. Poor site condition
DF15	15. Poor communication and coordination between project's parties
DF16	16. Weak sponsors
DF17	17. Safety issues in project
DF18	18. Lack of adequate skilled labours
DF19	19. Personal conflicts of labours
DF20	20. Unavailability of adequate unskilled labours
DF21	21. Labour Absenteeism
DF22	22. Equipment of lesser efficiency
DF23	23. Shortage of materials or equipment or both
DF24	24. Change in type and specification of materials during construction
DF25	25. Fluctuation in price of material and equipment
DF26	26. Delay in design works
DF27	27. Error in design works
DF28	28. Force Majeure
DF29	29. Loss of time by traffic control and restriction at job site
DF30	30. Unpredicted weather conditions
DF31	31. Political situations
DF32	32. Public agitation demanding other facilities/(law and order problem)
DF33	33. Delay in providing services from utilities (such as water and electricity)
DF34	34. Change in government laws and regulations
DF35	35. Global financial crises

V. RESULTS AND DISCUSSION

In questionnaire survey, there were 123 clients, 159 contractors and 102 consultants.

For example, Table: 2 shows the overall response of 70 respondents. For numerical example take the response of an example factor. Out of 70 respondents, 20 said that factor is very low, 13 said that factor is low, 7 said that factor is medium, 20 said that factor is high and 10 said that factor is very high. Now from crisp rating Table 2:

Table 2 Crisp Rating Table

Linguistic term	Crisp Rating
Very High Influence (VHI)	5
High Influence (HI)	4
Moderate Influence (MI)	3
Low Influence (LI)	2
Very Low Influence (VLI)	1
No Influence (NI)	0

Hence total respondent score of factor = $\sum W = 20\times1+13\times2+7\times3+20\times4+10\times5 = 197$

Number of respondents N = 70

Maximum value of crisp rating = 5

$$\textbf{Severity Index (SI)} = \frac{\sum W}{A\times N}$$

$$\text{RII} = \frac{197}{70\times5} = 0.562$$

Table 3: Ranking of Delay Factors

Delay Factor	Overall SI	Overall Rank
DF1	0.690625	16
DF2	0.848438	1
DF3	0.617188	21
DF4	0.831771	2
DF5	0.747917	11
DF6	0.751042	10
DF7	0.809896	3
DF8	0.720313	14
DF9	0.607292	22
DF10	0.447396	34
DF11	0.700521	15
DF12	0.504688	30
DF13	0.785938	7
DF14	0.598958	23
DF15	0.801563	5
DF16	0.805729	4
DF17	0.7375	12
DF18	0.688542	17
DF19	0.668229	18
DF20	0.624479	20
DF21	0.513542	28
DF22	0.778646	8
DF23	0.507813	29
DF24	0.464063	33
DF25	0.583854	24
DF26	0.728125	13
DF27	0.528646	27
DF28	0.759896	9
DF29	0.433854	35
DF30	0.554167	26
DF31	0.572917	25
DF32	0.789583	6
DF33	0.500521	31
DF34	0.648958	19
DF35	0.485417	32

VI. RECOMMENDATIONS TO REDUCE THE DELAY IN HAM INDIAN HIGHWAY CONSTRUCTION PROJECTS

After analysing the results of this study, the following recommendations to address the top ten factors for delay in road construction projects:

1) Construction manager's primary duties include planning construction projects and overseeing their progress in a well-timed and cost-effective manner. They are responsible for the budget, organization, implementation, and schedule of the projects. These skills are honed through immense exposure that requires technical experiences in managing construction projects.

2) Poor planning and administration of the construction projects might lead to several adverse effects on the project duration. Construction delays and duration issues are frequently responsible for transforming productive ventures into failures. These delays can be reduced or prevented by appropriate pre-project planning and effective project management, since they are critical success aspects for completing the construction project.

3) The implementing agency must address the disputes in land acquisition for road construction projects prior to implementation. The land must already be acquired so as not to cause any delay at the construction stage.

