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EVALUATION OF FACTOR AFFECTING FOR LABOUR PRODUCTIVITY IN CONSTRUCTION PROJECT BY AHP

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Abstract:-
The study aims at identifying the factors an affecting labor productivity of Building construction projects in the South Gujarat. . To do so, as per sample size 350 Stakeholders working in construction completed a structured questionnaire survey ranked the identified factors according to analytical hierarchy process. 40 factors were identified through a detailed literature review. Factors of similar nature were grouped together; giving rise to seven main groups that are: technical, labor, materials, equipments, external &environmental, safety and quality. The analysis of the identified factors indicated that the top ten important factors negatively affecting labor productivity of building construction projects in South Gujarat are: quality inspection delay, working at high places, rework, low quality raw material, lack of material, delay in arrival of material, equipment shortage, lack of labour skill, payment delay

Keywords:- Analytical *hierarchy process, labour productivity, stake holders.*

I.INTRODUCTION

Productivity is one of the most important factors affecting the overall performance of any organization, whether large or small. Productivity has been generally defined as the ratio of outputs to inputs. Construction projects are mostly labour based with basic hand tools and equipment, as labour costs comprise 30 % to 50 % of overall projects cost. Therefore, while numerous construction labour productivity research studies have been undertaken, only a few have addressed the productivity issue in developing countries factors affecting productivity in the construction. Productivity in economics refers to measures of output from production processes, per unit of input. Productivity may be conceived of as a measure of the technical or engineering efficiency of production (Saari, 2006). Construction is a key sector of the national economy for countries all around the world, as traditionally it took up a big portion in nation's total employment and its significant contribution to a nation's revenue as a whole. However, until today, construction industries are still facing number of problems regarding the low productivity, poor safety and insufficient quality. Productivity is the one of the most important factor that affect overall performance of any small or medium or large construction industry. There are number of factors that directly affects the productivity of labour, thus it is important for any organization to study and identify those factors and take an appropriate action for improving the labour productivity. At the micro level, if we improved productivity, ultimately it reduces or decreases the unit cost of project and gives overall best performance of project. There are number of activities involved in the construction industry. Thus the effective use and proper management regarding labour is very important in construction operations without which those activities may not be possible.

II. OBJECTIVE

- To identify most crucial factors associated with the labour productivity in building construction project.
- To give the ranking to those factors by AHP (analytical hierarchy process)
- To explore the conceptual remedial measures.

III. LITERATURE REVIEW

The construction industry also involves a large number of variables; the labor intensive work, the unique character and the occurrence of unpredictable events (Choromokos and McKee, 1981; Arditi and Mochtar, 2000; Thomas and Yiakoumis, 1987; Thomas et al., 1990; Horner and Talhouni, 1995; Kaming et al., 1997; Ng et al., 2004; Gulezian and Samelian, 2003; Zayed and Halpin, 2004; AbdelRazek et al., 2006). Therefore, the construction process results in relatively high costs (Gambao et al., 2000) and labor becomes a more important input in the production phase. Moreover, the labor cost is somewhere between 20% and 50% of the total project cost (Buchan et al., 1993; Zakeri et al., 1997; Kaming et al., 1998) and the reduction of these costs can be best carried out by improving productivity (Kaming et al., 1998). In addition, factors affecting productivity may vary from task to task. Although some factors could have similar influences on the productivity of a number of tasks, their rate of impact on productivity may vary (Sonmez and Rowings, 1998). The assignment decisions of resources such as labor, equipment and material control the overall duration and cost of a project (Hegazy, 1999). Construction productivity is traditionally identified as one of the three main critical success factors together with cost and quality for a construction project (Nkado, 1995; Walker, 1995). The application of productivity rate which is an indicator of the construction time performance is in the scope of planning and scheduling of the construction, controlling of the cost and worker performance, estimating and accounting. Labor productivity estimates are often performed by individuals using combinations of analytical techniques and personal judgment (Portas and AbouRizk, 1997); namely, the worker hour estimates are usually obtained through direct interaction with a scheduler, the site manager or related sub-contractors who are knowledgeable enough to reflect the actual conditions of a project and its constituent activities (Arditi et al., 2001). These individuals often have a library of basic productivity rates which are adjusted and recalculated for each project (Proverbs et al., 1998), and always modify their productivity rates for each specific estimate (Christian and Hachey, 1995). On the other hand, differences in these productivity rates are always likely and normal (Kazaz and Ulubeyli, 2004). Many articles have described, in general terms, the variation in labor productivity and the evidence of complex variability in construction labor productivity (Radosavljević and Horner, 2002), the decline in construction labor productivity (Rojas and Aramvareekul, 2003), trends in construction lost productivity claims (Klanac and Nelson, 2004), benchmarking of construction productivity (Park et al., 2005) and explaining labor productivity differentials (DiGiacinto and Nuzzo, 2006). However, few articles discussed quantitative issues relating the loss of productivity.

