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Identification of Critical Factors Affecting Construction Labor Productivity in India Using AHP

Avinash Tiwari, Anju Malik, C.P. Singh

Abstract: ***Construction sector plays a leading role in economic growth for countries all around the world. Since construction is a labor intensive industry, productivity is considered a primary driving force for economic development. In India, the economy is severely challenged by the combined effects of rapid population growth and the closure policy imposed on the area since 2007. Owing to this situation, construction projects are characterized by low profit margin, time and cost overrun making labor productivity a key component of company's success and competitiveness The main aim of this study is to identify key factors affecting labor productivity in India and to give the ranking to those factors by Analytical hierarchy process. By reviewing the literature and conducting depth interviews with experienced engineers, twenty five critical factors related to labor productivity were identified and categorized into six groups: Psychological, Human/labor, Design, Technological, Managerial and External factors. Based on the Analytical Hierarchy Process approach, a questionnaire was designed and delivered to 72 construction professionals to elicit the view on how labor productivity might be affected. A total of 35 feedbacks were analyzed and the results indicated that Shortage of material, Clarity of technical specifications, payment delay, site layout & construction methods have a significant impact on construction labor productivity in India.***

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I. INTRODUCTION

Construction is the world's largest and most challenging industry (Tucker, 1986). The output of the construction industry constitutes one half of the gross capital and is 3 to 8% of the Gross Domestic Product (GDP) in most countries (Arditi and Mochtar, 2000). Nevertheless, poor performance of the industry has been a cause of great concern among practitioners and academics. Construction projects worldwide have been experiencing significant cost and time overruns, with low labour productivity identified as a major reason for project delays and cost overruns

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The construction industry in India contributes to over 5% of the nation's GDP and employs over 41.88 million people (Planning Commission of India 2012-2017). The contribution of the industry to the economy and employment is expected to grow significantly in the forthcoming years. However, the industry is plagued by cost and time overruns. The current scenario of the Indian construction industry thereby warrants research in construction labour productivity, particularly in identifying opportunities for construction productivity improvement. The first step in improving construction productivity is to identify the influencing factors (Mojahed and Aghazadeh, 2008; Rivas et al., 2011). After productivity factors are identified, management can take actions to mitigate these issues. There have been several studies to identifiy labor productivity factors in many countries. However, there has been not much effort in identifying factors influencing construction labor productivity in the Indian context. Researchers maintain that the major productivity factors vary from country to country, place to place and project to project (Jarkas and Bitar, 2012; Mojahed and Aghazadeh, 2008). The productivity factors identified by researchers in other countries may not be relevant in the Indian scenario due to the different social, political and economic environment in India.

II. DEFINITION OF TERMS

Construction Productivity is by no means a new concept and as such has been utilized many times in the past, has been discussed extensively, and has been defined in many ways. The literature has substantial varia- tion in definitions and terminology. For consistency, this paper has adopted the following: Productivity: The term "productivity" in construction industry expresses the relationship between outputs and inputs (Borcherding and Liou, 1986). Output and input differ from one industry to another. Also, the productivity definition varies when applied to different areas of the same industry. In 1950, the Organization for European Economic Cooperation (OEEC) introduced the definition of productivity as a quotient obtained by dividing the output by one of the production factors (Sumanth, 1984).Labor Productivity: Labor is one of the basic requirements in the construction industry. Labor productivity usually relates manpower in terms of labor cost to the quantity of outputs produced (Borcherding and Liou, 1986). In other words, the definition of labor productivity is the amount of goods and services produced by a productive factor (manpower) in a unit of time (Drewin, 1982).

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In 1883, Littre defined productivity as the "faculty to produce," that is, the desire to produce (Jarkas, 2005).

III. SIGNIFICANCE OF PRODUCTIVITY

Productivity has a great significance in construction. Labor productivity constitutes a significant part of production input for construction projects. In the construction industry, many external and internal factors are never constant and are difficult to anticipate. This factor leads to a continuous variation in labor productivity. It is necessary to make sure that a reduction in productivity does not affect the plan and schedule of the work and does not cause delays. The consequences of these delays could result in serious money losses. Further, considerable cost can be saved if productivity is improved because the same work can be done with less manpower thus reducing overall labor cost (Thomas, 1991).

