ASSESSMENT OF LABOUR PRODUCTIVITY IN CONSTRUCTION WORK USING ANALYTICAL HIERARCHY PROCESS

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Abstract : Labour productivity is one the least studied areas within the construction industry. Construction industry requires a large workforce. Poor efficiency of development workers is one reason for cost and time attacks being developed endeavors. Because of a sensational move in the limit and volume of the Indian development area throughout the most recent decade, the need of an efficient examination and comprehension of the variables that impact the connection between the efficiency of a work and the consequence of the development ventures is very urgent.

Labour performance can be termed as accomplishment of certain task according to the prescribed standards of accuracy, completeness, efficiency and quality. This investigation means to analyze human asset rehearse followed in development industry. Recognizing Labour execution factor and assessing the development firms with the assistance of distinguished work execution factor to improving work gainfulness is evaluating work effectiveness.

In the current project, the factors affecting the productivity of construction labour in relation with the activities on construction sites are identified through literature survey based on previous research, site survey, and with input, revision and modifications by local experts. These identified factors will be further related to: Management, Site and Resource, Project characteristics, Labour characteristics and Miscellaneous. Questionnaires were created which were answered by labours, contractors, and experienced engineers. Thus, critical factors of labour productivity will be identified. These findings are expected to be worthwhile information in determining the major steps to improve the performance of project completion time. On collection of data analytical hierarchy process is used for evaluation of construction firms.

IndexTerms **- Construction firm, human performance factor, Analytical hierarchy process.**

I. INTRODUCTION

Construction is one of the country's biggest ventures of the world and has been assuming a critical part in financial improvement, and additionally in lessening unemployment. Profitability is one of the essential viewpoints for the organizations in the development business. Change in the efficiency of the development business is accordingly of basic significance thinking about its huge commitment to the GDP (Gross Domestic Product).

The construction company with the most efficient operations has a greater chance to make more money and deliver faster construction project to the project owner. Improving labor productivity can alleviate the shortage of skilled craft-workers, enhance the working conditions, and enhance the overall quality of a product. For every project, productivity, cost, quality and time have been the main concern. As appeared in Fig. 1, it is called "triple imperative". Here, labor productivity is a key halfway idea that can possibly influence these components and that ought to be considered in understanding the conceivable associations between them.

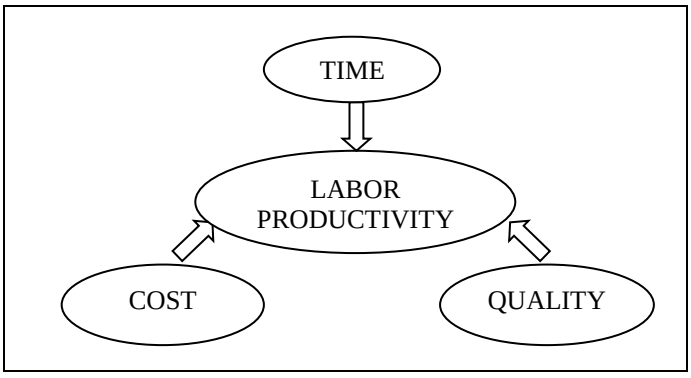

Fig .1 Triple Imperative

Accomplishing better labor productivity requires point to point investigations of the genuine labor cost. Different labors have diverse factors influencing their productivity levels. Due the absence of learns about the labor cost of the diverse construction trades in this zone, this research will center on it. The research passing the blend of the significance of the components influencing the labor productivity on a progression of basic development exchanges is a technique that should be the subject of this research. The development organization with the most proficient activities has a more prominent opportunity to profit and

convey quicker development task to the venture proprietor. Enhancing labor productivity can mitigate the deficiency of skilled labors, upgrade the working conditions, and improve the general nature of an item.

II. LITERATURE REVIEW

Ignacio Zaballos Palop, Victor Yepes Piqueras and Xueqing Zhang carried out "Study on improving labour productivity in the construction industry" in 2016.According to them work efficiency is one the minimum considered territories inside the development business. Efficiency changes accomplish high cost reserve funds with insignificant speculation. Because of the way that overall revenues are little on development ventures, cost investment funds related with efficiency are significant to turning into an effective temporary worker. The central misfortune to enhancing work profitability is estimating work efficiency.