IV. ANALYTICAL HIERARCHY PROCESS

Analytic Hierarchy Process is an effective decision making technique based on multi-criteria decision making methodology (MCDM). It consider the human judgment, experience, perception and feelings in the decision making process. This research focus on developing a theoretical selection model based on the AHP approach. It help decision maker to select the most appropriate contractor against a number of contractors with various alternatives. The Analytic Hierarchy Process was chosen for this study based on following reason:

- The ability of AHP to incorporate tangible and intangible factors in a systematic way.
- It able to solve constructed problems in a variety of decision making situation, ranging from the simple personal decisions to the complex capital intensive decision.
- The problem is broken down in a logical fashion from the large elements to smaller elements.
- It works by examining judgments made by decision makers and measure the consistently of those judgments.
- It does not required numerical judgment from the decision maker.

- **BACKGROUND OF APH**

The Analytic Hierarchy Process (AHP) was develop by Thomas Saaty in 1970's[1], to provide a simple but the theoretically sound multiple criteria methodology for evaluating alternatives. It aims at quantifying relative priorities for a given set of alternative on a ratio scale, based on the judgment of the decision maker and stresses the importance of the intuitive judgment of a decision maker as well as the consistently of the comparison of the alternative in the decision making process (Saaty. T.L. 1980) [4]. The application of Analytic Hierarchy Process can be found in such diverse fields as portfolio selection model solve by using AHP methodology include project procurement system (Mohammed I.A , Khalil 2000), project management (Kamal 2001) and Engineering problems (Saaty 2001).[5] According to Partovi (1992),the AHP is a decision aiding tool for dealing with complex , unstructured and multi attribute decision . Ny Dick and Hill (1992) described the AHP as a methodology to rank alternative courses of action based on the decision makers judgment concerning the important of the criteria and the extent to which they are met by each alternative.Golden (1989), described AHP as analytical by using members, hierarchy by structuring the decision problem into levels and process-oriented because its step- by-step approach. Murahdar (1990) support the belief that the AHP caters specifically for decision making with multi criteria.

- **AHP STEPS**

Saaty [2, 4, and 7] developed the following steps for applying the AHP:

1. Define the problem and determine its goal.
2. The hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which sub sequent levels depend) to the lowest level which usually contains the list of alternatives.
3. Construct a set of pairwise comparison matrices(size n x n) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 1. The pair-wise comparisons are done in terms of which element dominates the other.
4. There are n (n-1) / judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.
5. Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.
6. Having made all the pair-wise comparisons, the consistency is determined by using the eigenvalue, Imax , to calculate the consistency index, CI as follows: C.I.=(Imax-n) / (n-1) where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.
7. Steps (4-6) are performed for all levels in the hierarchy.

Table 1: pairwise comparison scale for ahp preferences, saaty [1, 3]

Numerical Scale	Verbal judgment of preferences
9	Extremely preferred
8	Very Strongly to Extremely
7	Very Strongly Preferred
6	Strongly to Very Strongly
5	Strongly Preferred
4	Moderately to Strongly
3	Moderately Preferred
2	Equally to Moderately
1	Equally Preferred

V. METHODOLOGY

The AHP is a structured practice for representing the elements of a problem, hierarchically. The AHP method was developed by T.L. Saaty (Saaty, 1990). It can enable decision makers to represent the interaction of multiple factors in complex, unstructured situations. The procedure is based on the pairwise comparison of decision elements with respect to attributes or alternatives. A pairwise comparison matrix M×M is formed, where M is the number of elements to be compared.

