A MODEL TO ESTIMATE THE TIME OVERRUN RISK IN CONSTRUCTION PROJECTS

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Abstract
This paper aims to develop a model to find the expected percentage of time overrun (Delay Index) in a construction project, because time overrun is one of the major criteria which could affect the success of any construction projects. Therefore, it will be a serious issue in today's construction. In view of that, six major groups causing the time delay in the project were identified from literature survey and opinions from the experts in construction sectors. A questionnaire was designed and the project managers were asked to fill the percentage of delay for each group related issues and the overall delay duration of the construction projects. Likewise, 112 completed project details were collected from various constructors. Then the collected data were analyzed using regression analysis. The results of a model were used to fine tune the relationship between the percentage of delay and the major group related issues that causes delay. This model estimates the expected percentage of the time overrun for a particular construction project during the planning stage itself. So that, the necessary action can be taken to minimize the delay and to complete the construction project on time and within budget.
Keywords: Construction Projects, Time overrun, Risk Factors, Statistical analysis, Delay Index, Model.

1. INTRODUCTION

Construction delay has been considered as a major risk as well as a source of disputes in any construction projects (Ogunlana,1996); (Aibinu and Jagboro, 2002). As far as the Indian construction projects are concerned, they are experiencing frequent and costly delays. According to the recent report from the Ministry of Statistics and Program Implementation (MOSPI) India, almost 52.1 % of projects are running behind their original/contract schedule. However, keeping construction projects within estimated time and cost requires sound strategies, good practice and careful judgement (Pourrostam and Ismail, 2012). Moreover, In large construction projects, the average time overrun indicated by the contractors is between 10% - 30% of contract duration while about 56% of the consultants specified the same percentage (Assaf

Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 2 / May 2017

and Al-Hejjei, 2006). Since time overrun in a project will lead to bad consequences of the project performances like quality, cost overrun, company's reputation, etc. so there is a need to develop the prediction model to estimate the time overrun in construction projects. The Scope of this study is limited to only the Indian building projects which includes commercial, residential and industrial buildings. The main objective of this study is to develop a model to find the expected time delay for the construction projects in the planning phases of the project and to suggest same suitable recommendations to minimize the time overrun risk in the construction project.

2. BACKGROUND OF THE STUDY

Many researches highlighted that the time overrun in construction projects is a complex issue across many countries. Hence the construction delay is the time overrun either beyond the completion date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project (Assaf and Al-Hejji, 2006). Therefore, delay in project might be occurs due to various reasons. Many researchers were identified the reason for the delay and they categorized under ten major groups and concluded that the total abandonment of the projects was due to the factors like i) manpower related, ii) material related, iii) Scheduling & control related, iv) Environment related, v) Change orders, vi) Client related, vii) Consultant related, viii) Contract related, ix) Financial related and x) External factors (Chan and Kumaraswamy, 1997); (Sambasivan and Soon, 2007); (Razek et al.,2008). Similarly, in Indian context, one of the research survey found 45 factors influenced the occurrence of delays and they were categorized into 6 major groups such as i) Manpower related factors, ii) Material related factors, iii) Equipment related factors, iv) Finance related factors, v) Scheduling & Control related factors and vi) Environmental related factors. Finally, it was found that all the six groups were having significant contribution for time delay in construction projects (Venkatesh et.al.,2012). Moreover, various researchers have made a study on individual factors which are responsible for time delay in various construction projects. Such studies were discussed in detail in the following section.

In the modern era labor shortage is one of the major issues which the construction industry is facing globally. Followed by, slow mobilization of labor, labor supply, absenteeism, strike, and low motivation and morale (Venkatesh et.al., 2012) were also the critical factors that contribute for time delays. Moreover, the quality of labor (Sambasiva and Soon 2006), labor productivity (Odeh and Bataineh, 2002), shortage of skilled labor (Chan and Kumaraswamy, 1996), (Ogunlana, et al.,1996) will have the major impact on the projects and they were having a high influence of causes of time delays. Hence the success of any project belongs to contractors. Contractors should be assigned enough number of labors and be motivated to improve productivity because the shortage and productivity of labors were one of the main contributors for time delay (Assaf and Hejji ,2005).