A. Problem Statement

In the construction industry productivity loss is one of the greatest and severe problems. Present construction contracts are not capable to recovery for productivity loss due to field factors (Construction Industry Institute [CII], 2000; National Electrical Contractors Association [NECA], 1989). Of various project-costs components such as labors, materials and equipment's; labor component is considered the most risky Whereas others components (equipment and material) are determined by the market price and price are, consequently, beyond the influence of project management. Labor cost in construction industry is estimated to be about 33%- 50% of the entire project cost (language Hanna et al., 2005). Because labor is more variable and unpredictable than other project-cost components, it becomes necessary to understand the effects of different factors on labor productivity. An increase in productivity can reduce the labor cost in a direct proportion. It can either benefit or reduce a project's profit, making it of vital interest to the construction industry for its success (Hanna et al., 2005). Previous researches confirm that productivity loss results from various factors, which includes but not limited to various variation in drawings, long hours of extra work, poor field management, and extreme climatic conditions (Alarcon and Borcherding, 1991; Leonard, 1987; Sanders and Thomas, 1991; Thomas and Oloufa, 1995) In fact, these factors typically produce extra disturbances that affect productivity and are beyond the direct control of a contractor, resulting in productivity loss or extra work hours necessary to accomplish the task.

B. Objectives

These are the following main objectives of this research

i. Critical review of literature on labor productivity.
ii. To do a field survey to capture opinion of experts.
iii. To identify the most critical factors associated with the labor productivity in construction projects with reference to Indian context.
iv. To rank the critical factors by Analytical Hierarchy Process

C. Scope and Limitations

- The research focuses on to identify most crucial factors associated with the labor productivity in construction project in the Indian context and give the ranking to those factors by using AHP (Analytical hierarchy process).
- Productivity for factory based construction (Precast concrete) is out of the scope of this research. only cast in situ or activities performed at site are investigated. Different types of projects such as residential building, Multistorey building, Industrial building, Grain storage silos, and Effluent treatment plant projects were investigated.
- Large infrastructure's project such as highways, bridges, tunnels, hydro projects are out of scope of the thesis, it is only applicable to small and medium size projects only.

IV. LITERATURE REVIEW

Increase of productivity was calculated prior to mid-1906's, in the construction industry (Stall, 1983). Later, decline in productivity has remained of great concern issue in the construction industry all over the world. In 1968, the Construction Roundtable was established due to concern about the increased cost of construction resulting from an increase in the inflation rate and a significant decline in construction productivity (Thomas and Kramer, 1988). Also in 1965, the United Nations Committee on Housing, Building, and Planning (UNC) published a significant manual concerning the effect of repetition on building operations and processes (UNC, 1965). The research discovered the necessity for a rise in productivity was perhaps more severe in the construction sector compared to any other sector. It was necessary to implement, as far as possible, industry-wide principles of production throughout the construction process. Though, it was known that careful adaptation would be required to implement the knowledge and experience gained in the manufacturing industry to the building construction industry (Alarcon and Borcherding 1991).

A. Project cost & Productivity

Past experience show that 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).

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B. Productivity in Construction Industry

The first step in improving construction productivity is to identify the influencing factors (Mojahed and Aghazadeh, 2008; Rivas et al., 2011). After productivity factors are identified, management can take actions to mitigate these issues. There have been several studies to identify labour productivity factors in many countries. However, there has been not much effort in identifying factor influencing construction labor productivity in the Indian context. Researchers maintain that the major productivity factors vary from country to country, place to place and project to project (Jarkas and Bitar, 2012; Mojahed and Aghazadeh, 2008). The productivity factors identified by researchers in other countries may not be relevant in the Indian scenario due to the different social, political and economic environment in India.

C. Factors affecting Construction Labor Productivity

Productivity is the outcome of several interrelated factors.; Twenty Five factors affecting Construction labor productivity are outlined with reference to Indian context by literature review, Field survey and expert opinion which are classified under the Six primary groups:
(A) Psychological factor group; (B) Human/Labor factor group; (C) Design factor group; (D) Technological factor group; (E) Managerical factor group; (F) External factor group;.

A. Psychological factors group
- Stress
- Job satisfaction
- Fear of height
- Personal clashes

B. Human/Labor factor group
- Level of skill
- Lack of experience worker
- Familiarity with job
- Motivation

C. Design factor group
- Design complexity level
- Clarity of Technical specification
- Degree of Quality control
- The extent of variation/Change orders during execution

D. Technological factor group
- Construction methods
- Site Layout
- Unavailability of suitable tools
- Rework

E. Managerical factor group
- Payment Delay
- Shortage of Material
- Work Planning and scheduling
- Lack of Labour SupervisionS
- SHE (Safety,Health & Envirnment.)

