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IDENTIFYING AND HIERARCHIZING THE FACTOR OF DELAY FACTORS WITH INTERPRETIVE STRUCTURE MODELLING A CASE IN INDIAN THERMAL POWER PLANT

Kaushik A. Naik
PG Research Scholar, Dept. Humanities and Management, Manipal Institute of Technology, Manipal Academy of Higher Education, India

J N. Ramprasad
GM, Reputed EPC Company, Bengaluru, India

Giridhar Kamath
Faculty, Humanities and Management, Manipal Institute of Technology, *Manipal Academy of Higher Education, India*

Shiva Prasad H. C*
Faculty, Humanities and Management, Manipal Institute of Technology, Manipal Academy of Higher Education, India
*(Corresponding Author)

ABSTRACT

For projects to succeed four key factors are important; they are manpower, finance, material and time. The finance is an essential component than the rest and the key role played by the finance department is critical for project completion success. This study sheds light on the delay factors that causes cost escalation on the project managers to have to deal with during the project. The objective is to list and rank the significant causes of delay that occurs during the construction of the project based on prior work done by other researchers and experts in the field from the company. The ranking the delays is done by three methods-Relative Importance Index (RII), Importance Index (IMP.I) and Total Risk Score (TRS). Using the three approaches the delay causes are ranked based on the responses from experienced projects managers via survey questionnaire in projects site. The cost of escalation by di-graph shows nine delay causes were considered as critical causes and the nine variables were used in developing and Interpretive Structural Model (ISM) showing the interrelationship among the delay causes. If was found that the cost of the project increases with a delay in completion time, based on the ranking of the delay causes.

Keywords: cost escalation; finance; interpretive structural modelling; project management

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1. INTRODUCTION

Planning is the critical functions of all projects. Planning is selecting objectives and then establishing programs and procedures for achieving the objectives/milestones. Decisions making is required because a choice is made from among the alternatives that are available. It may be a choice of systems, equipment, or contract strategy to mention a few. Eventually, the plan is accomplished through a structured sequence of events which leads to the desired set of objectives. A construction project requires a tremendous amount of investment and plays a significant role in the growth of several other sectors of the economy (Guan and Liao 2014). Owing to huge investments the need to complete the project on time is high. Like any project, there are always factors which tend to delay the project and cause an increase in completion time; power plant construction projects are no different. They are often plagued with delays and cost overruns. For any project to be successful, a few aspects are fundamental and need to be taken into consideration, i.e. Manpower, Money, material and Time and the capacity of the power plant is a significant factor. Many of the Engineering Procurement Construction (EPC) Company uses this form of classification. Sub-critical plants are those who have a capacity of up to 400 MW and below; Supercritical plants are those plants which have a capacity of around 800 MW; and Ultra-critical plans have a capacity of more than 800 MW.

2. LITERATURE REVIEW

Sweis et al. (2008) highlight that the primary cause of a construction project to not meet its required timeline is the fact that the clients may at a time face financial difficulties such as no capital in hand, lack of investors. Tumi and Omran et al. (2009) have underlined the causes of delays like the ineffective coordination of the project itself which is disastrous in its self as mismanagement of the project can lead to over or underuse of resources which in both forms are very bad for the project. The next point that is highlighted for the same is the Ineffective communication between the clients and vendor which may cause delay. Ravishankar et al. (2014) have stated that delays occur in every project, but it differs is the magnitude of the impact it will have on the completion time of the project. Some may be days behind, but some may be years behind schedule. Thus, they have insisted on identifying the causes to minimize the delay. They have identified 10 factors such as 1) Shortage of skilled labour, 2) Design change by owner, and 3) Fluctuation of prices. According to Megha et al. (2013), a list of more than 59 factors fewer than nine dominant groups are narrowed down through extensive literature review and expert opinion. In order to classify these factors, they have used methods such as: 1) Relative Importance index (RII), 2) Importance index technique, 3) Data accuracy check using Spearman's correlation factor. Based on the above analysis he has helped rank the delay factors. Alnuaimi and Mohsin (2013), have mentioned that owners in the most construction project in a developing country are directorates of central and local government which are directly or indirectly affected using bureaucracy. The other reasons that they have identified are the fact that the contractors at times are inexperienced to handle projects which in term lead to time overrun in the completion of the project. According to Shebob et al., (2012) have helped develop a delay analysis system where the critical activities are taken into consideration cause the leading causes of time delay is the critical activities. The authors have identified the delays and have arranged in ranked order as (i) Delay in material delivery, (ii) Low skill of manpower, (iii) waiting time for the approval of drawings and test samples of materials, (iv) External work due to agencies (v) Rework due to errors during construction, (vi) shortage of required equipment, (vii) Shortage of required materials, (viii) Severe weather conditions, (ix) Ambiguities, mistakes and inconsistency in drawings, (x) Improper technical study by the contractors before commencement of work. This research attempts to answer the following questions: Does there exist any delay factors that indirectly cause cost escalation? Do these factors identified by the project managers are appropriately dealt with during the project. Does cost escalation have a significant effect on the project? Do the client is informed about the financial requirement until the project gets completed?

