STATISTICAL APPROACH FOR CREW BALANCING IN CONSTRUCTION

***Haganesh,B,**Nithiarasu.S,Dr.T.Meenambal,@ Er.N.Balasubramanian,ME^**

***UG student,Jansons Institute Of Technology,Coimbatore.**

****UG student. Jansons Institute Of technology,Coimbatore.**

@Prof. in Civil Engg,GCT,Coimbatore

^ Research Scholar Bharathiar University, Coimbatore.

Corresponding author e mail: tmeenambal_gct@yahoo.co.in

ABSTRACT: A country needs sufficient infrastructure for its development, utilizing the resources such as man power, materials, machinery, time and money, etc., in which the crew balancing is a prime objective. A study has been conducted on labour requirement for various activities of a typical residential building in Coimbatore City in twenty five number construction sites of 162 activities, involving skilled, semi skilled and unskilled labours on various construction activities are observed.

A statistical model using analysis tool pack of micro soft excel software is developed to explain the relationship between the independent variable to the dependent variable is developed. From the correlation matrix, the output variable is found to have linear correlation with the input variable. A multi linear regression analysis is done between the input variable and the output variables which yields, the regression coefficient R^2 - 0.6233, which is reasonably good, and standard error of 216.145 for 162 observations which explains the relationship between the input and the output and also shows statistical relationship can be used for predicting the target that is the quantity of work executable and the targets are within acceptable error range.

Key words: infrastructure, man power, labour requirement, statistical model, correlation matrix, multi linear regression analysis, predicting the target, input and the output, reasonably good

1.0 INTRODUCTION:

Coimbatore is situated in the extreme west part of Tamil Nadu adjacent to Kerala State, and foot hill of Western ghat, at an elevation of about 398 meters from the mean sea level, surrounded by Blue Hills and Anamalai Wild Life Sanctuary, with a pleasant and moderate temperature climate region. Textile, metal processing industries are in boom and hence there are lots of multistory and individual buildings with heavy labour demand and wages in all industrial, educational, agricultural and recreational sectors necessitated to effective labour utilization.

The construction activities involves works such as earthwork, plain cement concreting, reinforcement fixing, shuttering, concreting, brick work, plastering, painting, wood works, steel grill fixing, ornamental works, tile fixing, plumbing, sanitary works, etc., Various types of unskilled, semi skilled and skilled labour labours are required involving plumber, fitter, mason, bar benders, crane operator, unskilled labour, semi skilled labour, skilled labour, painter, carpenter, electrician, etc., for the above construction.

1.1 FACTORS AFFECTING LABOUR PRODUCTIVITY

The factors affecting labour productivity or the performance of individual work roles are of broadly classifies includes:

- Physical-organic, location, and technological factors;
- Cultural belief-value and individual attitudinal, motivational and behavioural factors;
- managerial-organizational and wider economic and political-legal environments;
- levels of flexibility in labour markets and the organization of work activities – e.g. the presence or absence of traditional craft demarcation lines and barriers to occupational entry;
- individual rewards and payment systems, and the effectiveness of personnel managers and others in recruiting, training, communication and performance-motivating employees on the basis of pay and other incentives;
- International influences – e.g. levels of innovativeness and efficiency on the part of the owners and managers of inward investing foreign companies.

Aim of the study is to create a statistical analysis using artificial neural network model to predict the optimum labour requirements for the construction activities, so as to plan for effective utilization of the human resource. By this study, the labour requirement for residential building for a city or large area and major residential projects can be effectively estimated.

2.0 LITERATURE REVIEW ON LABOUR MANAGEMENT:

Some of the literatures available regarding labour management are as follows:

Udegbe, (2004) tried optimize the labour requirement for the building construction using the application of transcendental functions. The study relied on primary and secondary data. The values obtained using the transcendental involvement of labour in projects is approximately 36 percent of the total cost of any building project.

Thomas et al., (2004) determined symbiotic crew relationships and labour flow hence introduced a concept heretofore unrecognized in multiple crew relationships, symbiotic crew relationships. The performance of crews with symbiotic relationships is shown to be consistently worse than when symbiotic relationships are not present. Symbiotic relationships are also tied to time buffers.