Material related issues are also one of the critical factors for contributing the delay in the project. So many researchers have made a research to identify the material related delay factors in the construction industry such as the delivery of the material in construction site, shortage of materials (Chan and Kumaraswamy, 1996); (Ogunlana, et al.,1996), (Koushki, et al.,2005), poor quality of materials(Ogunlana, et al.,1996), (Odeh and Bataineh, 2002), (Koushki, et al., 2005) , poor procurement of materialFrimpong, et al, (2003), Koushki, et al, (2005), escalation of material prices (Wiguna and Scoot , 2005), and unreliable suppliers were the most critical factors that could contribute time delays in construction project (Abed Majid and McCaffer, 1998) . As in the Indian context factors like Shortage of materials, Delivery of materials, Delay in Procurement of materials, materials selection, changes in types and specification were the most critical factors causing delay (Venkatesan et al., 2012).

Equipment related factors are also one of the most important delay factors that cause suspension of construction project. Past studies revealed that the factors like insufficient numbers of equipment, frequent equipment breakdown, equipment allocation problem(Ogunlana et al., 1998), Low level of equipment operator's skill, Low productivity & efficiency of equipment (Rahsid et al.,2013), improper equipment, slow mobilization of equipment (Abd Majid and McCaffer, 1998), (Chan and Kumaraswamy 1996),(Odeh and Bataineh,2002), inadequate modern equipment (Long et al., 2004), were the most significant factors that contribute to time overrun in construction Projects.

Financial related issues are also one of the major parameters for time delay in the construction project because it will create difficulties for the contractors to meet the project objectives. Past studies revealed that the most significant factors in the financial related issues were inadequate fund allocation, delay payment to subcontractors / suppliers(Abed Majid and McCaffer, 1998) , high interest rate (Long et al. 2004), contractor's financial difficulties (Ogunlana, et al.,1996), client's financial difficulties and monthly payment difficulties(Chan and Kumaraswamy,1996), unreasonable constraints to client (Koushki, et al., 2005), inability of clients (building owners) to honour payments on time, failure to pay contractors regularly for work done, failure to provide adequate funding resources to contractors(Frimpong et al., 2003).

Normally the construction project is unique and complex nature, due to that there are many uncertainties in the entire project. Such factors are considered in the environmental related factors. Those environmental related factors also generate time delay in a project and they are difficult to predict, but it's having more impact on the schedule of the project. Hence some of the researchers were highlighted the most serious issue factors under environmental related such as weather changes, change in the rules and regulations of the local government, unforeseen site conditions (Mansfield et al., 1994), natural disasters, organizational changes, conflicts and problems with neighbors were the most important and highly impacted factors(Haseeb, et al., 2011); (Assaf and Al-Hejji, 2006).

Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 2 / May 2017

The life cycle of the project is decided based on the scheduling and control. Hence, researchers were spotted out some drawback in this system also; such factors should be considered under the scheduling and control related problems. These factors are viewed in two aspects one is based on the firm size and the capability for assigning personnel and the other one is the deviation occurs in projects scope. However the small firms are reluctant to employ higher level skilled staff and they may not be willing to pay highly skilled staff. Therefore the factors like lack of management personnel, lack of training personnel and improper estimating skills will lead to the time delay in construction project. On the other hand the most critical factors in the project scope, such as change orders and reworks, lack of conceptual stage, management support to model the construction, operation, monitoring of projects, often change of contractors and subcontractors and preparation of scheduling networks and revisions by client/consultant/Architect (Venkatesan et al., 2012). Similarly the documentation of the project also one of the other factors in building construction project such as Lack of database in estimating activity duration and resources, Inspection and testing procedures used in the project, and Application of quality control based on foreign specification (Razek et al.,2008).