3. RESEARCH METHODOLOGY

3.1. Interpretive Structural Modelling (ISM)

ISM model is an interactive learning process where in the group's judgement decides how each of the factors is related to each other and how one affects the other (Singh, 2011). ISM helps to establish order and direction of action among the factors of the system into consideration. Using ISM approach helps managers reassess things of the system that are previously not known and helps in restructuring the process to improve efficiency. Following are the steps for performing ISM: Step 1: Identifying the causes of delay in the power plant using a literature survey or any other problem-solving technique. Step 2: A contextual relationship between the different causes should be established. Step 3: A structural self-interaction matrix (SSIM) which shows the pair-wise relationship between the different causes. Step 4: Developing a reachability matrix from the SSIM and the checking the matrix for transitivity. Transitivity is the underlying assumption in ISM which can be explained as if the element A→B and element B→C then by default A→ C. Step 5: Partitioning the reachability matrix into different levels. Step 6: Based on the relationship that is given in the reachability matrix draw a directed graph and remove the transitivity links. Step 7: Replace the nodes of the digraph with statements. Step 8: Review the ISM model and check for conceptual inconsistency and make the modifications if required.

Structural Self-Interacting Matrix (SSIM) is used to show the relations between the causes of the problems. ISM method suggests the use of expert opinion such as brainstorming, nominal technique (Ravi and Shankar 2005). In order to narrow down the delay causes a literature survey and interview methods were used. A total of forty-five causes were identified and through the data analysis method mentioned above nine causes were finalized as being the most important. The contextual relationship between the causes was established through expert opinion. Total of three experts was consulted. For expressing the relationship between the causes four symbols were used which are explained as: V: Factor i leads to factor j; A: Factor j leads to factor I; X: Factor i and j lead to each other; O: Factor i and j are unrelated. Cause one leads to five then 'V'; If Cause one and two are unrelated then 'O'; If cause three and four lead to each other then 'X'; If cause five to one then 'A'. The next step is to find the reachability matrix. It is derived using the results from the SSIM. The primary aim to achieve the reachability matrix is to convert the SSIM matrix into a binary matrix which means that substituting the values V, A, X and O by 1 and 0. The rules that need to be followed for the substitution process is given as: If the (i,j) entry in the SSIM is V, then the (i,j) entry in the reachability matrix showed be entered as 1 and (j,i) entry showed be entered as 0. If the (i,j) entry in the SSIM is A, then the (i,j) entry in the reachability matrix showed be entered as 0 and (j,i) entry showed be entered as 1. If the (i,j) entry in the SSIM is X, then the (i,j) entry in the reachability matrix showed be entered as 1 and (j,i) entry showed also be 1. If the (i,j) entry in the SSIM is O, then the (i,j) entry in the reachability matrix showed be entered as 0 and (j,i) entry showed also be 0. The next step is the partitioning of the levels. The reachability matrix with transitive closure the partitioning is performed next. For determining the levels, the reachability and antecedent sets are determined. The reachability set consists of causes itself and also other causes which it may help achieve. The antecedent set is a collection of the causes itself and also other causes which may help to achieve it. After that, the intersection of both sets is taken. The reachability set and antecedent sets which share the same causes are taken, and that forms the first level of the partition. After that, the cause is separated out, and the process is repeated thus giving us the next level. The process is repeated until all the portioning is done. After the partitioning of the levels is done, the conical matrix is developed using the final reachability matrix. A conical matrix is developed by clustering the benefits together across the rows and columns in the final reachability matrix that helps to develop the diagraph and links they share. After the diagraph is constructed the links are checked, and if any transitive links are there they are removed, and the diagraph is then replaced with the actual causes and constructed.

