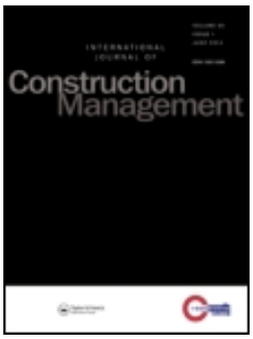

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CRITICAL ANALYSIS OF THE KEY FACTORS AFFECTING CONSTRUCTION LABOUR PRODUCTIVITY –AN INDIAN PERSPECTIVE

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Abstract
Construction labour productivity is influenced by a multitude of factors. Though considerable research exists on productivity factors in other countries, no study has addressed productivity issues in India. A questionnaire survey was conducted, in the state of Kerala in India, to identify the factors impacting construction labour productivity and their underlying relationships. Among the 44 factors considered, material unavailability was identified as the most critical factor impacting construction productivity. Factor analysis employed to understand the underlying relationships among the factors, categorized the factors into ten groups, namely, (1) tool and equipment issues; (2) poor labour motivation; (3) improper supervision; (4) poor material planning; (5) poor site management; (6) improper drawing management; (7) project management incompetency; (8) craftsmen issues; (9) lack of meetings and (10) lack of communication. The research findings will provide better insights to construction practitioners into productivity issues in India and guide their efforts to achieve productivity improvement.

Keywords
construction industry, labour productivity, factors, India.

INTRODUCTION

Construction productivity, commonly defined as the ratio of the output to the input, is a topic that has been widely researched. The importance of construction productivity arises from the fact that it is a major determinant of success of a construction project. With the business environment becoming highly competitive, it is essential that organizations improve construction productivity performance for survival (Park et al., 2005). Because construction is a labour intensive industry and labour is the flexible resource available for the management, focus of the majority of the researchers and practitioners has been on improving construction labour productivity.

Construction labour productivity is influenced by a multitude of issues, which are rarely independent of the others (Dai et al., 2009). Considerable research has been carried out in various countries to understand the relative influence of the factors on labour productivity. Though poor labour productivity was identified as one of the

major reasons for delays to construction projects in India (Doloi et al., 2012), no effort has been placed on identifying or understanding the factors influencing labour productivity in India. This research, therefore, aims to identify the relative influence as well as the underlying relationships of the factors impacting productivity in the Indian context.

Many of the productivity studies identified productivity issues from the perspective of the management. Dai et al. (2009) stressed the necessity of obtaining the perception of the craftsmen also on factors influencing productivity, as the craftsmen working in the field tend to be more aware of productivity problems. In the present study, the input of all project participants, i.e., the project managers, site engineers, supervisors and craftsmen have been sought in identifying productivity problems in the state.

LITERATURE REVIEW

Numerous studies have been carried out to identify the factors affecting construction labour productivity. In a survey administered to craftsmen in the United States, material availability, tool availability, rework, overcrowded work areas and inspection delays were identified as major factors influencing productivity (Borcherding and Garner, 1981). In the United Kingdom, bricklayers who participated in a survey geared towards identifying the factors influencing productivity ranked lack of materials, gang interference, repeat work, supervision and lack of equipment as the key factors impairing productivity (Olomolaiye, 1988). A survey on craftsmen in Indonesia, identified lack of material, rework, absenteeism, interference and lack of tools among the most significant factors impacting construction labour productivity (Kaming et al., 1997).

In a survey carried out on project managers in Thailand, Makulsawatudom et al. (2004), using relative importance index, ranked the following five factors as the most significant factors affecting construction labour productivity: (1) lack of material; (2) incomplete drawing; (3) incompetent supervisors; (4) lack of tools and equipment and (5) absenteeism. In Uganda, project managers rated incompetent supervisors, lack of skills of the workers, rework, lack of tools/equipment and poor construction method as the major factors influencing productivity (Alinaitwe et al., 2007).

In Singapore, Lim and Alum (1995) studied productivity problems encountered by contractors and identified difficulty in recruitment of supervisors, difficulty in recruitment of workers, high rate of labour turnover, absenteeism at the worksite and communication problems with foreign workers among the most significant factors affecting productivity. Kadir et al. (2005) studied the impact of 50 factors on construction labour productivity in Malaysia and identified material shortage at project site, non–payment to suppliers causing stoppage of material delivery to site, late issuance of progress payment by client to main contractor, lack of foreign and local workers in the market and incapability of site management to organize site activities as the major factors impairing productivity. The respondents in the study included contractors, developers and consultants. In a research in Gaza Strip, contractors ranked material shortages, lack of labour experience, lack of labour surveillance, misunderstandings between labour and superintendents and drawings

and specification alteration during execution as the topmost factors influencing productivity (Enshassi et al., 2007). In a survey addressed to contractors engaged in water and wastewater treatment plant construction in the United States, Mojahed and Aghazadeh (2008) deduced skills and experience of workforce, management, job planning, motivation and material availability as the major drivers of construction productivity. In Kuwait, contractors ranked clarity of technical specifications, the extent of variation/ change orders during execution, coordination level among various design disciplines, lack of labour supervision and proportion of work subcontracted as the most significant factors affecting productivity (Jarkas and Bitar, 2012).