From the past researchers, it is concluded that groups such as i) Manpower related factors, ii) Material related factors, iii) Equipment related factors, iv) Finance related factors, v) Scheduling & Control related factors and vi) Environmental related factors are the critical and the most significant major groups causing delay in the Indian construction industry. Some researcher has made a prediction model to establish the relationship between the critical attributes for assessing the impacts of these factors. Hence the relationship was formulated between initial estimated and final achieved construction time using regression analysis as $Y = 13.1159 + 1.1341x$ where x is the initial estimated time of a project or 35.3% additional time to be added to the amount of initial contract time to estimate the final contract time(Aiyetan et al., 2012). In the same line, a causal relationship was proposed between the factors of cost overrun for large construction projects using structural equation modelling method with the global fit index of 0.405 which explained the model fit (Rahman et al., 2013). However it was done for cost overrun in a project, hence this study focus on causal relationship with the time overrun factors in a project since there are only limited studies carried out with the causal relationship model in India. While most of the previous studies have focused on the findings of the causes of delay in construction projects. However, construction delay is an important risk in the different phases of the project, it is necessary to investigate into this problem in order to overcome time overrun risk in a construction project. For that, a time overrun prediction model (delay Index (DI)) which will relate the major group related issues in a particular project is formulated. It gives the delay duration for a real construction site and so it is useful to minimize the delay by proper resource based scheduling process.

3. RESEARCH METHODOLOGY

In this study, six major group related issues for causing delay in Indian context were identified from literature survey and expert opinion. Based on this, a structured questionnaire was designed to know the various construction project details. The questionnaire consists of 2 Parts. In Part I the project managers were asked to fill the type of the project, type of client, the actual duration of the project and the no of days delay in the project. In Part II ,the project managers were asked to answer six major questions; Example: What is the percentage of delay in this particular project due to manpower related issues? Similarly the questions were asked for material, equipment, finance, environment and scheduling and control related factors to know the percentage contribution of delay due to each group. The sampling method used in this study was random sampling technique. This sampling method enabled us to obtain a large number of completed questionnaires quickly and economically. About 200 questionnaires were distributed to the respondents at construction site through referral networks and friends. Of these about 112 filled responses were retrieved, comprising both the government and private projects in India. This study covered residential, commercial and industrial projects in metro cities like Chennai, Bangalore, Mumbai, Calcutta, and Delhi. Further the collected data were analyzed by means of multiple linear regression analysis using Statistical Product and Service Solutions (SPSS). The regression analysis was used in this study is to find out the relationship between the overall percentage of delay in the project and the percentage of delay by each group and also to test the model's ability. From these results the model was formulated to find out the delay index.

4. SURVEY SAMPLES

4.1. Client Details

The client details collected from the completed construction projects had a proportionate mix of 57% from private organization and 43% from government clients.

4.2. Type of Projects

The type, nature and details of project collected from the completed construction projects consisted of 11% residential, 36% commercial and 53% industrial buildings.

4.3. Project cost details

The total project cost details of the completed projects consisted of 43% - less than rupees 100 million, 36% in-between rupees 100-500 million and 21% - more than rupees 500 million.

Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 2 / May 2017

4.4.Significance of percentage of delay with each resources:

Table 1 shows the number of samples, mean and the standard deviation of the percentage of delay with each resource related issue. The null hypothesis were considered to find the significant relation between the each group and the percentage of delay.