3.2. Relative Importance Index (RII)

Kometa et al., (1994) has used the relative importance of index to establish the importance among each delay factor. This method was used to find the ranking of the delay based on the impact they have on the cost of the project. The method is applied to various studies and gives a right rating scale of the factors.

Relative Importance Index (RII) is calculated as

$$\mathrm{RII} = \sum \mathrm{W} / (\mathrm{A} * \mathrm{N}) \qquad 1$$

3.3. Importance Index (IMP.I)

The second method suggested by Kometa et al., (1994) in the called the importance index. The importance index focuses on getting the ranking of the delay based on the effect of delay on time of project completion. The importance index uses values from two indexes which are frequency index and severity index. One index measures the frequency of occurrence of the delay and the other measure the severity of the delay.

Frequency Index (FI) (%) $$FI = \sum a\left(n/N\right) * \left(100/4\right) \qquad (2)$$

Severity Index (SI) (%) $$\mathrm{SI} = \sum \mathrm{a}(\mathrm{n}/\mathrm{N}) * \left(100/4\right) \qquad (3)$$

Importance Index (IMP.I) $$\mathrm{IMP.I} = [\mathrm{FI}\ (\%) * \mathrm{SI}\ .(\%)]\ 1/100 \qquad (4)$$

3.4. Total Risk Score (TRS)

The total risk score is a combination of both the above factors into one. Jayasudha et al. (2014) suggested this method of ranking based on both the above factors which impact on cost and impact on time and thus it gives a more generalized raking of the delays.

4. RESULT

Ranking of the delay factors is shown in the table. It is calculated using the RII, IMP.P and TRS methods. The ranking of the first ten delay factors are given out of the total of forty- five factors that were listed for the interview.

4.1. Delay Ranking

The method used to rank the delays is given below.

4.1.1. Relative Importance Index (RII)

The ranking in this method was done concerning the impact of delay on whole cost aspect. The below table gives us the ranking of the delay. For the analysis of the survey results, three methods were used which are given below.

Table 1 Delay factors ranking using Relative Importance Index (RII)

Sl. No.	Delay factors	Weightage of factors
1	Ineffective planning and scheduling activities by contractor	0.97
2	Improper construction methods implemented by the contractor	0.97
3	Delay in obtaining permits from the government	0.97
4	Delay in progress payment by the owner	0.95
5	Inadequate experience of consultant	0.95
6	Change in government regulations and laws	0.93
7	Delay to handover the site to the contractor by the owner	0.93
8	Rework due to errors during construction	0.92
9	Unclear & inadequate details in drawing	0.92
10	Low productivity and efficiency of equipment	0.90

4.1.2. Importance Index (IMP.I)

The ranking in this method is done concerning the impact of delay on project completion time. Two different aspects were considered for the ranking in this case which includes the delays severity on the project completion and its frequency of occurrence which indicate how frequently it occurs. The table below gives the ranking based on the Importance index.

Table 2 Delay factors ranking using Importance Index (IMP.I)

Sl. No.	Delay factors	Weightage of factors
1	Shortage of labour	60.92
2	Delay in obtaining permits from the government	54.89
3	Ineffective planning and scheduling activities by contractor	54.83
4	Imported Materials and equipment delivery delays	53.08
5	Poor communication/coordination between consultant and other parties Consultant	50.92
6	Delay in inland material delivery	48.56
7	Low productivity level of labours	48.31
8	Effect of social and cultural factors	47.78
9	Inadequate experience of consultant	46.28
10	Delay in carrying out a performance test	46.25

4.1.3. Total Risk Score (TRS)

The ranking, in this case, considered the impact of both, time and cost of the project by the delay factors and is a combination of both. The table 3 gives a ranking of the delay factors.

Table 3 Delay factor ranking using Total Risk Score (TSR)

Sl. No.	Delay factors	Weightage factor
1	Shortage of labour	34.44
2	Delay in obtaining permits from the government	33.96
3	Ineffective planning and scheduling activities by contractor	33.92
4	Imported Materials and equipment delivery delays	30.58
5	Poor communication/coordination between consultant and other parties Consultant	29.33
6	Inadequate experience of consultant	28.14
7	Delay in inland material delivery	26.41
8	Low productivity level of labours	26.28
9	Delay in progress payment by the owner	26.14
10	Late procurement of materials	26.01

Table 4 Self Structured Interaction Matrix

Delay Cause (DC)	1	2	3	4	5	6	7	8	9
1		O	O	V	A	O	A	O	A
2			A	O	O	A	V	O	O
3				V	V	V	V	V	V
4					A	A	O	A	O
5						V	V	V	V
6							V	V	O
7								V	O
8									A
9									

4.2. Preparation of ISM Model

Step 1: Listing the research variables are done with the help of the survey analysis and taking experts advice that has relevant experience in the field of concern.

