ASSESEMENT OF CRITICAL SUCCESS FACTORS OF CONSTRUCTION LABOUR PRODUCTIVITY BY USING PRINCIPAL COMPONENT ANALYSIS

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Abstract: Construction industry is that world's biggest also practically testing industry. Construction labor Productivity plays an important part in determining the financial outcome of any construction project. As this project aims to determining critical success factors which really affects construction labor productivity. These factors are identified by studying detailed literature review and discussion made with industry experts.

After identification of factors the questionnaire has made and circulated among stake holders. The four point Likert scale has considered for questionnaire. The data is further analyzed by using Statistical Package for Social Science (SPSS 23) after collecting it from stake holders. Data analyzed in two parts as Frequency analysis and factor analysis. The analysis has shown critical factors which affects construction labor productivity most. As this research has direct applications on site, the necessary suggestions and remedial measures against factors are discussed.

IndexTerms **– Labour Productivity, Principal Component Analysis**

I. INTRODUCTION

The aggregate of all human physical and mental effort used in creation of goods and services. Labor is a primary factor of production. The size of a nation's labor force is determined by the size of its adult population, and the extent to which the adults are either working or are prepared to offer their labor for wages.

Productivity is an average measure of the efficiency of production. It can be ex- pressed as the ratio of output to inputs used in the production process, i.e. output per unit of input. When all outputs and inputs are included in the productivity measure it is called total productivity. Outputs and inputs are defined in the total productivity measure as their economic values. The value of outputs minus the value of inputs is a measure of the income generated in a production process. It is a measure of total efficiency of a production process and as such the objective to be maximized in production process.

Many definitions of the word productivity exist. For the basis of this study the Merriam-Webster definition will be used. Merriam-Webster defines productivity as the quality or state of being productive. Labor productivity is typically measured as output per worker or output per labor-hour. Although there are endless definitions for productivity, they all refer to productivity as a comparison of input versus output.

Productivity= Output/ Input.
Increased productivity occurs when either,
1. Output is constant, while input is reduced, and/or
2. Input is constant, while either the quantity or quality of output has been increased or enhanced.

Increased productivity in the construction industry can be viewed from two perspectives, the consumer and the contractor. From the consumer's perspective, increased productivity lowers costs, shortens construction schedules, offers more value for the money and achieves better returns on investments. From the contractor's perspective, increased productivity leads to a more satisfied customer, while also providing a competitive advantage, and in return leading to faster turnover and increased profits (Horner 2001).
The definition for productivity with regards to construction is the measurement of the output of construction goods and services per unit of labor (McTague 2002). Productivity Improvements on Alberta Major Construction Projects compiled the following list of commonly used definitions to measure productivity in the construction industry:

Labor Productivity = Output/ Labor Cost or
Labor Productivity = Output/Work Hours

In case the input is a combination of various factors, productivity is termed as,
Total Factor Productivity = Total Output/ Labor + Material + Equipment + Energy + Capital.

Labor Productivity- It is a ratio of production output to what is required to produce it. The measure of productivity is defined as a total output per one unit of a total input. In construction, the output is usually expressed in weight, length, or volume, and the input resource is usually in cost of labor or man-hours. Since labor constitutes a large part of the construction cost and the quantity of labor hours in performing a task in construction is more susceptible to the influence.

II. LITERATURE REVIEW

According to Jiukun Dai and Paul M. Goodrum (2011), the influx of Hispanic workers helped the U.S. construction industry alleviate its shortage of craft workers in the last decade. In 2009, Hispanics accounted for nearly a quarter (22.5%) of the construction workforce in the United States. However, no research has been conducted to examine how various factors influence Hispanic craft workers' productivity. This paper analyzes the data from a nationwide survey to obtain craft workers perspective on construction productivity. The respondents were categorized as Spanish- or English-speaking workers according to their declared primary language, irrespective of their ethnic background. The findings reveal that Spanish- and English-speaking craft workers generally agreed on the priority of the factors affecting labor productivity.

Abdulaziz M. Jarkas (2012)stated several factors influence labor productivity, but buildability is among the most important. Concreting is an integral, labor intensive, trade of in situ reinforced concrete construction, the objective of this research is to explore the influence of primary build ability factors on concreting labor productivity. In achieving this objective, a sufficiently large volume of productivity data was collected and analyzed by using the categorical-regression method. As a result, the effects and
relative influence of: (1) concrete workability; (2) reinforcing steel congestion; (3) volume of pours; and (4) height relative to ground level, on labor productivity of skipped and pumped placement methods are determined and quantified.