Carl Haas (2000) carried out a study about allocation optimization of a multi skilled workforce, in which the workers possess a range of skills that

allows them to participate in more than one work process. The success of multi skill greatly relies on the foreman's ability to assign workers to appropriate tasks and to compose crews effectively.

Kuprenas, (2003) made a study on a general contractor performing work on a highway project in Western United States. The crew balancing chart was prepared to represent every workers' duty on day to day basis. Proverbs et al., (1997) adopted a method for estimating labour requirements and costs for international construction project, which is a fresh approach in that ambition. During inception, while design information is at a premium, cost forecasts were within 20 percent of the final cost of the building. Planned productivity rates form the basis of the estimate used to generate a 'Labour Estimate Factor'

Thompson et al., (1993) did an accounting for the multi-period impact of service when determining employee requirements for labour scheduling. Providing good customer service, inexpensively was the problem commonly faced by managers of service operations. In an experiment simulating 13824 service delivery environments, the new method demonstrated its superiority by serving 2.74 percent more customers within the specified waiting time limit while using 7.57 percent fewer labour hours. Tung et al., (2008) carried his work in the field of work force allocation; his findings were basically the reliability requirement to serve a job request and the cost of the job's assignment. The risks for workers to execute a job are taken into consideration.

There are lots of author carried out work in the field of crew balancing, work force allocation, labour handling and so on. But no one has done the research work on residential project. The main aim of this project is to create labour requirement for each job and effective usage of labour in terms of scheduling for residential building.

3.0 MATERIALS AND MEHTODS:

The construction process involves many steps and stages involving labour component as prime factor for the progress of work. The construction process should take place in a continuous manner in such a way that one work is followed by the other. For the sequential progress, there should be a proper planning before executing the work. There should also be alternate mode so that if something goes wrong, work be progressive without any hinderence. The success of a project is dependent on how effective the Project Manager manages these main attributes namely time, cost and quality within the project duration.

In this study, 25 sites in Coimbatore city were chosen as sample. All the activities right from the clearing the site, earth work excavation, till the finishing and handed over were considered and the number of labour and time required for the completion of task were noted down. Cost effectiveness can be arrived by considering the time taken by them to complete the job.

Table 3.1 Extract of model of work force and work done

3.1 Data collection:

Job code	skilled (Mason)	Semi skilled (Men Mazdoor)	Unskilled (Women Mazdoor)	Total quantity of work executed	Work Description
1	0.00	173.85	260.77	32596.00	Earth work excavation for Main building
2	0.00	14.56	21.85	2730.80	Compound wall earth work
3	0.00	22.34	33.52	4189.44	Garden earth work
4	0.00	1.60	2.00	283.50	Generator Bed earth work
5	0.00	1.27	1.39	233.75	Carport plinth beam earth work
6	0.00	4.00	4.25	408.00	EB room earth work
7	0.00	3.67	4.00	575.49	Out house earth work
8	0.00	10.58	15.86	1057.50	Front compound wall earth work
9	0.00	3.50	4.00	425.00	Steps earth work

Right from the start of work, the labour required for the work and time taken for the completion of the particular work is noted then and similar type of work is tested in another site. Likewise 162 different works were selected from the above 25 different sites and their readings were noted down. The data obtained from each site like type of work, quantity of work, quantity of labours are recorded in work book for the study. Then data obtained from site were entered in the computer using analysis tool pack of the Microsoft excel spread sheet and a statistical model is derived. From the correlation matrix the positively correlated variables are identified and concluded that these variables are having linear relationship among them.

3.2 Multi Linear Regression

This linear relationship is further confirmed by the multi linear regression performed with four input variables and one output variable. The total number of observations is 162. The option of confidence level is given as 95 percent, and standardized residual plot option also given. From the regression analysis the regression statistics such as adjusted R^2, coefficient of relationship, standard error are found. From the ANOVA (analysis of variance) F test statistics is analysed for developing null hypothesis and null hypothesis is rejected based on the critical F value. By performing ANOVA the P-value is found less than one. Hence the results of statistical analysis are considered as significant.

From the constant and coefficients of regression statistics a multi linear regression equation is developed and given in the equation 3.1.

$Y = K + A X_1 + B X_2 + C X_3 + D X_4$ ---------- (3.1)

Where Y = dependent variable / target

X_1, X_2, X_3, X_4 = independent variables which influence the dependent variable

K = a constant/ intercept of multi linear relationship

A,B,C,D = Co-efficient of each independent variables.