Structuring the hierarchy for evaluation
The AHP method is used to make the arrangement of the problem as a hierarchy. In general, the AHP method divides the problem into three levels (Saaty, 1990):

- Define a goal for resolving the problem
- Define objectives for achieving the goal
- Determine evaluation criteria for each objective.

• **Constructing the pairwise comparison matrix**
After structuring a hierarchy, the pairwise comparison matrix for each level is constructed. During the pairwise comparison, a nominal scale is used for the evaluation. The scale used in AHP for preparing the pairwise comparison matrix is a discrete scale from 1 to 9, as presented in Table 1.

Table 2: Comparison matrix of main attributes

Technical	Material	Labour / Motivational	Equipment	External/ Environmental	Quality	Safety	WEIGHT	
1	0.333333333	0.5	2	0.5	1	1	0.0999	Technical
3	1	0.5	2	1	1	2	0.1704	Material
2	2	1	4	2	2	2	0.2494	Labour / Motivational
0.5	0.5	0.25	1	0.333333333	0.25	0.25	0.0502	Equipment
2	1	0.5	3	1	2	0.5	0.1536	External/ Environmental
1	1	0.5	4	0.5	1	1	0.1293	Quality
1	0.5	0.5	4	2	1	1	0.1472	Safety

Table 3: Pairwise comparison matrix of suppliers with respect to Technical

CTS	TEV	DC	CL&D	ID	PWP	MUTS	WEIGHT	
1	2	1	2	0.5	0.5	1	0.1455	CTS
0.5	1	0.5	1	0.5	2	2	0.1237	TEV
1	2	1	1	0.5	1	2	0.1444	DC
0.5	1	1	1	1	4	2	0.1755	CL&D
2	2	2	1	1	1	1	0.1827	ID
2	0.5	1	0.25	1	1	2	0.1356	PWP
1	0.5	0.5	0.5	1	0.5	1	0.0927	MUTS

CTS = Clarity of Technical Specification,
TEV = The Extent of variation in order,
DC = Design Complexity,
CL&D= Coordination level & Design,
ID = Inspection Delay
PWP = Poor work planning
MUTS = Miss use of time scheduling

Table 4: Pairwise comparison matrix of suppliers with respect to Labor

LLS	ILA	LT	ASEL	PP	LPE&R	LFS	LW	UA &D	BRLM	UT	WEIGHT	
1	0.5	2	2	1	1	1	1	2	1	0.5	0.0988	LLS
2	1	1	0.5	2	0.5	0.5	1	2	1	1	0.0931	ILA
0.5	1	1	0.5	1	1	0.5	0.5	1	1	2	0.0722	LT
0.5	2	2	1	1	1	0.5	1	1	1	1	0.0891	ASEL
1	0.5	1	1	1	1	0.5	1	1	1	1	0.0759	PP
1	2	1	1	1	1	0.5	1	1	1	1	0.0868	LPE&R
1	2	2	2	2	2	1	1	1	1	1	0.1209	LFS
1	1	2	1	1	1	1	1	2	2	2	0.1112	LW
0.5	0.5	1	1	1	1	1	0.5	1	1	1	0.0722	UA &D
1	1	1	1	1	1	1	0.5	1	1	5	0.1018	BRLM
2	1	0.5	1	1	1	1	0.5	1	0.2	1	0.0781	UT

LLS = Lack of labour skill
LT = Lack of training
PP = Personal Problem,
LFS = Lack of financial system,
BRLM= Bad Relation to Labour to Management,

ILA = Increase of labour Ag
ASEL= A shortage of Experience Labour
LPE&R= Lack of Places for eating & relaxation
LW= Low wages, UA &D= Use of Alcohol & Drug
UT= Unproductive time

Table 5: Pairwise comparison matrix of suppliers with respect to material.