J. W. Fedderke and T. E. Kaya (2014) study explores the impact of some key infrastructure measures in transportation, telecommunication, and electricity production sectors on labor productivity, using data on two-digit sectors for the Turkish economy for the years 1987 - 2006. We find both statistical and economic significance for the positive productivity impact of infrastructure on productivity growth, for road, port, and air transport, telecommunications, and electricity production. In the rail-way sector, only measures of actual freight carried are consistently and significantly associated with productivity growth, whereas other measures of infrastructure are insignificantly or inversely associated with productivity growth.

Zhigang Shen, Wayne Jensen, Charles Berryman and Yimin Zhu (2011) research compares construction labor productivity (CLP) of the United States with its Chinese counterpart at the activity level to evaluate productivity differences between the two countries from an operational perspective. Supplementing other comparative construction studies measuring productivity by output value per person, this research examined CLP measured by physical quantity installed per labor hour based upon published national average productivity data. Sampled activities included earth- work, concrete, masonry, structural steel, waterproofing and interior finishes.

H. Randolph Thomas (2014) study details, a six-step procedure for conducting a labor productivity benchmarking study. The procedure addresses the questions of how, who, and why. The procedure is illustrated using three case study projects. Labor productivity study has several unique features. First, the objective must be precisely defined. A study of labor productivity can be done for many reasons and the purpose must be clearly defined because the objective influences subsequent decisions involving protocols.

H. Randolph Thomas and Karl A. Raynar (1997) study describes a study of 121 weeks of labor productivity data from four industrial projects. The objective is to quantify the effects of scheduled overtime. First, it describes how the data were collected, processed and analyzed. The results show losses of efficiency of 10-15% for 50 and 60-h work weeks. The results compare favorably to other published data including the Business Round table (BRT) curves. Therefore, it was concluded that the BRT curve is a reasonable estimate of losses that may occur on average industrial projects.

2.1 FINDING FROM LITERATURE SURVEY

- 30% to 50% expenses of any project are spend on labor, so construction labor productivity is important in case of economy.
- The construction labor productivity is important factor in construction industry in order to increase the efficiency of work.
- Lack of supervision affects labor productivity.
- Improper communication among managerial and sub-ordinates affects labor productivity.
- The frequent changes in drawings, designs, orders, etc. affects the labor productivity.
- Overtimes, work delays reduce the work efficiency of labors.
- Improper safety at work and lack of good construction equipment's affects labor productivity.

III. SCOPE OF STUDY

The scope of the study covers how to increase labor productivity in construction industry and related to residential buildings and infrastructure projects. This study is needed to apply labor productivity dependent factors in planning, supervisor direction, communication, safety, tools and consumables, materials, engineering drawing management, labor, foreman, superintendent, project management, construction equipment, etc. As India is developing country, this study is important to consider labor productivity in construction industry so that it will contribute to improvement.

IV. OBJECTIVE

- To conduct a comprehensive literature review about labor productivity.
- To identify labor productivity dependent factors and categorize it.
- To frame questionnaire and conduct questionnaire survey.
- To analyze questionnaire with Frequency analysis.
- To analyze questionnaire with Principal Component analysis in SPSS.
- Examine the difference in the impact of the CSFs on labor productivity.

V. RESEARCH METHODOLOGY

The Research Methodology adopted for this research comprises three stages as follows:

- Literature research to determine research focus.
- Specific Survey of stakeholders (Owners, Contractors and Engineers, etc.) for response.
- Data Collection
- Analysis of the data by using SPSS software.
- Factor analysis to explore the interrelationships among the CSFs.
- Result and conclusion.

Based on the job description and roles and responsibilities of stake holders (contractor, engineer, project manager, supervisor, etc.) and reviewing literature, 11 most critical factors are considered. The questionnaire survey was designed and developed which includes 11 factors with 83 questions which described factors affecting construction labor productivity in detail.

The four point Likert scale is designed to collect the response for survey. 1- Yes, 2- Most of the, 3- No, 4- Not at all.The survey was conducted to obtain opinion from construction industry profession- als working in private as well as government sectors. The respondent includes Jr. engineer, Sr. Engineer, project managers, Contractors, owners, etc. Total number of questionnaire passed was 135 out of which 119 were answered and returned. The data collected were further analyzed by two methods.