TABLE 1 - DESCRIPTIVE STATISTICS: RESOURCE RELATED ISSUES WITH PERCENTAGE OF DELAY

Resource Groups (Independent Variable)	Overall % of delay (Dependent Variable)	N	Mean	Std. Deviation
Manpower related issue	5% to 25%	48	2.25	0.43
	26% to 50%	24	2.50	0.51
	51% to 75%	16	2.75	0.85
	76% to 100%	8	4.00	0.00
	above 100%	16	4.75	0.44
	Total	112	2.85	1.02
Material related issue	5% to 25%	48	2.41	0.49
	26% to 50%	24	2.16	0.70
	51% to 75%	16	2.25	0.44
	76% to 100%	8	2.00	0.00
	above 100%	16	2.75	0.85
	Total	112	2.35	0.61
Equipment related issue	5% to 25%	48	1.75	0.60
	26% to 50%	24	1.66	0.48
	51% to 75%	16	2.00	0.00
	76% to 100%	8	2.00	0.00
	above 100%	16	2.50	0.89
	Total	112	1.89	0.62
Finance dispute	5% to 25%	48	2.25	0.72
	26% to 50%	24	2.16	0.70
Finance dispute	51% to 75%	16	2.25	0.44
	76% to 100%	8	2.00	0.00
	above 100%	16	2.75	0.85
	Total	112	2.28	0.70
Environment related issue	5% to 25%	48	1.41	0.49
	26% to 50%	24	1.83	0.38
	51% to 75%	16	2.00	0.00
	76% to 100%	8	2.50	0.53
	above 100%	16	2.50	0.51
	Total	112	1.82	0.60
Scheduling and control problems	5% to 25%	48	1.83	0.37
	26% to 50%	24	2.66	1.12
	51% to 75%	16	2.25	0.44
	76% to 100%	8	2.00	0.00
	above 100%	16	2.25	0.44
	Total	112	2.14	0.69

TABLE 2 - STANDARD ANOVA : RESOURCE RELATED ISSUES WITH PERCENTAGE OF DELAY

Resource Groups (Independent Variable)	Overall % of delay (Dependent Variable)	Sum of Squares	df	Mean Square	F-Value	Sig.
Manpower related issue	Between Groups	88.71	4	22.17	81.83	0.00
	Within Groups	29.00	107	0.27		
	Total	117.71	111			
Material related issue	Between Groups	4.71	4	1.17	3.40	0.01
	Within Groups	37.00	107	0.34		
	Total	41.71	111			
Equipment related issue	Between Groups	8.38	4	2.09	6.53	0.00
	Within Groups	34.33	107	0.32		
	Total	42.71	111			
Finance dispute	Between Groups	4.52	4	1.13	2.40	0.05
	Within Groups	50.33	107	0.47		
	Total	54.85	111			
Environment related issue	Between Groups	19.42	4	4.85	24.74	0.00
	Within Groups	21.00	107	0.19		
	Total	40.42	111			
Scheduling and control problems	Between Groups	11.71	4	2.92	7.461	0.00
	Within Groups	42.00	107	0.39		
	Total	53.71	111			

The table 2 shows the standard ANOVA between the resource groups and the overall percentage of delay in a project. In this analysis results the groups like manpower, material, equipment,finance and scheduling and control related problems are having the significance value less than 0.05. so the null hypothesis is rejected and it is concluded that that there is significant relationship exists between the overall delay percentage and the resource related issues. The descriptive statistics Table 1 shows that the man power related issue is having a highest the mean value, when the overall percentage of delay is above 100% (4.75)and it is least for 5-25% (2.25). Similarly, the material related issue is having a highest the mean value, when the overall percentage of delay is above 100% (2.75) and it is least for 76-100%(2.00). The equipment related issue is having a highest the mean value, when the overall percentage of delay is above 100% (2.50) and it is least for 26-50%(1.67). The finance related issue is having a highest mean value, when the overall percentage of delay is above 100% (2.75) and it is least for 76-100%(2.00). The environment related issue is having a highest the mean value, when the overall percentage of delay is above 100% (2.5) and it is least for 5-25%(1.41). The scheduling and control related issue is having a highest the mean value, when the overall percentage of delay is 26-50% (2.67) and it is least for 5-25%(1.83).