4) Effective communication is critical for the success of any construction project since it can improve collaboration and lead to better project partnerships. Deprived communication may result in misunderstanding, delays, and other problems during the project work. It is important to determine a chain of command for communication in a construction project. These are usually spelled out in the contract documents and typically require the owner and general contractor to communicate with each other. Effective communication promotes the successful implementation of a construction project. Problems and delays may occur when construction parties stop communicating or replying to queries. When everyone is cooperating and communicating well, projects should run smoothly and be completed on schedule and within the budget. Planning is very important in project implementation because improper planning could lead to a delay. The authors often find that planning personnel are rushing to complete their tasks, so the plan they produce is prone to contain errors. Although changes in some aspects of the plan are quite common in road construction projects, alterations made to almost the entire plan poses a major problem. This is either because the designer was not able to develop the blueprint properly or there is something wrong with the survey data that they gather during the planning stage.

5) The shortage of equipment is certainly a major problem in implementing road projects in all developing countries. The reason is that during the procurement process, the adequacy of equipment from the contractor was not properly reviewed. They were not able to check that the equipment pledge in the project was already committed to some other projects of the contractor. Therefore, it is recommended that proper checking of the pledge equipment is conducted by the evaluators during the qualification stage of the procurement phase.

6) It is almost impossible to predict the occurrence of natural disasters, which could, among other things, impact road projects. Delays associated with such events can be avoided by incorporating certain precautionary measures in the preparation stage. It is necessary to create a proper plan and schedule to conduct construction activities in extreme field conditions. Since most road projects Infrastructures 2020, 5, 84 10 of 16 are scheduled during the rainy season, it is recommended that the government and contractors must consider what project activities are appropriate during such conditions.

7) A significant number of contract modifications (even some unforeseen work) can be avoided during the pre-construction phase (planning and design stage) of a project's life cycle. In the public sector, it may not be possible to have a contractor do a constructability review prior to award due to restrictions on bid work. Procedures to reduce design error and omissions are being conducted, such as a formal review process of plans and specifications, pre-bid conferences, and quality management programs during design.

8) In reference to the execution of the progress billing of the contractor, it is crucial that those who are in charge of the finances of a specific project must evaluate and monitor the cash flows properly and foresee the financial requirements of the project. Progress billing requirements for governments are arduous, and it takes a considerable time for the finances to be released. To avoid a shortage of construction materials, the contractor must always have a contingency fund.

9) Shortage and delay in materials supply are argued to be one of the most important factors that lead to delay in construction project delivery globally. The most important cause of the shortage of materials relates to the origin or availability of construction materials. On the other hand, the most influential cause of delay in material supply was found to be poor materials procurement and the inventory management system, which has other underlying reasons such as late identification of the type

of materials needed; however, this is deemed avoidable. The impact of late payment translates to a delay in the progress of the project. It will affect the schedule and budget of the work. Thus, clients should search for co-investors for support on financial assurance. Working closely with the stakeholders as a team in the project is recommended to respond to problems easily expected in contract payment procedures.

10) Productivity remains a fascinating and dominant matter in the construction area. It assures cost savings and the practical use of resources. Without adequate and efficient human resources, it is not feasible to proceed with a construction project. Hence, there is a need to ensure that labor offers the best input for achieving the project goals.

VII. CONCLUSION

The presented study has been provided a detail analysis of delay causing factors of HAM Indian highway construction projects. For this purpose, this study provides a questionnaire survey based detailed study over identified 35 delay causing factors. Severity of each delay factor was elicited from 384 HAM highway construction experts including 123 government/client employees, 159 concessionaire/contractor employees and 102 consultant employees. Based on the various statistical analysis such as ranking of delay factors and correlation analysis, the study illustrates following conclusions:

A. The obtained value of ACP and Cronbach's alpha was 92% and 0.973 respectively. Therefore, the data obtained from questionnaire was found as valid and reliable.
B. About more than 200 HAM highway construction projects were found behind the schedule.
C. Delay in land acquisition is found as the main delay causing factor of HAM Indian highway construction projects.
D. PCA analysis also shows that delay in land acquisition is found as the main delay causing factor of HAM Indian highway construction projects.
E. Spearman's Coefficient of correlation shows that there was strong correlation between the responses of client, contractor and consultant data.
F. Inefficient planning, scheduling and controlling of project is found as topmost contractor related delay causing factor.
G. Delay in inspection of work by consultant is found as topmost consultant related delay factor.
H. Weak sponsors are found as topmost project related delay factor.
I. Lack of adequate skilled labours is found as topmost labour related delay factor.
J. Equipment of lesser efficiency is found as topmost material and equipment related delay factor.
K. Delay in design works is found as topmost design related delay factor.
L. Public agitation demanding other facilities/(law and order problem) is found as topmost external delay factor.
M. Delay is land acquisition is found as topmost government related delay factor.