F. External factor group
- Weather conditions
- Social-Economic Condition
- Location of Project
- Project Nature

V. RESEARCH METHODOLOGY

Twenty five main factors affecting labor productivity were identified through an intensive literature, personal interviews of local contractors and expert opinions. Initially, a review of professional journals, publications, text books and previous research papers was conducted. Then, the local contractors with an experience of more than 10 years in the Indian construction industry were consulted to give relatively accurate judgment on different factors affecting labor productivity with respect to Indian context and attempted to identify most critical factors as input to research To give the ranking to those factors by Analytical hierarchy process a questionnaire (Appendix-A) designed and distributed to various contractors, Engineers & Project managers to obtained relative importance value based on a 1-9 number scale (Saaty scale). Data obtained from questionnaire survey has been analyzed & summarized as input data for pair-wise comparison.

A. Analytical hierarchy process

AHP is a decision-aiding method developed by Saaty (1980). It aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the judgment of the decision maker, and stresses the importance of the intuitive judgments of a decision-maker as well as the consistency of the comparison of the alternatives in the decision-making process. Since decision-makers base judgments on knowledge and experience, then make decisions accordingly. The AHP approach agrees well with the behavior of a decision-maker. In the present work, AHP has been used to rank the critical success factors from the data obtained through field survey.
The following steps were applied by the author to analyze the data (Saaty 1980, Saaty 1990):

1. Define the problem and determine its goal.
2. Structure the hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which subsequent level depend) to the lowest level which usually contains the list of alternatives.
3. Construct a set of pair-wise comparison matrices (size nxn) 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 3.1. The pair-wise comparison are done in terms of which element dominates the other.

Table 1.1: Pair-wise comparison scale for AHP preferences (Saaty, 1980)

Level of Importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Absolute Importance
2,4,6,8	Intermediate values between adjacent scale values

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4.0 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.

5.0 Hierarchical synthesis is then 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.

6.0 Having made all the pair-wise comparisons, the consistency is determined by using the eigenvalue, λ_{max}, to calculate the consistency index, CI as follows:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)}$$

where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) as CI/RI, taking the appropriate value of RI from Table 3.2. 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.

7.0 Steps 3-6 performed for all levels on the hierarchy.

B. Field Survey & Analysis

Field Survey is done to study the prevalent environment that entails the sphere of uncertainty in labor productivity during execution of construction project. This survey is done to have first hand information, essential to be aware of the problems encountered in the construction projects with reference to labor productivity. The objective of doing a field survey in this study is to validate the findings of the literature review. Personal interviews were conducted to find the extent and the critical factors causing reduction in labor productivity. The analysis of survey is done by Analytical Hierarchy process. For the survey a questionnaire was prepared in two parts.

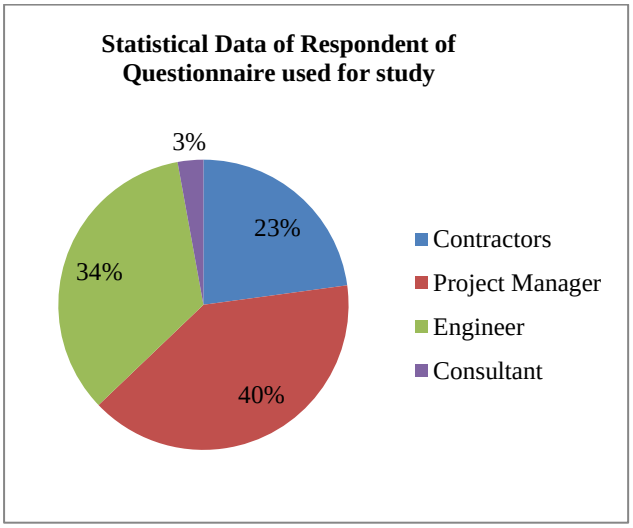
The first part contains the general information of the respondents such their Experience, Designation, organization type etc. The second part of the questionnaire is based on the AHP pair wise comparison of critical factors extracted from literature review, field survey and expert opinion by rating relative importance on 1-9 scale (Saaty scale).