5. MODEL FOR TIME OVERRUN RISK IN CONSTRUCTION PROJECT

According to the past research, the critical factors causing delay in Indian construction projects were due to five major groups such as manpower, material, equipment, finance, environment and scheduling &

Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 2 / May 2017

control related issues(Venkatesh et.al.,2012)and there is a significant contribution of all the six groups in the causes of delay in construction projects. So there is a casual relationship between the groups and the causes of delay. Considering these major groups a multiple linear regression model was developed with a relationship between the dependent variable as a percentage of delay and independent variables as manpower, materials, equipment, finance, environment and scheduling & controlling related issues. The causal relationship between the variables is shown in figure 1. The overall model fit can be explained by the significance value of F test, t- test and the r2 (coefficient of determination) value.

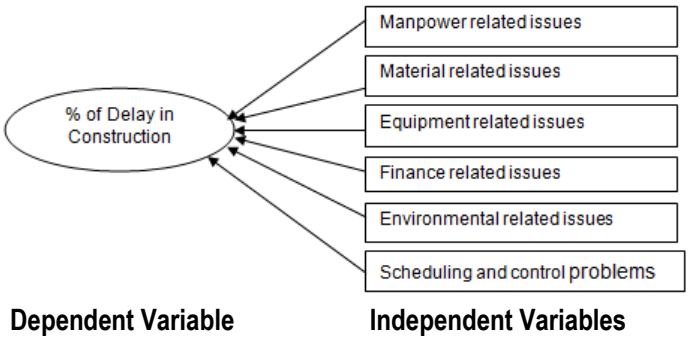

FIGURE 1 - SHOWS THE RELATIONSHIP BETWEEN THE DEPENDENT VARIABLES AND INDEPENDENT VARIABLES

In this regression analysis, the coefficient of determination r2, explains the overall model fit for estimating the strength of the relationship between the model and percentage of delay. R, the multiple correlation coefficients was found to be 0.920 which is near to 1, it assured that there was a linear correlation between the observed and model-predicted values of the dependent variable. The higher the r2 value increases the strength of the predictive power of the dependent variable with the other independent variables. R Square, the coefficient of determination, is the squared value of the multiple correlation coefficients. From the analysis, it was found that r2 value is 0.846 which is also close to 1; therefore the model explains 84.6 % variance in the delay percentage. Since the r2 value was high, the predictive power of the delay index with the group related issues that cause delays will be more.

The ANOVA, tests the acceptability of the linear regression model from a statistical perspective. The variation accounted by the model is represented in the regression value. The variation that is not accounted by the delay model is represented in the residual value. If the F statistic value is higher and also the significance value is less than 0.05, it implies that the calculated regression coefficient is significant. In this analysis F statistic test value was found to be 96.026 which was a higher value and the significance value was found to be 0.00 which implied that the calculated regression coefficient was more significant. The variance in the independent variables contributed to the change in the dependent variable. Therefore, it inferred that the variance in the group related issues will contribute to change in the

percentage of delay. While the ANOVA table is useful to test the model's ability to explain any variation in the dependent variable, it does not directly address the strength of that relationship.

The coefficients of the regression line are given in table 3. In this the beta coefficients of the independent variables and its significant value are explained. The independent variables having significant value, p value < 0.05 implies a strong relationship with the dependent variable. According to this coefficients table, the predictor variables like manpower, materials, finance, environment related issues and scheduling & control problems have a p value < 0.05, so they were significant and it was found that there was a causal relationship between these variables and the % of delay. The variance coefficients of the each independent variable were represented by B value. The standard error and B value for constant term were resulted as 12.5 and -157.46.

Multicollinearity refers to the correlation among six independent variables. This multicollinearity was tested by finding the VIF (Variance influence factor). If VIF for all the independent variables is less than 10, there is no multicollinearity between the variables. Therefore the dependent variables have a direct effect on independent variables. Similarly, according to the table 3, the VIF value was found to be less than 10, so there was no multicollinearity between the six resources. Therefore, it inferred that the percentage of delay had a direct effect on the group related issues.

The standardized residuals were normalized with respect to the regression line is represented in Figure 2.