A. Frequency distribution of responses for each type of Likert scale along with graphical analysis.
B. Reliability test and factor analysis is done by using the Statistical Package for Social Sciences (SPSS 23).

VI. DATA COLLECTION & ANALYSIS

The data is collected form stakeholders in the form of questionnaire survey.

6.1 Identification of Critical Success Factors

The identification of the critical success factors a questionnaire was designed to survey stakeholders (owners, contractors, project managers, engineers). The main aim of the questionnaire is to assess the perception and responses of the participants. The 11 factors are developed with their 83 questions. The Annexure - A shows de- tailed questionnaire given to stakeholders.

The questionnaire consists of various factors which affects construction labor productivity. Top level in organization to almost bottom levels area considered in the questionnaire. There are various factors which affects construction labor productivity among those 11 is selected which affects most. Factors are related project management, supervisor direction, communication, equipment, etc. are considered are these affects labor productivity most.
In the questionnaire stakeholders (contractors, owners, project managers, engineers) are asked to evaluate construction project in general. The 4 point Likert scale is taken for evaluation of questionnaire and is as below,
1. Yes
2. Most of the
3. No
4. Not at all

The detail of questionnaire is shown below. The table 6.1 shows total number of questionnaire made and received by the respondents and how much questionnaire is being used for analysis.

Table 6.1 Questionnaire Details

	Frequency	Percentage
No of Questionnaire Sent	150	100
Questionnaire Received	128	85
Invalid data	9	6
Used for study	119	79

6.2 Data analysis Part-I (Response Frequency Distribution)

The questionnaire survey having 119 respondent have been analyzed first to find out the frequency of response for each Likert scale of each question. The detailed frequency distribution of responses has shown below.

Table 6.2 Questionnaire Survey Responses

Sr. No.	Factor	Question	Frequency of response			
			1	2	3	4
1	Supervisor Direction	Inadequate instruction provided	39	63	11	6
2		Not receiving directions because of the size of the project	34	67	13	5
3		Receiving compliments for doing a good job	51	62	6	0
4		Being notified of mistakes when they occur	56	60	3	0
5		Lack of goals for craft workers	39	40	40	0
6	Communication	Different languages spoken on a project	45	61	13	0
7		Disregard of crafts' productivity improvement suggestion	33	60	26	0
8		Lack of "Big Picture" view on behalf of the crafts	35	50	28	6
9		Craft-worker importance	49	49	21	0
10		Lack of communication among site management	32	42	42	3
11	Safety	Shortage of personal protective equipment	47	47	25	0
12		Lack of site safety resources	34	57	28	0
13	Tools & Consumables	Availability of consumables	37	81	1	0
14		Restrictive project policy on consumables	26	59	34	0
15		Availability of hand tools	56	54	9	0
16		Availability of power tools	68	40	11	0
17		Lack of power source for tools	27	40	46	6
18		Lack of extension cords	41	31	44	3
19		Inexperienced tool room attendants	47	53	18	1
20		Misplaced tools	39	59	20	1
21		Poor-quality power tools	39	28	47	5
22	Material	Availability of material	62	54	3	0
23		Poor material quality	34	53	28	4
24		Availability of bulk commodities	44	65	9	1
25		Errors in prefabricated material	41	53	22	3
26		Difficulty in tracking material	30	60	29	0
27	Engineering Drawing Management	Inadequate instruction provided	30	74	10	5
28		Not receiving directions because of the size of the project	50	67	2	0
29		Receiving compliments for doing a good job	39	57	21	2
30		Being notified of mistakes when they occur	59	48	12	0
31		Lack of goals for craft workers	37	44	34	4
32	Labor	Availability of skill training	57	61	1	0
33		Jobsite orientation program	51	66	2	0
34		Availability of health and safety training	58	60	1	0
35		Qualified craftsmen	59	49	8	3
36		Craftsmen's pride in their work	62	48	9	0
37		Craftsmen's incentive	51	63	5	0
38		Motivated craft workers	60	54	5	0
39		Equal pay on projects in a geographic area	56	50	13	0