C. Methodology for data collection

In order to facilitate the study, after the Literature review and the focus interviews, a plan was formulated for collecting field information and creating an evaluation process and numerical values. It was necessary to provide straight forward communication to respondents to ensure a clear understanding of all the applicable definitions, procedures, and guidelines that were used in collecting data**.**

D. Respondents

A total of 72 questionnaires were sent to construction professional through e-mail and personally handed over. However reply rate form email was very low as compared to personal interview. By the due date, a total of 37 questionnaires were received, resulting in a nearly 51.38% reply rate. Missing data frequently occur after the respondent chooses not to response a question or when the respondent rejects to answer the question. (Kim, 1993). The most serious concern presented in the responses was some missing data. Some of the unclear response was clarified over the phone. A total of 2 (i.e., 2.7%) invalid data received were deleted from research study. Total 35 number of Questionnaire Data used for this study. Out of which eight were contractors, fourteen project managers of contractor organizations, twelve Engineers and one consultant who responded for the research questionnaire.



E. Analysis of data

Data obtained from questionnaire survey was in the form of pair wise relative importance value on 1-9 scale (Saaty scale.) This data was used as an input to form a pair wise comparison matrix.

Geometric mean of each pair wise comparison matrix of all selected thirty five questionnaire were determined and prepared an average value as input data for pair wise matrix as shown table1.2 given below.

After determining average value, the analysis was carried out with the application of the AHP using the 'Microsoft Excel' support software. The importance of each main group factor was firstly developed (Tables 1.3). Then, The importance of each factor with respect to classified group was developed (Tables 1.4,1.5,1.6,1.7,1.8 & 1.9) Finally an overall assessment was carried out to determine Cumulative importance value. It is calculated from the product of Priority/importance value of group factors to their corresponding factors (Table 1.10). The consistency of responses is considered satisfactory; as the value of Consistency Ratio (CR) is less than 0.1 across different groups of factors.

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Table 1.3: Priority and Ranking Vectors for Group of factors

Criterion	Priority vector	Ranking Vector
Psychological factors	0.077548	0.287301
Human/Labor factors	0.096032	0.35578
Design factor	0.190592	0.706106
Technological factor	0.191368	0.708983
Managerial factor	0.269919	1
External factors	0.102935	0.381355
Consistency ratio	0.063944 < 0.1	

Table 1.4 : Priority and Ranking Vectors for Psychological group

Criterion	Priority vector	Ranking Vector
Stress	0.214216	0.570645
Job satisfaction	0.149964	0.399484
Fear of height	0.375393	1
Personal clashes	0.260427	0.693745
Consistency ratio	0.041426 < 0.1	

Table 1.5: Priority and Ranking Vectors for Human/Labor group

Criterion	Priority vector	Ranking Vector
Level of skill	0.467501	1
Lack of experience	0.137359	0.293816
Familiarity with job	0.126934	0.271515
Motivation	0.268205	0.5737
Consistency ratio	0.015992 < 0.1	

Table 1.6 Priority and Ranking Vectors for Design factor group

Criterion	Priority vector	Ranking Vector
Design complexity level	0.209729	0.560903
Clarity of technical specification	0.373913	1
Degree of quality control	0.200769	0.536941
The extent of variation/change orders during execution	0.215589	0.576576
Consistency ratio	0.017555< 0.1	

Table 1.7: Priority and Ranking Vectors for Technological group

Criterion	Priority vector	Ranking Vector
Construction methods	0.265422	0.985952
Site layout	0.269204	1
Unavailability of suitable tools	0.211757	0.786603
Rework	0.253617	0.942101
Consistency ratio	0.044014 < 0.1	

Table 1.8 : Priority and Ranking Vectors for Managerial group

Criterion	Priority vector	Ranking Vector
Payment delay	0.226046	0.68627
Shortage of material	0.329384	1
Work planning & scheduling	0.157932	0.479477
Lack of labor supervision	0.124136	0.376874

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SHE(safety, Health& Envir.)	0.162502	0.493353
Consistency ratio	0.03689 < 0.1	

Table 1.9 Priority and Ranking Vectors for External factor group

Criterion	Priority vector	Ranking Vector
Weather conditions	0.452082	1
Social & Economic conditions	0.223994	0.495471
Location of project	0.15557	0.344119
Project's nature	0.168354	0.372397
Consistency ratio	0.036739 < 0.1	