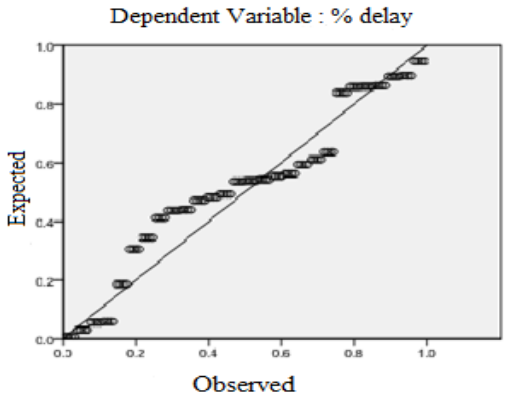

FIGURE 2 - NORMAL P-P PLOT OF REGRESSIONSTANDARDIZED RESIDUAL

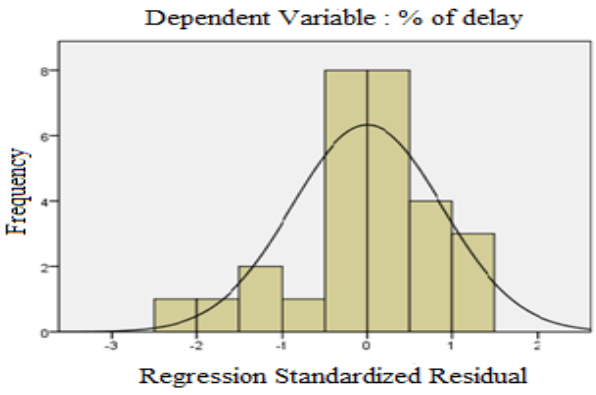

FIGURE 3 - HISTOGRAM OF REGRESSION STANDARD RESIDUAL

As they were distributed normally, it satisfied the assumptions of multiple linear regression models. The histogram of the standard residual is represented in Figure 3. In this the residuals were normally distributed, so the p values for t- test were valid. Thus the model was having a goodness of fit.

Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 2 / May 2017

TABLE 3 - TIME OVERRUN RISK COEFFICIENTS

Model	*t*- Test			Collinearity Statistics	
	Coefficients B	t	Sig.	Tolerance	VIF
Manpower related issue (MAN)	1.01	11.29	0.00	0.52	1.94
Material related issue(MAT)	0.17	1.39	0.02	0.76	1.32
Equipment related issue(EQU)	-0.05	-0.42	0.66	0.61	1.63
Finance dispute(FIN)	0.25	2.66	0.00	0.94	1.07
Environment related issue(ENV)	0.48	3.27	0.00	0.56	1.79
Scheduling and control problems(SCH)	0.32	3.14	0.00	0.85	1.17
Constant	-2.05				
Std. Error	0.44				

Therefore the expected percentage of the construction delay model was formulated from the coefficient Table 3 result is given in equation 1.

Percentage of delay in construction project (or) Delay Index = 1.01 X MAN + 0.17 X MAT + 0.25 X FIN + 0.48 X ENV + 0.32 X SCH - 2.05 + 0.44 (1)

In this proposed model, where y is the delay index (dependent variable) which is linearly dependent on manpower, material, finance, environment and scheduling related issues (independent variables x1, x2, x3, x4 & x5). The partial regression coefficients B value is given in the table 3. It describes the rate of the unit change of the percentage due to group related issues with respect to delay index.

From the data collected on the completed projects, the average percentage contribution of each group related issues which cause delay was calculated and it is represented in figure 4. From the figure, it can be understood that the manpower related issue was the highest, contributing 21% of delay followed by material related issues contributing 18% of delay.