Be that as it may, work profitability includes numerous angles. The point of this examination is to center in some of them, for example, development exchanges and how extraordinary variables influence their work efficiency through benchmarking in both on the web and printed version design. A rundown of 37 development exchanges was chosen in light of the Construction Industry Council of Hong Kong (CIC) keeping in mind the end goal to see their development cost, work cost and work deficiency criticality and their mechanization level. A rundown of 40 factors influencing the work profitability was chosen in view of specialists at The Hong Kong University of Science and Technology, with a specific end goal to find in which level they influence the basic development exchanges work efficiency discovered beforehand. The two outcomes were investigated utilizing the relative significance record (RII).

These outcomes are utilized as a part of an extra contextual analysis, in view of the correlation of them with another investigation with similar targets did by a few partners from The Hong Kong University of Science and Technology. An extra change of the work profitability should be possible by the blend of the two investigations.

Varun. V et al., (2014) inspected the convincing organization of this human financing to improve the proficiency and wealth of affiliation and furthermore to keep up amicability between the experts and organization. The examination perceives the segments that can be used for appraisal of human capital being developed industry and distinctive Multi Criteria Decision Making Techniques used for execution evaluation of Human Resource. Human resource organization is a specialty of pushing the human oblige for achieving the progressive destinations. However improvement industry with its significantly considerable work drive unmistakable evidence of the necessities of the workers and its fulfillment is a dull occupation. The examination gone for recognizing the distinctive components that impacts the bona fide execution of workforce in the advancement business and the diverse systems for examination used for their evaluation. The review suggests that usage of Multi criteria essential authority methodology like Analytical different leveled get ready, Analytical Hierarchy process and TOPSIS methodologies are more dominating in evaluating human execution than traditional techniques like reward structure, mental systems and 360 appraisal strategies. Since both subjective and quantitative data can be inspected by using the MCDM strategies.

T. Czumanskia, and H. Löddinga, studied "Integral Analysis of Labor Productivity". According to them, dissecting and enhancing the profitability of work concentrated assembling and gathering activities remains a significant errand for modern organizations. In light of the heterogeneous foundations for profitability misfortunes, the investigation requires an extensive information obtaining and assessment. With this paper we present a state-situated approach giving the likelihood to recognize and organize the distinctive effects on work profitability for consequent process upgrades. With a contextual investigation, we demonstrate to envision and assess state information of a get together cell to set up an objective situated change process.

Laura Floreza and Jean C. Cortissozb suggests that stone work temporary workers try to expand work profitability by gathering definite data on the laborers efficiency and the components that impact profitability. Quantitative factors, for example, hours, exercises, and errands are regularly estimated nearby and are utilized to appraise efficiency and decide times of development. In any case, there might be subjective factors, for example, identity that may likewise should be estimated nearby in light of the fact that it can profoundly affect the efficiency of a group. This paper proposes a numerical structure that uses the individual similarity between the specialists in a group to better gauge efficiency. An instrument to gauge and measure identity is proposed to decide the similarity of the specialists in a team. Bunch investigation standards are connected to amass teams that offer comparative similarity and profitability scores and utilize this data to observationally characterize a likelihood thickness work that will decide, for a given group, its normal efficiency. To represent how the capacity is utilized to foresee the efficiency of a group, this paper introduces a case connected in brick work development in which times of development and profitability are resolved utilizing the individual similarity between the laborers in the team.

Hongmei Li, Fujian Ni, Qiao Dong and Yuqin Zhu proposed an Analytic Hierarchical Process (AHP) hypothesis based technique to decide the heaviness of the decision-making impact factors, considering their relative essentialness and creating a general positioning for each road section. A contextual analysis on the highway network maintenance need was led to outline the proposed system. A sum of five pavement maintenance related components were considered in the examination, including pavement execution, pavement structure quality, activity loads, pavement age and road grade. The weightings of the five components were evaluated through AHP technique. At that point, ranking index value Ui was resolved, which showed the upkeep need of a road section in network level decision making. From the part of maintenance cost, the sensitivity analysis comes about were as per the weightings of various maintenance decision-making factors. The pavement maintenance cost was fundamentally touchy to the difference in pavement execution. The case study unmistakably showed the applicability and rationality of the AHP hypothesis based decision-making method and it can be utilized as a rule for pavement maintenance organizations.