Chan and Kaka (2007) administered a questionnaire survey in U. K. to understand the difference in perception among project managers and construction workers on factors affecting construction labour productivity. The white collar sample ranked supervision, simplicity of building design, level of site experience, information flow and communication with sub-contractors as the top five factors. On the other hand quality requirements, health and safety management, communication within gangs, utilization of plant and health and safety and Construction Design and Management (CDM) were considered important by the blue collar workers. The research provided an insight on factors important to the two groups and emphasized the need for integrating the differences in opinion between the two groups to achieve productivity improvement. In Chile, Rivas et al. (2011) administered a craftsmen questionnaire to direct workers and midlevel employees to analyze factors influencing construction productivity. The study recognized materials, tools, equipment and trucks, rework and absenteeism as the critical factors influencing productivity.

Researchers have adopted different classification schemes in categorizing productivity factors. Olomolaiye (1988) classified the factors influencing productivity into external and internal factors, external factors being those beyond the control of management and internal factors as those originating in and around the firm. Borcherding and Alarcon (1991), cited in Rivas et al. (2011), classified the factors under eight categories, namely: (1) schedule acceleration; (2) poor coordination; (3) changes; (4) resources and site management; (5) management characteristics; (6) project characteristics; (7) labour and morale and (8) project location and external conditions. In a different classification, Lim and Alum (1995) grouped productivity issues under three categories: manpower, management and environment. Thomas and Raynar (1997), in describing the factor model, classified impediments affecting labour efficiency under two categories: work to be done, related to the physical components of the work, and the work environment. Liberda et al. (2003) cited in Dai et al. (2007), classified productivity factors as labour, management and external factors.

In a survey carried out in the Gaza Strip, Enshassi et al. (2007) adopted a more elaborate classification of productivity factors. Forty five factors influencing productivity as identified by the researchers were classified under: (1) manpower; (2) leadership; (3) motivation; (4) time; (5) materials/tools; (6) supervision; (7) project; (8) safety; (9) quality and (10) external groups. The materials/tools and supervision groups were ranked as the major groups negatively affecting construction productivity in the study.

Jarkas and Bitar (2012) reviewed various classification schemes of productivity factors and argued that all the productivity factors may be classified under four primary groups namely, management group, technological group, human/labour group and external group and studied the relative importance of forty five factors affecting productivity, classified under these major groups. Based on the average relative importance of factors under each group, the survey identified technological group to have the highest ranking, followed by human/labour group, management group and external group.

In the United States, Dai et al. (2009) employed factor analysis to define a classification scheme of the productivity factors. A craftworker survey involving 1996 craftsmen was carried out by the researchers to assess the impact of 83 factors on productivity. Factor analysis extracted 10 latent factors, namely, (1) tool and consumable; (2) direction and coordination; (3) engineering drawing management; (4) construction equipment; (5) material; (6) project management; (7) foreman competency; (8) superintendent competency; (9) training and (10) craftworker qualification. The study identified construction equipment, project management and craftworker's qualification as the areas with greatest potential for productivity improvement.

A review of literature reveals numerous productivity factors and different classification schemes. 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 classification of the productivity factors have also largely been based on the intuitional experience of the researchers. The applicability of the factors and the classification schemes in the Indian construction industry remains unexplored making it essential to probe the issues impacting productivity in the Indian context.

The majority of the previous research studies identified the productivity factors from the perspective of one of the major project participants. Previous research efforts were rarely directed at identifying the differences in perception of the various project participants on the factors influencing construction labour productivity. The study in the United Kingdom did not capture the perception of the middle level employees (Chan and Kaka, 2007); whereas the opinion of the project managers was not sought in identifying productivity problems in the Chilean study (Rivas et al., 2011). It is essential to understand the differences in perception among the various project participants, on the factors influencing productivity, to make effective plans for productivity improvement. In the present study, the opinion of all the project participants, i.e., the project managers, the site engineers, the supervisors and the craftsmen, have been sought in identifying and classifying the factors influencing productivity.