40		Craft workers' trust in supervisors	54	51	11	3
41	Foreman	Foremen people skill	60	58	1	0
42		Qualified foremen	51	64	4	0
43		Fair/just performance reviews	39	75	5	0
44		Foremen allowing crafts to work autonomously	28	35	41	15
45		Lack of construction knowledge on behalf of foremen	27	50	40	2
46		Lack of authority to discipline craft workers	32	48	39	0
47		Lack of proper resource allocation	44	47	22	6
48		Proper managerial and administrative support	43	58	13	5
49		Excessive paperwork	26	42	26	25
50	Superintendent/	Superintendent's people skill	45	74	0	0
51	Engineer	Qualified superintendents	54	65	0	0
52		Lack of experience on behalf of superintendents	24	70	24	1
53		Respect for craft workers	56	59	2	2
54		Micromanagement on behalf of superintendent	56	51	12	0
55		Political/performance competitions within company	32	43	35	9
56		Inconsistent safety policies established by different superintendents	44	51	23	1
57		Different work rules by superintendents	37	53	26	3
58	Project Management	Delay in work permits	40	62	16	1
59		Out-of-sequence work assignments	40	59	19	1
60		Absenteeism	44	57	18	0
61		Reasonable project goals and milestones	60	57	2	0
62		Respect for craft workers and foremen	53	65	1	0
63		Layoff of qualified craft workers	18	39	30	32
64		Awareness of on-site activities and project progress	46	59	12	2
65		Pulling people off a task before it is done	16	32	38	33
66		Jobsite congestion	25	50	43	1
67		Different pay scales for the same job on a project	27	52	38	2
68		Different per diem rate	29	41	24	25
69		Incentive for good performance	52	54	12	1
70		Material storage area is too far from workplace	37	53	26	3
71		Insufficient size of material storage area	36	60	18	5
72		Shortage of temporary facilities	33	66	18	2
73		Coordination between the trades	42	59	14	4
74		Slow decisions	25	61	24	9
75		Correct crew size	53	50	7	9
76		Vehicle traffic routes	53	52	10	4
77		Weather protection	73	42	3	1
78	Construction	Availability of crane or forklift	63	54	2	0
79	Equipment	Availability of man lift	57	59	3	0
80		Waiting for people and/or equipment to move material	42	66	10	1
81		Poor equipment maintenance	40	45	27	7
82		Equipment repairs	73	40	4	2
83		Maintenance of power tools	58	47	12	2

6.3 Data analysis Part – II (Using data Mining Tool)

The first part of data analysis has explained earlier in frequency analysis with graphs and tables. In the second part data analysis is done by data mining tool. The data mining tools is reliable and is been used by many researchers effectively. The data mining tools is basically the statistical software which performs various statistical operations and interprets them into results. This tool is called as "Statistical Package for Social Science (SPSS)".

The SPSS is used for analysis of responses for reliability test and secondly for factor analysis. The reliability test was used to find out consistency of data. To perform any type of analysis in SPSS it is necessary to check its reliability.

The second part of this analysis is Factor analysis. For factor analysis "Principal component analysis (PCA)" method is used. The factor analysis is basically the data reduction tool which cluster number of large factors into small number of sets of similar type**.**

6.3.1 Reliability Test

In SPSS the Cronbach Alpha (α) coefficient is used for reliability test. The Cronbach Alpha calculated by,

$$\alpha = \frac{N\,\bar{C}}{\bar{V} + (N-1)\,\bar{C}}$$

Where,
N = Number of items
$\bar{C}$= Average inter-item covariance among the items
$\bar{V}$= = Average Variance

The following table shows the reliability test result foe the questionnaire survey analysis. As explained the acceptable range of Cronbach Alpha is in between 0.7 to 0.9. For this research the Cronbach Alpha is 0.721. Hence the data used and Likert scale applied is reliable. As this test shows data is reliable, so factor analysis can be applied to same data set. It is shown in table 6.3.1

Table 6.3.1 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.721	0.683	83

The Cronbach's alpha gives the covariance among the items, whereas the cronbach's alpha based on standardized items employs the correlations among items.

6.3.2 KMO and Bartlett test

The KMO test gives adequacy of sample and Bartlett's test shows sphericity suggests relationship between factors. Kaiser-Meyer-Olkin (KMO) Test is a measure of how suited your data is for Factor Analysis. The test shows sampling adequacy for each variable in the model and for the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited your data is to Factor Analysis.