Table 1.2. The Geometric means of different groups of factors

Productivity factor group			**Importance**
Human/Labor factor	More important than	Psychological factor	1.251033
Design factor	More important than	Psychological factor	2.246192
Technological factor	More important than	Psychological factor	3.609309
Managerial factor	More important than	Psychological factor	3.935979
Psychological factor	More important than	External factor	1.446814
Design factor	More important than	Human/labor factor	1.810012
Technological factor	More important than	Human/labor factor	1.86121
Managerial factor	More important than	Human/labor factor	2.847315
External factor	More important than	Human/labor factor	1.053312
Design factor	More important than	Technological factor	1.620353
Managerial factor	More important than	Design factor	1.464154
External factor	More important than	Design factor	1.002515
Managerial factor	More important than	Technological factor	1.148645
Technological factor	More important than	External factor	2.166853
Managerial factor	More important than	External factor	3.453847
Psychological factors group			Importance
Stress	More important than	Job satisfaction	2.163491
Fear of height	More important than	stress	1.957973
Personal clashes	More important than	Stress	1.769228
Fear of height	More important than	Job satisfaction	1.955515
Personal clashes	More important than	Job satisfaction	1.540275
Fear of height	More important than	Personal clashes	1.769228
Human/ Labor factor group			Importance
Level of skill	More important than	Lack of experience	3.631389
Level of skill	More important than	Familiarity with job	2.912951
Level of skill	More important than	Motivation	2.118029
Lack of experience	More important than	Familiarity with job	1.338217
Motivation	More important than	Lack of experience	2.303248
Motivation	More important than	Familiarity with job	2.221894
Design factor group			Importance
Clarity of technical specification	More important than	Design complexity level	1.527899
Design complexity level	More important than	Degree of quality control	1.168613
The extent of variation/change orders during execution	More important than	Design complexity level	1.382347
Clarity of technical specification	More important than	Degree of quality control	1.767007
Clarity of technical specification	More important than	The extent of variation/change orders during execution	2.178277
Degree of quality control	More important than	The extent of variation/change orders during execution	1.028286
Technological factor group			Importance

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Construction methods	More important than	Site layout	1.509804
Construction methods	More important than	Unavailability of suitable tools	1.115646
Rework	More important than	Construction methods	1.321044
Site layout	More important than	Unavailability of suitable tools	1.778279
Site layout	More important than	Rework	1.1276
Unavailability of suitable tools	More important than	Rework	1.053312
Managerial factor group			Importance
Shortage of material	More important than	Payment delay	1.089139
Payment delay	More important than	Work planning & scheduling	1.301735
Payment delay	More important than	Lack of labor supervision	1.76164
Payment delay	More important than	SHE (safety, Health & Envir.)	1.192199
Shortage of material	More important than	Work planning & scheduling	2.951568
Shortage of material	More important than	Lack of labor supervision	2.847315
Shortage of material	More important than	SHE (safety, Health & Envir.)	1.765474
Work planning & scheduling	More important than	Lack of labor supervision	1.364262
Work planning & scheduling	More important than	SHE (safety, Health & Envir.)	1.1276
SHE (safety, Health & Envir.)	More important than	Lack of labor supervision	1.140848
External factor group			Importance
Weather conditions	More important than	Social & Economic conditions	2.926223
Weather conditions	More important than	Location of project	2.889545
Weather conditions	More important than	Project's nature	1.955515
Social & Economic conditions	More important than	Location of project	1.92499
Social & Economic conditions	More important than	Project's nature	1.433387
Location of project	More important than	Project's nature	1.192199

Table 1.10. Cumulative Importance for factors affecting labor productivity

Group Factors	Importance	factors	Importance	Cum. Importance
Psychological factor group	0.07754798	Stress	0.1926999	0.01494
		Job satisfaction	0.0890689	0.00691
		Fear of heights	0.3773012	0.02926
		Personal clashes	0.34093	0.02644
Human/Labor factor group	0.09603193	Level of skill	0.4675014	0.04490
		Lack of experience	0.1373595	0.01319
		Familiarity with job	0.1269337	0.01219
		Motivation	0.2682054	0.02576
DESIGN FACTOR GROUP	0.19059167	Design complexity level	0.2097289	0.03997
		Clarity of technical specification	0.3739128	0.07126
		Degree of quality control	0.2007692	0.03826
		The extent of variation/ Change orders	0.2155891	0.04109
Technological factor group	0.19136814	Construction methods	0.2654221	0.05079
		Site layout	0.2692039	0.05152
		Unavailablity of suitable tools	0.2117567	0.04052
		Rework	0.2536173	0.04853
Manegerical factor group	0.26991924	Payment delay	0.2260462	0.06101
		Shortage of material	0.3293835	0.08891
		Work planning & scheduling	0.1579319	0.04263
		Lack of labor supervision	0.124136	0.03351
		SHE (safety, Health & Environment)	0.1625024	0.04386