III. WHAT IS LABOUR PRODUCTIVITY

Productivity can be characterized from numerous points of view. In construction, productivity is normally interpreted as meaning work efficiency, that is, units of work put or delivered per man-hour.

Labour Productivity = Output
Work hour

Factors affecting Labor Productivity

Factors which influence execution of human performance are mentioned below:

1) Adaptability
2) Job knowledge
3) Judgment
4) Productivity
5) Competency
6) Effective safety management
7) Attitude
8) Quality
9) Risk
10) Ethics
11) Cost & Benefit Evaluation
12) Openness
13) Conscientiousness
14) Extraversion
15) Agreeableness
16) Neuroticism
17) Wage regulation
18) Pensions and Insurance
19) Workplace participation
20) Equality

IV. ANALYTICAL HIERARCHY PROCESS

- A organized method for managing complex choices. In view of arithmetic and brain science, it was produced by Thomas L. Saaty in the 1970s and has been broadly considered and refined from that point forward.
- The AHP gives a thorough and normal system for organizing a choice issue, for speaking to and measuring its components, for relating those components to general objectives, and for assessing elective arrangements.
- It is utilized the world over in a wide assortment of choice circumstances, in fields, for example, government, business, industry, human services and instruction.
- The reason for the AHP is to help individuals in sorting out their considerations and judgments to settle on more successful choices.
- The Analytic Hierarchy Process (AHP) gives the target science to process the inevitably subjective and individual inclinations of an individual or gathering in deciding.
- Fundamentally, the AHP works by creating needs for options and the criteria used to judge the choices.

Basic AHP procedure
Basic steps for formulation of problem:
Step1. Develop the weights for the criteria by
1) Developing a single pair-wise comparison matrix for the criteria
2) Multiplying the values in each row together and calculating the nth root of said product
3) Normalizing the aforementioned nth root of products to get the appropriate weights
4) Calculating and checking the Consistency Ratio (CR).

Step2. Build up the appraisals for every choice option for every foundation by building up a couple shrewd correlation lattice for every model, with every grid containing the match astute examinations of the execution of choice choices on every measure**;**
1) Multiplying the values in each row together and calculating the nth root of said product;
2) Normalizing the aforementioned nth root of product values to get the corresponding ratings
3) Calculating and checking the Consistency Ratio (CR).

Step3. Calculate the weighted average rating for each decision alternative.

Data Collection
The information was gathered from various development firms from proprietors, venture engineers, directors through poll study. The poll study comprised of point by point data about the firm and human execution factors. Respondents were solicited to rate factors from human execution on clear scale which was introduced to them. The organizations were grouped by their experience criteria in development industry into 5 unique classes. Grouping of firms is as per the following:-

Table1. Classification of Firms

Sr.No.	Class	Experience
1	A	Up to 3 years
2	B	Ranging between 4 to 6 years
3	C	Ranging between 7 to 9 years
4	D	Ranging between 10 to 12 years
5	E	More than 12 years

The hierarchy for selection of best construction firm class has five different levels.
1) The top level of the hierarchy describes the overall decision, which is to select the best construction class of human performance factors
2) The middle level of the hierarchy describes the human performance factors that are to be considered: Job knowledge, Judgment, Motivation, Productivity, Adaptability
3) The lower level of the hierarchy reveals the different construction classes: Class A, Class B, Class C, Class D, Class E
4) Pair-wise comparisons are used to establish the relative priority of each criterion against every other criterion as well as the relative priority of each system against every other system for each criterion,
5) The pair-wise comparisons use a scale that ranges from equally preferred to extremely prefer.
6) Reciprocal relationships are possible. Consider an integer having value n, its reciprocal would be 1/n.