Table 5 List of causes based on RII, IMP.I and TRS

Cause No.	Delay Causes	Delay Type		
		RII	IMP.P	TRS
1	Delay in obtaining permits from the government	0.97	54.89	33.96
2	Shortage of labour	0.88	60.92	34.44
3	Ineffective planning and scheduling activities by contractor	0.97	54.83	33.92
4	Imported Materials and equipment delivery delays	0.90	53.08	30.58
5	Poor communication/coordination between Owner- Vendor-consultant	0.90	50.92	29.33
6	Poor site management and supervision by the contractor	0.88	45	25.44
7	Delay in site mobilization	0.88	41.25	23.32
8	Delay in bid review / finalization of vendors/Sub-vendors	0.88	44.72	25.28
9	Delay in floating enquires and receiving offers by bidders	0.87	36.67	20.34

Step 2: The expert opinion is taken in this step and is asked to fill the table based on the rules that are mentioned in the ISM model. The table is called the Self Structured Interactive Matrix (SSIM) and the rules are explained in the methodology.

Step 3: The reachability matrix is the binary form of the SSIM. The rule for substitution of the alphabets with 0 and 1 is given in the methodology. The matrix that is generated is also tested for transitivity and the transitivity closure is performed on the same.

Table 6 Final Reachability matrix with transitive closure

D C	1	2	3	4	5	6	7	8	9
1	1	0	1	0	0	0	0	0	0
2	1*	1	1*	0	0	0	1	1*	0
3	1*	1	1	1	1	1	1	1	1
4	0	0	1	0	0	0	0	0	0
5	1	1*	1	1	1	1	1	1	1
6	1*	1	1	0	0	1	1	1	0
7	1	0	1*	0	0	0	1	1	0
8	1*	0	1	0	0	0	1	1	0
9	1	0	1*	0	0	0	1*	1	1

Step 4: The next step is the partitioning of the cause into different levels. In order to do that the reachability set and the antecedent set is found out (Warfield 1974). The cause in the reachability set consists of itself and also the cause that it drives. The cause in the antecedent set consists of the cause itself and also the causes on which it depends. After that, the intersections of both these sets are found.

Table 7 Delay Causes level partitioning

Levels	Delay Causes		Delay Type
I	4	Imported Materials and equipment delivery delays	L R
II	1	Delay in obtaining government permits	O R
III	7	Delay in site mobilization	C R
	8	Delay in bid review and finalization of vendors	V R
IV	2	Shortage of labour	L R
	9	Delay in floating enquires and receiving offers by bidders	O R
V	6	Poor site management and supervision by the contractor	C R
VI	5	Poor communication/coordination between consultant and Consultant	O R, C R, V R
VII	3	Ineffective planning and scheduling activities by contractor	C R

Step 5: The conical matrix is developed for the preparation of the diagraph. It is developed by clustering the benefits at the level achieved, across rows and column in the final reachability matrix.

Table 8 Conical Matrix

D C	4	1	7	8	2	9	6	5	3
4	1	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0
7	1	1	1	1	0	0	0	0	0
8	1	1	1	1	0	0	0	0	0
2	1	1	1	1	1	0	0	0	0
9	1	1	1	1	0	1	0	0	0
6	1	1	1	1	1	0	1	0	0
5	1	1	1	1	1	1	1	1	0
3	1	1	1	1	1	1	1	1	1

Step 6: Based on the above conical matrix a di-graph is constructed, and the links are check.

Step 7: Now the nodes in the di-graph is substituted with actual statements

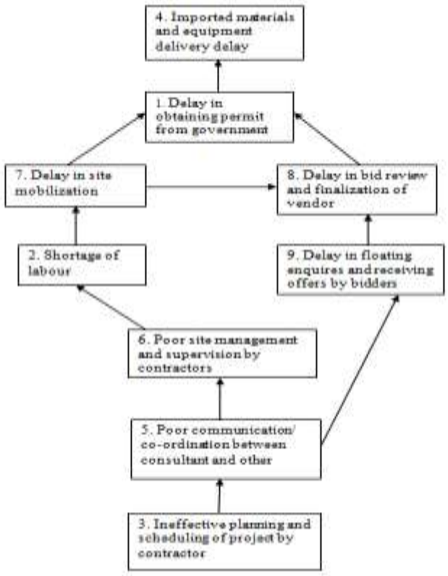

Figure 1 Final ISM Model

Step 8: The final ISM model is prepared and is verified for inconsistencies in the model, and the necessary changes made in the model.