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External factor group	0.10293497	Weather conditions	0.4520822	0.04654
		Social economical conditions	0.2239937	0.02306
		Location of project	0.1555701	0.01601
		Project location	0.168354	0.01733

VI. RESULT AND CONCLUSIONS

- Construction projects worldwide have been experiencing significant cost and time overruns, with low labour productivity identified as a major reason for project delays and cost overruns. Past experience show that The construction industry also involves a large number of variables; the labor intensive work, the unique character and the occurrence of unpredictable events 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). The first step in improving construction productivity is to identify the influencing factors (Mojahed and Aghazadeh, 2008; Rivas et al., 2011). There have been several studies to identify labour productivity factors in many countries and determine the factors affecting the productivity like Time, Managerial Factors, Safety, Manpower Group, Motivation, Material/Tools. External Factors, Natural Factors, Supervision, Quality, & Schedule Compression etc**.** However, there has been not much effort in identifying factor influencing construction labor productivity in the Indian context. The productivity factors identified by researchers in other countries may not be relevant in the Indian scenario due to the different social, political and economic environment in India.
- The objective of doing a field survey in this study is to validate the findings of the literature review. Personal interviews were conducted to find the extent and the critical factors causing reduction in labor productivity.
- Twenty five most critical factors associated with the labor productivity in construction projects with reference to indian context have been selected for this study based upon literature review, field survey & expert opinion and these were grouped into six major categories with respect to present study as given below.
- Ranking to critical factors by using AHP

  Based on analysis carried out above using AHP, top 25 factors affecting labor productivity in India are presented in table 1.11 and figure 2.1 respectively and discussed the same rankwise.

  A material shortage was ranked first position among factors affecting labor productivity in India. A shortage of material refers to the inaccessibility of certain materials or the excessive time expended to obtain them.

The Clarification in Technical Specifications factor ranked 2nd among the 25 factors have Priority 0.07126. So it was second most critical factor affecting construction labor productivity in India Lack of clarity in technical specification become a cause's disturbance in the work progress. Continuous request for clarification is required in the case of unclear and incomplete technical specifications. Payment delay factor was ranked 3rd. Without smooth cash flow we cannot imagine good productivity of project. A time to time payment will motivate labor.

Site layout factor was ranked 4th. Site layout involves identifying, sizing, and placing temporary facilities (TFs) within the boundaries of construction site. These temporary facilities range from simple laydown areas to warehouses, fabrication shops, maintenance shops, batch plant, and residence facilities. Required temporary facilities and their areas are depending in many factors including project type, scale, design, location, and organization of construction work.

The 5th rank factor was Construction method with a Priority 0.05079. Effect of Construction method is related to way of working. It depends on intelligence of people those who work on the project. The wrong method of work is very harmful. It may result in cost and time overrun.

Table 1.11. Critical factors affecting labor productivity in construction rank-wise

Rank	Critical factors	Importance
1	Shortage of material	0.08891
2	Clarity of technical specification	0.07126
3	Payment delay	0.06101
4	Site layout	0.05152
5	Construction methods	0.05079
6	Rework	0.04853
7	Weather conditions	0.04654
8	Level of skill	0.0449
9	SHE (safety, Health & Environment)	0.04386
10	Work planning and Scheduling	0.04263
11	The extent of variation/Change orders	0.04109
12	Unavailability of suitable tools	0.04052
13	Design complexity level	0.03997
14	Degree of Quality control	0.03826
15	Lack of labor supervision	0.03351
16	Fear of height	0.02926
17	Personal clashes	0.02644
18	Motivation	0.02576
19	Social- Economical conditions	0.02306
20	Project's nature	0.01733
21	Location of project	0.01601
22	Stress	0.01494

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23	Lack of experience	0.01319
24	Familiarity with job	0.01219
25	Job satisfaction	0.00691

A. Practical Implications

Outcome of this research can be used to provide professionals and contractors guidance for focussing, acting upon and controlling the most significant factors perceived to influence the construction labor productivity (CLP) on site.

FUTURE RESEARCH

The current research study was limited to the general construction industry in the India. Future study could be done in other parts of the nation and could emphasize specific types of building construction, including commercial, education, government buildings, skyscrapers, etc. A study similar to the present research is needed for transportation projects to find the factors that affect the productivity of highway construction, which will help departments of transportation to minimize unnecessary cost escalations and project-schedule delays. Central and state governments invest significant amounts of capital on road construction.

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