Table2. Rating scale

Rating	Remark
1	Equally preferred
2	Equally to moderately preferred
3	Moderately preferred
4	Moderately to strongly preferred
5	Strongly preferred
6	Strongly to very strongly preferred
7	Very strongly preferred
8	Very to extremely preferred
9	Extremely preferred

Step1. Develop the weights for criteria.

Table3. Criteria Evaluation of Labor Productivity Factors

Sr. No		Adaptability	Motivation	Judgment	Productivity	Job Knowledge	Nth Root of Product	Priority Vector
1	**Adaptability**	1	0.333	0.142	0.111	0.111	0.225	0.026
2	**Motivation**	3	1	0.200	0.142	0.111	0.393	0.045
3	**Judgment**	7	5	1	0.200	0.142	0.998	0.116
4	**Productivity**	9	7	5	1	0.333	2.536	0.295
5	**Job Knowledge**	9	9	7	3	1	4.427	0.516
Total		**29**	**22.333**	**13.342**	**4.453**	**1.697**	**8.579**	**0.998**

Calculation of Nth Root of Product

Sample calculation:
Adaptability: (1x0.333x0.142x0.111x0.111)^(1/5) = 0.225

Calculation of Priority Vector

Sample calculation:
Adaptability: (0.225/8.579) = 0.026

Calculating and checking Consistency Ratio

1) First we must calculate value of (sum x priority vector) for each performance factor.

Sample calculation:
Adaptability: (29x0.026) = 0.754

2) Adding all the values will give lambda max value

Calculation of Consistency Index

CI = (Lambda-max –*n*) / (*n*–1)

Where *n* is the number of criteria or systems being compare. In this case, *n*= 5, for the five different criteria being compared.

Calculation of Consistency Ratio

Consistency Ratio (CR) is calculated by dividing the Consistency Index (CI) by a Random Index (RI), which is determined from a lookup table. The Random Index (RI) is a direct function of the number of criteria or systems being considered. The table of random indices is given below:

Table4. Table of Random Indices
(Analytical Hierarchy Process, Jeff Kunz)

N	Random Index
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

Consistency Ratio (CR) = Consistency Index / Random Index

Step2. Develop the ratings for each decision alternative for each criterion

In this step the different classes firms of construction would be evaluated against every human performance factor. Priority vector, lambda max, consistency index, consistency ratio is calculated for each human performance factor against different types of classes of construction firms which is classified on the basis of experience.

Table5. Analysis of Adaptability

Sr. No.		**Class D**	**Class A**	**Class B**	**Class C**	**Class E**	**Nth root of product**	**Priority Index**
1	**Class D**	1.00	5.00	7.00	9.00	7.00	0.46	0.59
2	**Class A**	0.20	1.00	3.00	5.00	3.00	1.55	0.19
3	**Class B**	0.14	0.33	1.00	3.00	3.00	084	0.10
4	**Class C**	0.11	0.20	0.33	1.00	3.00	4.66	0.59
5	**Class E**	0.14	0.33	0.33	0.33	1.00	0.35	0.04
	Total	1.59	6.86	7.66	11.3	17.0	7.87	0.99
Lambda max=5.137								
CI=0.034								
CR=0.028								

Table6. Analysis of Motivation

Sr. No.		Class D	Class A	Class B	Cl ass C	Class E	Nth root of produc t	Priorit y Index
1	**Class D**	1.00	0.33	0.20	0.14	0.11	0.25	0.03
2	**Class A**	3.00	1.00	0.20	0.11	0.11	0.37	0.04
3	**Class B**	5.00	5.00	1.00	0.20	0.20	1.00	0.12
4	**Class C**	7.00	9.00	5.00	1.00	0.33	2.53	0.30
5	**Class E**	9.00	9.00	5.00	3.00	1.00	4.13	0.49
	Total	25.0	24.3	11.4	4.45	1.75	8.30	0.99
Lambda max=5.443								
CI=0.110								
CR=0.091								