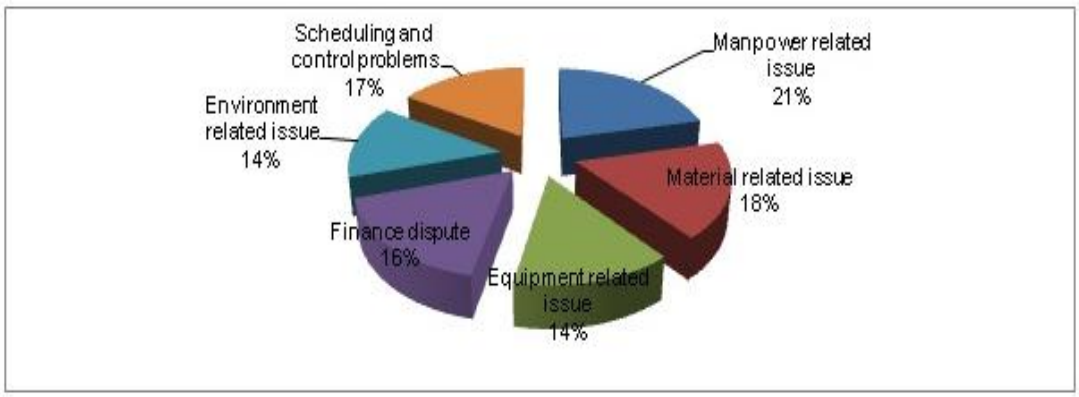

FIGURE 4 - PERCENTAGE CONTRIBUTION OF EACH GROUP IN DELAY

6. CONCLUSIONS

This study was carried out by collecting details of 112 construction projects. In this the project managers were asked to rank the major groups like manpower, materials, equipment, finance, environment and scheduling and control related issues as per their project conditions and the percentage of time delay was categorical into 5 points such as Nil, 1-25%, 26-50%, 51-75% and 76-100%. The nil option was given if there is no delay due to a particular group, but intentionally that nil option was not used by the respondents. From this, it was clear that there was some minimum percentage of delay prevailing in all groups. The data were analyzed using regression analysis. From the results, the delay index model was formulated. The model has a strength of about 84.6 % in relation to percentage of delay and the independent variable. In the previous studies, the researchers proposed a linear relationship by taking x at the initial time of the contract and y as the final contract time. In this study, the model is formulated by taking delay index as y and resource related issues that cause delay as x1, x2, x3, x4 & x5. This developed model will predict the expected deviation in advance with more accuracy. By knowing the expected deviation in advance the planners can prepare the schedule of the project accommodating the expected deviation. The major groups such as manpower (21%), materials (18%), scheduling and control related problems (17%) were having the highest contribution in the construction delay, so these percentages should be taken into consideration during the planning and scheduling process to minimize the construction delay. This model has been suggested a strategy to the real projects for forecasting the delay duration depends upon the project conditions and improve the overall project performance.

RECOMMENDATIONS

In this study, a developed model has been recommended for contractors, government and schedulers in the construction field for minimizing the time delay in construction projects. Based on that, the following suggestion and important recommendations are presented below. This study provides a good guidance for managerial intervention and provides some guidelines and actionable information that managers can utilize to manage their projects.

1. The above mentioned six critical factors are to be seriously considered in project planning & scheduling phase, so as to reduce / control the delay.
2. Proportionate weightages are to be given to the each group causing delay according to the percentage contribution of delay during the schedule phase.
3. Contractors must be prepared at source and assign required number of skilled labors at the site.

Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 2 / May 2017

4. Labours are to be motivated monetarily, emotionally by providing incentives and conducive work environments. The satisfied labor force increases productivity.

5. Material procurement schedule must be planned in advance by forecasting the requirements. Just in time orders for critical materials are to be avoided and are stored in their economical store quantity. Care to be taken to minimize adhoc orders for materials in demand.

6. Scheduling and controlling are to be viewed as a dynamic and continuous process during construction.

7. Projects are to be tracked with time and resource on a regular interval basis to understand the smooth running of the project so that appropriate, timely steps can be taken, if there are any symptoms of delay.

8. Smooth and continuous cash flow is to be maintained so that the delays due to financial reasons can be minimized.

9. The Project Implementation Unit (PIU) and the Project Management Unit (PMU) are to be strengthened.

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