LM	DAM	UMSL	ICM	PD	Weight	
1	1	1	1	1	0.1894	LM
1	1	1	1	0.25	0.1475	DAM
1	1	1	1	1	0.1894	UMSL
1	1	1	1	0.333333333	0.1522	ICM
1	4	1	3	1	0.3215	PD

LM = Lack of material
UMSL= Unsuitable material storage location
PD = Payment Delay

DAM = Delay in arrival of material,
ICM = Improper construction method

Table 6: Pairwise comparison matrix of suppliers with respect to equipment.

Equipment shortage	Improper training for operating equipment	Old and inefficient equipment	WEIGHT	
1	1	1	0.3333	Equipment shortage
1	1	1	0.3333	Improper training for operating equipment
1	1	1	0.3333	Old and inefficient equipment

Table 7: Pairwise comparison matrix of suppliers with respect to external/ environmental.

Working with confined space	Project size	Weather change	High wind	Heavy rain	Weight	
1	2	2	0.5	1	0.2211	Working with confined space
0.5	1	2	1	2	0.2178	Project size
0.5	0.5	1	0.5	0.5	0.1056	Weather change
2	1	2	1	3	0.3044	High wind
1	0.5	2	0.333333333	1	0.1511	Heavy rain

Table 8: Pairwise comparison matrix of suppliers with respect to safety.

Ignore safety precautions	Accident	No safety engineer at project site	Insufficient lighting at project site	Working at high places	weight	
1	0.333333333	0.5	3	2	0.2051	Ignore safety precautions
3	1	0.5	1	1	0.1625	Accident
2	2	1	2	2	0.3035	No safety engineer at project site
0.333333333	1	0.5	1	2	0.1573	Insufficient lighting at project site
0.5	1	0.5	0.5	1	0.1238	Working at high places

Table 8: Pairwise comparison matrix of suppliers with respect to Quality.

Low quality raw material	High quality of required work	Rework	Quality inspection Delay	weight	
1	0.5	0.25	2	0.1520	Low quality raw material
2	1	0.5	0.5	0.2010	High quality of required work
4	2	1	5	0.5197	Rework
0.5	1	0.2	1	0.1273	Quality inspection Delay

• Calculating the weights and testing the consistency for each level

This step is to find the relative priorities of criteria or alternatives implied by these comparisons. The relative priorities are worked out using the theory of eigenvector. And the consistency check should be done at each stage of the selection process. To evaluate the consistency of the obtained result three components are needed from the analysis namely Consistency index (CI), Random consistency Index (RI). Following techniques are used to determine the above said elements of calculation. Where M×M is the matrix size.

Weights are calculated from the comparison matrices. After putting the values in each cell of the matrix the first step would sum up the value of the columns. Then the summations of values of the columns would be equated, after that the each column summation is divided the total sum of the columns to find the weights of the criteria/ factors of PCWM.

$$CI= \lambda_{max} – n / (n-1)$$

And the random consistency index (RI) is computed as, RI=1.98((n-2)/n)

Where λ_{max} is the maximum eigenvalue and n is the size of the pairwise comparison matrix. Thus the consistency ratio (CR) is obtained using,

CR= CI/RI

It is always appreciable that the value of CR should less than or equal to 0.1 or 10%, then the computed result is said to be consistent or acceptable. At the final step of the calculation, the overall preference matrix would be constructed by multiplying all the weights with the factors, therefore the results are added to get the composite score of each factor.

VI. RESULT

According to above procedure top ten Factors Are:

Rank	Factor Affecting labour productivity	AHP
1	Quality inspection Delay	0.0352
2	Working at high places	0.0326
3	Project size	0.0320
4	Rework	0.0302
5	Low quality raw material	0.0293
6	Lack of material	0.0285

CONCLUSION

From the present study, total 40 factors were identified which factor affecting the labour productivity in building construction projects. 151 feedbacks from various stakeholders were collected to identify critical factors by ahp techniques. Rii technique gives first 5 crucial factors as: (1) quality inspection delay, (2) working at high places, (3) project size, (4) rework, (5) low quality raw material.

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