5. DISCUSSIONS

According to the survey responses from the experts the critical delay cause is as follows: 1. Shortage of labour 2. Delay in obtaining permits from the government 3. Ineffective planning and scheduling activities by the contractor 4. Improper construction methods implemented by the contractor. According to the ISM model, it is seen how the nine factors are interrelated to each other. The ISM method depends a lot on the selected group of experts and may vary based on the group selected for conducting the study. It identifies the relationship between each factor that is considered for the studies. Delay in site mobilization will also cause delay in finalization of vendor because once the vendor is finalized, the preparation of the site will help get the things that are required for the completion of the work in place and will also ensure that the essentials required for the construction are available on site. Delay in finalization of vendor for the equipment will affect the permit acquisition from the government as in order to obtain the permit for importing of the equipment and functioning of the same the government will require that the specification of the equipment and also the working parameters will need to be submitted to the government after which the permits will be obtained. These things will only happen once the vendor submits the specification and the government can review it and issue the permit.

6. CONCLUSION AND FUTURE SCOPE

As the demand for power increases in India more and more projects are coming up. Thus it is essential to realise the cost aspects of the projects and the time of completion of the project. This study highlights the delay factors based on past literature and also an expert opinion. The ranking was carried out using three distinct methods which considered the cost aspect along with the time aspect too. Based on the above results the ISM model was prepared which highlighted the interrelationship between the factors and how each of the factors has influenced each other. The cost projections were also shown which finally give the influence of delay on cost.

The delay factors collected using an extensive literature survey and expert opinion. Further factors can be added if necessary and can be done for specific packages of the power plant. Based on the ISM model the different relationships are identified which are only nine in number. In order to show the better relationship among the factors more delay factors can be considered for the study and the ISM model can be prepared once again. Structural equation modelling can be used to check the validity of the ISM model which help give a better understanding of the inter relationship. Since both the models complement each other, it is right way to validate each other.

REFERENCES

[1] Alnuaimi, A. S., & Mohsin, M. (2013, December). Causes of delay in completion of construction projects in Oman. In International Conference on Innovations in Engineering and Technology (pp. 267-270).

[2] Kometa, S. T., Olomolaiye, P. O., & Harris, F. C. (1994). Attributes of UK construction clients influencing project consultants' performance. Construction Management and Economics, 12(5), 433-443.

[3] Megha, D., & Rajiv, B. (2013). A methodology for ranking of causes of delay for residential construction projects in Indian context. International Journal of Emerging Technology and Advanced Engineering, 3(3), 396-404.

[4] Ravisankar, K. L., AnandaKumar, S.& Krishnamoorthy, V. (2014). Study on the Quantification of Delay Factors in Construction Industry. International Journal of Emerging Technology and Advanced Engineering.4(1), 105-113.

[5] Shebob, A., Dawood, N., & Shah, R. K. (2012). Development of a methodology for analysing and quantifying the impact of delay factors affecting construction projects. Journal of Construction Engineering and Project Management,2(3), 17-29.

[6] Singh, R. K. (2011). Developing the framework for coordination in the supply chain of SMEs. Business Process Management Journal, 17(4), 619-638.

[7] Sweis, G., Sweis, R., Hammad, A. A., & Shboul, A. (2008). Delays in construction projects: The case of Jordan. International Journal of Project Management, 26(6), 665-674.

[8] Tumi, S. Al. H., Omran, A. & Pakir, A. H. K.(2009). CAUSES OF DELAY IN CONSTRUCTION INDUSTRY IN LIBYA. The International Conference on Economics and Administration, Faculty of Administration and Business, University of Bucharest, Romania ICEA – FAA Bucharest, 14-15th November 2009, p. 265 – 272.

[9] Jayasudha, K., Vidivelli, B. & Surjith, E. R. G.(2014), Risk Assessment and Management in Construction Projects. International Journal of Scientific & Engineering Research, 5(8), 387-396.

[10] Warfield, J. N. (1974). Developing interconnection matrices in structural modeling. IEEE Transactions on Systems, Man, and Cybernetics, 4(1), 81-87.