KMO returns values between 0 and 1. A rule of thumb for interpreting the statistic:

- KMO values between 0.8 and 1 indicate the sampling is adequate.
- KMO values less than 0.6 indicate the sampling is not adequate and that remedial action should be taken. Some authors put this value at 0.5, so use your own judgment for values between 0.5 and 0.6.
- KMO Values close to zero means that there are large partial correlations compared to the sum of correlations. In other words, there are widespread correlations which are a large problem for factor analysis.

For reference, Kaiser put the following values on the results:

- 0.00 to 0.49 unacceptable.
- 0.50 to 0.59 miserable.
- 0.60 to 0.69 mediocre.
- 0.70 to 0.79 middling.
- 0.80 to 0.89 meritorious.
- 0.90 to 1.00 marvelous.

For large sample set Bartlett's test approximates the Chi-Square distribution. The Bartlett's test shows positive result for large sample size, but for small sample size it is less reliable. Very small values of significance below 0.05 give high probability that there is significant relationship between the variables. The value more than 0.1 indicates data is inappropriate for factor analysis.

The following table 6.3.2.1shows the KMO and Bartlett's test results. As the value of KMO test for sample is 0.709 shows middling and is adequate to perform factor analysis. In Bartlett's test value of significance is 0.000 and which is less than 0.05, this

shows there is significant relationship between the variables. These results show that factor analysis can be performed on developed questionnaire survey.

Table 6.3.2.1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.709
Bartlett's Test of Sphericity	Approx. Chi-Square	212.861
	df	55
	Sig.	0.000

6.3.3 Factor Analysis

The qualitative type of research is carried out in which questionnaire survey is done for collecting data. The most suitable kind of method of factor analysis for this type of data is "Principal Component Analysis (PCA)". In this method multiple questions are used to analyze their factors. In data analysis multivariate data plays important role. Multivariate data consists of different factors made for each question. The multi-dimensional hyperspace is very difficult to visualize and hence main aim of PCA is to reduce dimensionality, scoring all observations on composite index and clustering similar observations together based upon multi-attributes.

PCA does uncorrelated factors are extracted by linear transformation of the original variables so that first few factors (Principal components) contain most of the variation in the original data. These factors are extracted in descending order of importance in terms of variance so that the first factor accounts as much of variation as possible and each successive component account for a little less. If the first few factors account for large proportion of variability (80%-90%), we have achieved dimension reduction objective.

The table 6.3.3.1shows the result for Principal Component analysis for the questionnaire carried out. The minimum Eigen value criteria were used for factors in Principal Component analysis. The criterion requires ranking the Eigen values for all the variables from largest to smallest. Then by selecting Eigen value greater than 1 as the number of factor to be retained. This shows the Eigen values less than 1 represents very less variance explained by factors resulted from PCA hence were not considered as significant in further analysis.

The factors after 3 has less than 1 Eigen values, thus factors only up to 3 will be considered. The table is divided in 3 parts. The Part-I of table describes all the 11 factor analysis for Eigen values, percentage of variance and cumulative percentage. Part-II explains extracted factors which are having Eigen values more than 1 along with percentage of variance and cumulative percentage of respective factors. Part-III explains change in Eigen values of each factor. These results are got after factor rotation technique has applied.

Table 6.3.3.1 Principal Component Analysis

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	2.830	25.725	25.725	2.830	25.725	25.725	2.437
2	1.712	15.562	41.287	1.712	15.562	41.287	1.866
3	1.142	10.384	51.671	1.142	10.384	51.671	2.033
4	.917	8.338	60.009				
5	.865	7.861	67.870				
6	.797	7.243	75.113				
7	.710	6.456	81.569				
8	.656	5.962	87.531				
9	.511	4.645	92.176				
10	.461	4.189	96.365				
11	.400	3.635	100.000				

Extraction Method: Principal Component Analysis.

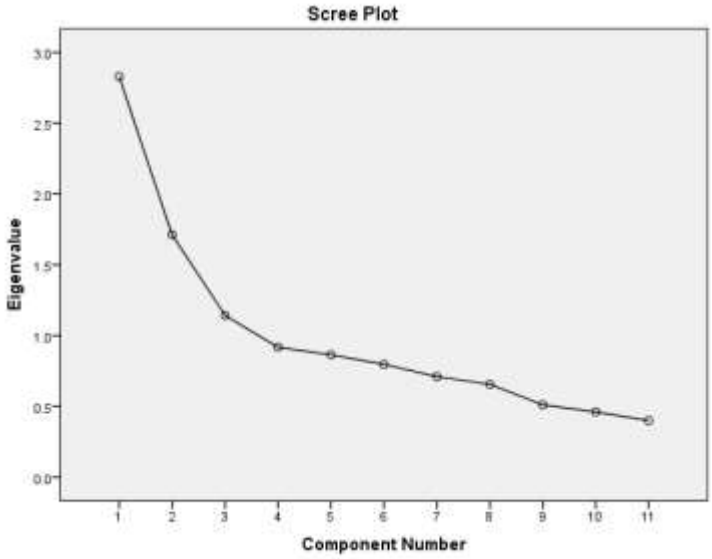
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