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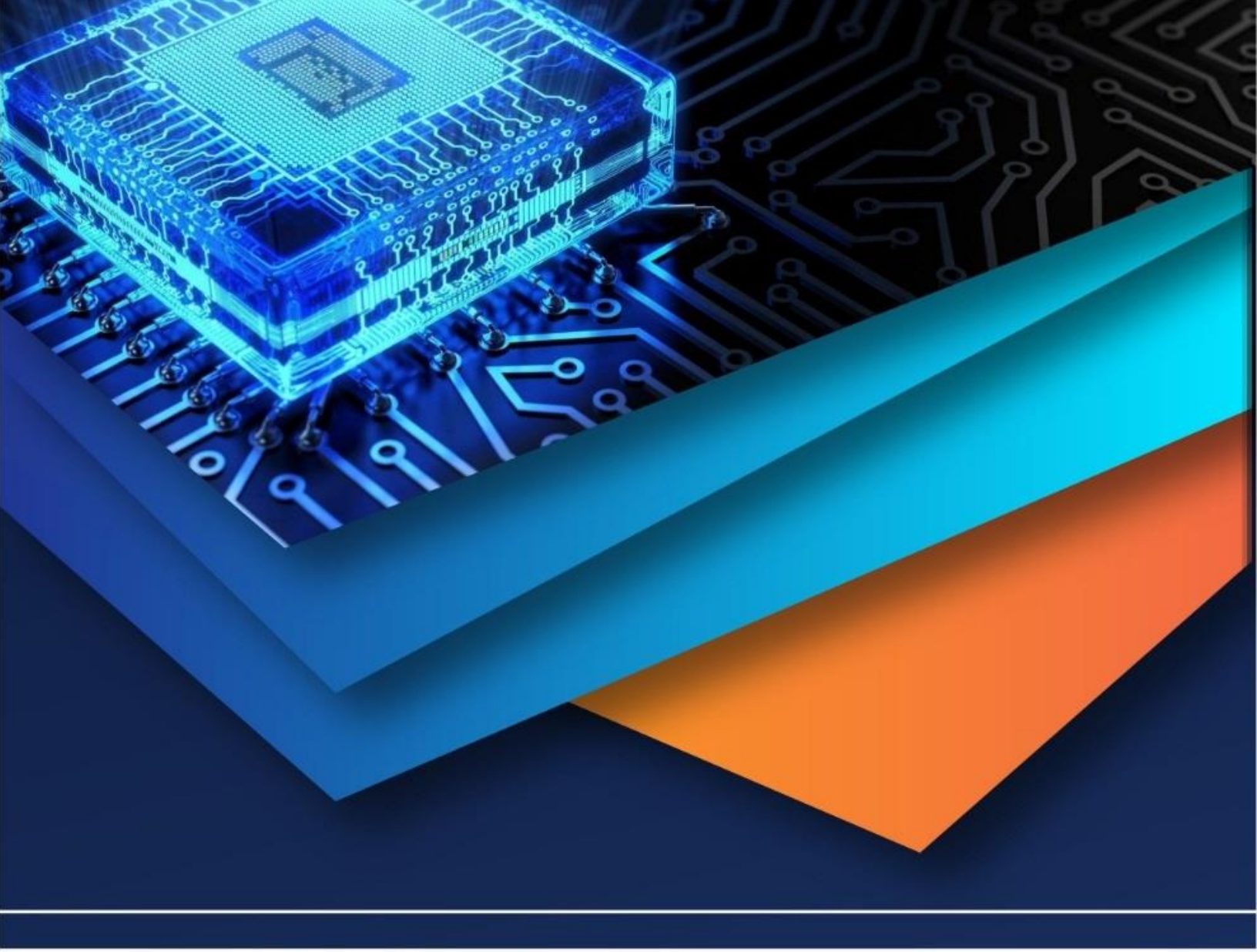

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