Table7. Analysis of Judgement

Sr. No.		Class D	Class A	Class B	Cl ass C	Class E	Nth root of product	Priority Index
1	**Class D**	1.00	0.33	0.14	0.20	0.11	0.25	0.03
2	**Class A**	3.00	1.00	0.20	0.20	0.14	0.44	0.05
3	**Class B**	7.00	5.00	1.00	0.33	0.33	1.31	0.17
4	**Class C**	5.00	5.00	3.00	1.00	0.20	1.71	0.22
5	**Class E**	9.00	7.00	3.00	5.00	1.00	3.93	0.51
	Total	25.0	18.3	7.34	6.73	1.78	7.66	0.99
Lambda max=5.448								
CI=0.112								
CR=0.093								

Table8. Analysis of Productivity

Sr. No.		Class D	Class A	Class B	Cl ass C	Class E	Nth root of product	Priority Index
1	**Class D**	1.00	0.33	0.20	0.14	0.11	0.25	0.03
2	**Class A**	3.00	1.00	0.20	0.20	0.14	0.44	0.05
3	**Class B**	5.00	5.00	1.00	0.33	0.20	1.10	0.14
4	**Class C**	7.00	5.00	3.00	1.00	0.33	2.03	0.26
5	**Class E**	9.00	7.00	5.00	3.00	1.00	3.93	0.50
	Total	25.0	18.3	9.40	4.67	1.48	7.77	0.99
Lambda max=5.125								
CI=0.031								
CR=0.025								

Table9. Analysis of Job Knowledge

Sr. No.		Class D	Class A	Class B	Cl ass C	Class E	Nth root of product	Priority Index
1	**Class D**	1.00	3.00	3.00	7.00	9.00	3.55	0.46
2	**Class A**	0.33	1.00	3.00	5.00	7.00	2.03	0.26
3	**Class B**	0.33	0.33	1.00	5.00	9.00	1.37	0.18
4	**Class C**	0.14	0.20	0.20	1.00	3.00	0.44	0.05
5	**Class E**	0.11	0.14	0.11	0.33	1.00	0.22	0.03
	Total	1.91	4.67	7.31	18.3	29.0	7.63	0.99
Lambda max=5.335								
CI=0.083								
CR=0.069								

STEP 3. CALCULATE THE WEIGHTED AVERAGE RATING FOR EACH DECISION ALTERNATIVE. CHOOSE THE ONE WITH THE HIGHEST SCORE.

In step three, the final scores for each system are determined by (a) multiplying the criteria weights (from Step 1) by the ratings for the decision alternatives for each criteria (from Step 2); and (b) summing the respective products. This is known as a sum-of-products mathematical operation and AHP refers to this matrix as the "Principle of Composition of Priorities."

Table10. Analysis of classes with respect to Human Performance factors

	Judgement	Adaptability	Motivation	Job knowledge	Productiity	Score
P.V	0.026	0.045	0.116	0.295	0.516	0.998
Class D	0.032	0.592	0.030	0.465	0.033	0.185
Class A	0.056	0.197	0.045	0.266	0.057	0.123
Class B	0.142	0.106	0.120	0.180	0.171	0.166
Class C	0.261	0.059	0.305	0.057	0.224	0.177
Class E	0.506	0.044	0.498	0.029	0.513	0.346

V. RESULT

Table11. Result obtained from Evaluation of Construction Classes

Class	Score
Class A	0.123
Class B	0.166
Class C	0.177
Class D	0.185
Class E	0.346

Job Knowledge factor has the highest ratings in all the classes. Adaptability has the lowest rating in all classes. Job knowledge proves to be the most important among all other factors.

Class E acquired highest score in evaluation of construction firms which proves to be the best class satisfying human performance factor.

Fig. Labours working on Site

V. CONCLUSION

1. During this study we found out various factors, which affect Labor Productivity. Adaptability, Job Knowledge, Judgment, Motivation, Productivity are the important human performance parameters derived from the study.
2. Job Knowledge is highly rated by all classes and proves to be the most important factor which firms consider in human performance among all other factors.
3. Class E emerges to be the best class as it scored the highest in analytical hierarchy process evaluation.
4. Productive staffing can be done in construction firms according to the outcomes.
5. These would assist the organizations with maximizing their profitability through representatives.
6. This will encourage smooth working of the organizations and will assist firms with setting another benchmark.

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