The result obtained by predicting the target by the statistical equation is compared with that of measured output and the model efficiency is checked.

5.0 RESULTS BY STATISTICAL MODEL:

The relationship between the input variable to the target is explained by statistical analysis. To understand the relationship between the dependent variable with the independent variables a correlation matrix is arrived and shown in the table 4.1

TABLE 5.1 – correlation matrix for dependent and independent variables

Description	JOB code	Skilled	Semi Skilled	Un Skilled	Quantity of work
JOB code	1				
Skilled	0.045733	1			
Semi-skilled	-0.17532	0.786081	1		
Un-skilled	-0.12863	0.615033	0.682781	1	
Quantity of work	-0.13459	0.406714	0.73904	0.467885	1

From the correlation matrix the quantity of work that is the output having positive correlation with the type of labourship that is skilled, semiskilled and unskilled labourship are found out. After obtaining the relationship pattern using correlation matrix, a regression analysis is performed. Since the number of input variables is four, a multi linear regression model is developed using Microsoft excel 2007.

The result of multi linear regression model is shown in the table 4.2 and table 4.3.

Table 5.2 regression statistics

Regression Statistics	
Multiple R	0.795411022
R^2	0.632678693
Adjusted R^2	0.623320189
Standard Error	2162.14579
Observations	162

In this regression statistics the adjusted R^2 value is 0.6233, which is reasonably fair value for the good correlation. From the ANOVA analysis F value is greater than significant F value and hence strong evidence is made that the expected value in these groups differs. The 'p' value is less than one. Hence the results by this model are significant. The multi-linear correlation between the independent variables with the dependent variables is given by the relation in eqn. 5.3.

Table 5.3 Constant and coefficients of correlation

Description	Coefficients	Standard Error
Intercept	-438.892	372.685
job code	6.731	3.879
Skilled	-84.746	14.149
Semi Skilled	120.767	9.465
Un Skilled	0.255	2.812

$$Y = K + A X_1 + B X_2 + C X_3 + D X_4 \quad \textbf{(5.3)}$$

Where Y = Total quantity of work executable for this combination,

X_1,X_2,X_3,X_4 = variables , i.e. job, skilled, Semi Skilled, Un Skilled

K,A,B,C,D = Co-efficient of each variables.

From the table, the relation can be written as

$Y = (-438.892) + 6.731\ X_1 + (-84.746)\ X_2 + 120.767\ X_3 + 0.255\ X_4$ **-(5.4)**

The results obtained by the statistical model are tabulated and compared with measured output for determining statistical model's efficiency. The standard error for the statistical model is 2162.14 for the 162 number of observations; hence the above said statistical relationship can be used for predicting the target that is the quantity of work executable. The statistical model predicts the target with acceptable range of error and explains the relationship between the input and the output.

6.0 CONCLUSIONS FROM STATISTICAL MODELLING:

The following conclusions are made from the statistical model.

1. The statistical model explains the relationship of input variables with the output.
2. The magnitude of constant obtained from the regression analysis is -438.89, which explains that the input variables taken for regression analysis having less weights.

REFERENCES:

1. Carl I Haas, P.E. David, P. Morton, 2000, "Assignment and Allocation Optimization of a partially multi-skilled workforce" A Report of Center for Construction Industry Studies, The University of Texas at Austin.
2. Kuprenas J. A. (2003), 'Implementation and performance of a matrix organization structure' International Journal of Project Management, Volume 21, Issue 1, pp 51-62.
3. Proverbs DG, Holt GD, Olomolaiye Po 1997 " A method of estimating labour requirements and costs for international construction projects at inception" Building environment 31 (1) PP 43-48.
4. Thomas H., Michael J. Horman, and Ubiraci Espinelli Lemes de Souza 2004 "Symbiotic Crew Relationships and Labor Flow" J. Constr. Engrg. and Mgmt. Volume 130, Issue 6, pp. 908-917.
5. Tung H W, 2008 A Risk-Oriented Job Dispatching Mechanism for Workforce Management System Book Series IFIP International Federation for Information Processing, Publisher Springer Boston Volume 189, Pages 559-570.
6. Udegbe, 1997. " Labour Force Utilization in Construction." Seminar Paper Delivered in NBRRI Lagos, Nigeria. 1–5.