The following figure. 6.3.3.1 gives screen plot in factor analysis. It is plotted factor against Eigen values. This is generated from Part-I of PCA table. It is clear from table and screen plot that factors only up to 3 are considered for further analysis. In Principal

Component Analysis the first factor generated always shows maximum Eigen value and maximum percentage variance. To get more fineness the factor rotation technique is used.

From Part-III it can be seen that after performing factor rotation technique the loading of factors were distributed among all 3 retained factors. There are various method are available for factor rotation. The result of each method will be different along with different loading values. It has been seen that it's very difficult to select most appropriate technique for data analysis as final results differ a lot.

Fig.6.3.3.1 Factor Analysis Plot



6.3.3 Factor Rotation Technique

The factor rotation technique improves interpretability of factors in the questionnaire. It is used to spread variability more evenly among factors. The factor rotation helps in redefining factors in more systematic and most simplified way. Rotation actually increases the loading on extracted factors and minimizes loading on other remaining factors.In this study Promax reduction technique is used.

From table 6.3.3.1, it is clearly seen that all the three factors are group of variables which are independent of each other while in this each factor consist of interrelated variables

Table 6.3.3.1Pattern Matrix[a]

	Component		
	1	2	3
F1	.270	.425	.124
F2	.589	.450	.011
F3	.669	-.075	.130
F4	.751	.202	-.023
F5	.180	.558	.025
F6	-.186	-.005	.706
F7	-.786	.194	.272
F8	-.032	.048	.800
F9	-.185	.668	.207
F10	.134	.120	.538
F11	-.340	.685	-.343

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
Rotation converged in 5 iterations.

For the ease of understanding the factors are grouped and highlighted in table 6.3.3.2 .These three factors are most important factors resulting from Principal Component Analysis and Promax rotation technique are described below with variance percentage for each in tabular format. The following factors are named according to their properties.

Table 6.3.3.2 Critical Success Factor(CSF)

Factor	% Variance	CSF
Factor-1 : S1	25.725	Communication
		Safety
		Tools and consumables
Factor- 2 : S2	15.562	Materials
		Superintendent / Engineers
		Construction Equipment
Factor- 3 : S3	10.384	Engineering Drawing Management
		Foreman
		Project Management

The detail analysis of these factors is explained below.

Factor-1: S1

The very first and important factor has seen by factor analysis is S1. The Factor 1 i.e. S1 has 25.725% of percentage variance. This factor has higher percentage of variance among all other factors hence it very important factor for Construction Labor Productivity.

The S1 factor combines communication, safety, tools and consumables as sub factors. The construction labor productivity concerns communication is most important thing among site. Lack of communication among site managements may lead to confusion. Different languages are spoken on site may cause misunderstandings with people. The productivity improvement suggestions have to be there on site. To raise construction labor productivity there has to be proper communication among site management.

As far as labor concerns, the safety is most important thing on site. The safety includes personal protective equipment's or site safety resources, etc. Another most important factor seen by rotation method is tools and consumables. In order to keep flow of work site has constant supply of tools and consumables. The availability of hand tools, power tools, power source, extension cords, misplaced tools, poor quality materials, etc. are the important things in tools and consumables.

Factor- 2: S2

The second and important factor S2 has percentage variance is 15.562 % which has materials, superintendents and construction equipment has sub factors. The material availability is the main thing for construction labor productivity. The poor quality of material, availability of bulk commodities directly affects work on site. Errors less prefabricated materials are required on site. The difficulty of tracking material has to be reduced as possible.

The most important factor has seen by rotation method is a superintendent's person on site. The superintendent's people skill, qualification, experience, etc. are the important quality has to be there. Because Engineer's directly and indirectly communicates to labors. The superintendent should focus on micromanagement. The inconsistent policies by different superintendents cause congestion in understanding and regulation in work.