RESEARCH METHOD

Though innumerable factors influencing labour productivity arose from the review of literature, further discussions with construction practitioners identified 44 factors as influencing productivity in the state of Kerala in India. An empirical survey questionnaire was designed to quantify the impact of the identified factors on

construction labour productivity. The questionnaire was prepared in both English and the local language (Malayalam) as it was intended to capture the perceptions of all project participants, namely, the project managers, the site engineers, the supervisors and the craftsmen. The respondents were requested to rate the effect of the factors on labour productivity on a five point scale, with 1 representing 'no effect', 2 representing 'slight effect', 3 representing 'significant effect', 4 representing 'very significant effect' and 5 representing 'extremely significant effect'. The respondents were also asked to rate the frequency of occurrence of each factor with respect to their ongoing projects on a three point scale, with 1 indicating 'low', 2 indicating 'medium' and 3 indicating 'high'. In addition, demographic information was also sought from the respondents.

The state of Kerala has been witnessing a boom in construction of high rise buildings for both residential and commercial purposes in recent years, especially in the private sector. The major builders in the private sector are members of the Confederation of Real Estate Developers' Associations of India (CREDAI) and hence permissions were sought to visit the construction sites of the members of CREDAI Kerala Chapter. The construction sites of the members who permitted access were visited to collect responses on the questionnaire. Though there are several methods of administering a questionnaire survey, direct delivery of the questionnaire by hand was preferred to improve the response rate and the quality of the responses. Responses collected on the questionnaire were analyzed using the Statistical Package for the Social Sciences (SPSS) software.

A pilot study was first carried out on a small sample of the respondents to ensure the clarity and comprehensibility of the questions used in the questionnaire and to determine the ease of completing the questionnaire. Five project managers and three site engineers/supervisors participated in the pilot study. The respondents suggested few changes to the questionnaire, mainly regarding the wording of the questions. The questionnaire was then modified based on the comments of the respondents and data collection was carried out using the modified questionnaire.

RESPONDENT'S CHARACTERISTICS

Sixty seven project sites in major cities of Kerala were visited to collect data on the questionnaire. Most of the projects were residential construction projects. The respondents of the questionnaire included project managers, site engineers, supervisors and craftsmen. The site engineers and supervisors were considered as a single group as the title is used interchangeably on construction sites of the state. Altogether 35 project managers, 90 site engineers/ supervisors and 60 craftsmen participated in the survey, yielding a total of 185 responses.

RANKING OF THE ATTRIBUTES

From the responses on the effect of the factors on labour productivity, an importance index (I.I.) was calculated using the following formula (Kadir et al., 2005):

$$Importance\ index = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{5(n_1 + n_2 + n_3 + n_4 + n_5)}$$

(1)

where n_1 represents the number of respondents who answered 'extremely significant effect', n_2 represents the number of respondents who answered 'very significant effect', n_3 represents the number of respondents who answered 'significant effect', n_4 represents the number of respondents who answered 'slight effect' and n_5 represents the number of respondents who answered 'no effect'.

For the frequency of factors, a frequency index (F.I.) was evaluated as follows (Kadir et al., 2005):

$$Frequency\ index = \frac{3n_1 + 2n_2 + n_3}{3(n_1 + n_2 + n_3)}$$

(2)

where n_1 represents the number of respondents who answered 'high', n_2 represents the number of respondents who answered 'medium', n_3 represents the number of respondents who answered 'low'. A severity index (S.I.) was calculated for each factor, by multiplying the importance and frequency indices (Kadir et al., 2005).

$$Severity\ index = Importance\ index \times Frequency\ index$$

(3)

Table 1 presents the ranking of the factors based on importance, frequency and severity indices when all the responses were considered. Problems relating to materials were ranked topmost both in terms of importance and severity indices. Material unavailability was also rated overall second, in terms of the frequency index. Unavailability of drawings, equipment and tools has also been recognized as having detrimental effect on productivity. Poor pay and labour strikes are other attributes that were considered important by the respondents. However these issues were not frequent and hence do not appear among the ten most severe factors. Strikes called by political parties or hartals, harsh weather conditions, frequent revisions of drawing/design resulting in additional work/rework, craftsmen turnover and craftsmen absenteeism, though not rated among the top factors based on importance index, occur more frequently and hence have emerged among the ten most severe issues. Improper project coordination has been ranked among the top ten factors based on all the three indices. A close scrutiny of the factors reveals that except for political strikes and hartals, all other problems arise as a result of poor management of the construction projects. Management should concentrate their efforts in mitigating the issues identified to achieve productivity improvement. By efficient project planning and scheduling and proper project coordination, the majority of the productivity issues faced by construction personnel in the state can be controlled.