The next factor considered by rotation method is construction equipment. Availability crane or fork lift, man lift, improper equipment maintenance, equipment repairs, etc. are the important points has to be consider.

Factor- 3: S3

The third and last important factor has percentage variance is 10.384%. This factor has engineering drawing management, foreman and project management as sub divisions. The engineering drawings include availability of drawings, drawing legibility. The needed information has to be on drawing. Quick response to questions raised on drawings has to be there. Minimum errors on drawings are most suitable for smooth work.

The foreman people skill and qualification is important aspect. The foreman should not allow to crafts to work autonomously. Improper resource allocation causes so much of disturbance and it is depend on foreman. Mostly foreman has no excessive paper work.

Another important factor listed out by rotation method is project management. Stronger the project management better would be the productivity of project. Delays in work permits, out of sequence work, reasonable project goals, different per diem rate, etc. things are considered in project management.

VII. DATA COLLECTION & ANALYSIS

The research work has been carried out in two parts .

Part-I: Frequency Distribution of questionnaire survey

Part-II: Reliability test and factor analysis by using "Statistical Package for Social Science (SPSS)

7.1 Part-I: Partial analysis by using Frequency Distribution

The questionnaire survey is analyzed to find responses given by stakeholders for Likert scale. The graphs are formed based on frequency distribution for each factor. From the graph and frequency distribution table the question which has responses more than 55 for "Yes – 1" are only considered on Likert scale.

Depending on frequency analysis out of 83, 21 questions have response as "Yes - 1". So they are considered for construction labor productivity analysis.

It has been seen that Factor No.1 which is supervisor direction. This shows that labors are being notified when they make mistakes. This shows good sign of supervisor on most of the sites.

Another important factor responded by stake holders is factor 4 which is tools and consumables. This factor has three questions which are responded more. Availability of hand tools, power tools and misplaced tools has got "Yes-1" by stake holders. On most of the sites hand tools and power tools are available with some misplaced tools.

Factor No.5 materials have one question which has more response by stakeholders. The availability of materials has seen positive response by respondent. On most of the sites work doesn't delay or affected because of scarcity of materials.

Engineering drawing management i.e. factor no. 6 has one question rated high by respondent. The legibility of drawing is considered more important and drawing is legible on almost every site. Another factor i.e. Labor has more responses by respondent i.e. 7 questions are considered highly important. The skill training, health and safety, qualified craftsman, equal pay on projects, etc. questions has yes response and it is available though.

Forman should possess some skill in order to convey message to labor. The availability of skilled foreman has seen on most of the sites. The micromanagement on behalf of superintendent has clearly seen on most of the construction sites, which is most important factor considered by stakeholders.

Project management factor has two questions which are considered more important those are reasonable project goals by management and whether protection. The last and important factor is construction equipment. Forklift, man lift arability has seen on almost every site. The maintenance and equipment repair carried out on most of the sites.

7.2 Part-II: Factor analysis by using SPSS

SPSS used in analysis of questionnaire data and reliability of data. After doing these tests the data has seen reliable and carried for further analysis. The reliability test confirmed that the scale used for questionnaire data is reliable and data is suitable for factor analysis.

Factor analysis is data reduction tool. For this kind of research the Principal component analysis is used because it's a qualitative type of research. This factor analysis has given three most important factors which have been described in previous chapter. Out of these three important factor, factor 1 (S1) has highest percentage of variance and it is proved to be most important factor for construction labor productivity.

The factor 1: S1 has three sub factors those are,

- Communication
- Safety
- Tools and consumables

Thus these three factors are most important by factor analysis. This does not mean that other two factors which are found from factor analysis are not important. But micro evaluation process factor 1 (S1) is considered.

6.3 Conclusion

From Part- I and Part – II analysis it has been clear that, both analysis has some common factors which affects construction labor productivity. Those common factors are,

- Tools and consumables
- Materials
- Engineering drawing management
- Foreman
- Superintendent / Engineer
- Project management
- Construction equipment

There is few more conclusion has seen by both analysis as, Part-I analysis has not given importance to communication whereas in Part-II analysis communication is most important factor.

Supervisor direction is important in frequency analysis whereas it's not so important in factor analysis. Factor No. 3 i.e. safety has considered more important in factor analysis and it is not considered so vital in frequency analysis.

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