Table 1. Results of The Ranking of Factors Affecting Construction Labour Productivity

Attributes	I.I.	Rank	Attributes	F.I.	Rank	Attributes	S.I.	Rank
Unavailability of material on time at the workplace	0.879	1	Strikes called by political parties or hartals	0.550	1	Unavailability of material on time at the workplace	0.442	1
Delayed material delivery by the supplier	0.839	2	Unavailability of material on time at the workplace	0.503	2	Delayed material delivery by the supplier	0.395	2
Unavailability of drawings on time at the worksite	0.816	3	Harsh weather conditions	0.497	3	Strikes called by political parties or hartals	0.394	3
Equipment necessary to do the job not available on time	0.778	4	Frequent revisions of drawing/design resulting in additional work/ rework	0.492	4	Frequent revisions of drawing/design resulting in additional work/ rework	0.362	4
Poor pay	0.775	5	Craftsmen turnover	0.483	5	Unavailability of drawings on time at the worksite	0.357	5
Labour strikes	0.771	6	Craftsmen absenteeism	0.477	6	Craftsmen absenteeism	0.346	6
Poor project planning and scheduling	0.770	7	Delayed material delivery by the supplier	0.470	7	Improper project coordination	0.341	7
Unavailability of tools on time at the worksite	0.769	8	Lack of recognition of good and efficient workers	0.463	8	Harsh weather conditions	0.340	8
Poor quality of materials	0.761	9	Improper project coordination	0.449	9	Craftsmen turnover	0.329	9
Improper project coordination	0.760	10	Errors in the drawings	0.441	10	Poor project planning and scheduling	0.329	10
Unsafe working conditions	0.752	11	Interference from other trades or other crew members	0.438	11	Errors in the drawings	0.325	11
Accidents causing stoppage of work at the site	0.746	12	Lack of periodic meeting among the management, site personnel and the contractors	0.438	11	Equipment necessary to do the job not available on time	0.324	12
Lack of experience of craftsmen	0.744	13	Unavailability of drawings on time at the worksite	0.438	11	Lack of experience of craftsmen	0.315	13
Errors in the drawings	0.737	14	Lack of adequate space for storage of materials	0.436	14	Poor pay	0.310	14

Table 1. Results of The Ranking of Factors Affecting Construction Labour Productivity (cont'd)

Attributes	I.I.	Rank	Attributes	F.I.	Rank	Attributes	S.I.	Rank
Frequent revisions of drawing/design resulting in additional work/ rework	0.736	15	Excessive overtime	0.434	15	Slow equipment repair in case of breakdown	0.309	15
Inadequate instructions provided by supervisor	0.731	16	Lack of weekly project evaluation meetings	0.434	15	Lack of experience of supervisor	0.306	16
Slow equipment repair in case of breakdown	0.726	17	Rework due to field errors committed by craftsmen	0.429	17	Craftsmen unaware of safety precautions	0.303	17
iCraftsmen absenteeism	0.724	18	Lack of monetary incentives	0.429	17	Poor quality of materials	0.300	18
Poor quality of tools provided /used	0.720	19	Poor project planning and scheduling	0.427	19	Lack of maintenance of tools and plants	0.299	19
Lack of maintenance of tools and plants	0.719	20	Lack of experience of supervisor	0.427	19	Rework due to field errors committed by craftsmen	0.298	20
Craftsmen unaware of safety precautions	0.718	21	Slow equipment repair in case of breakdown	0.425	21	Unsafe working conditions	0.297	21
Lack of experience of supervisor	0.717	22	Lack of experience of craftsmen	0.423	22	Unavailability of tools on time at the worksite	0.296	22
Strikes called by political parties or hartals	0.717	22	Unrealistic project goals and deadlines	0.422	23	Lack of team spirit among craftsmen	0.295	23
Communication problem among craftsmen and supervisors	0.716	24	Craftsmen unaware of safety precautions	0.422	23	Lack of adequate space for storage of materials	0.292	24
Lack of team spirit among craftsmen	0.704	25	Lack of team spirit among craftsmen	0.420	25	Inadequate instructions provided by supervisor	0.291	25
Rework due to field errors committed by craftsmen	0.694	26	Equipment necessary to do the job not available on time	0.416	26	Lack of recognition of good and efficient workers	0.286	26
Slow response on doubts arising from the drawings	0.690	27	Lack of maintenance of tools and plants	0.416	26	Communication problem among craftsmen and supervisors	0.286	27
Harsh weather conditions	0.684	28	Lack of interaction among the site community	0.407	28	Labour strikes	0.285	28

Table 1. Results of The Ranking of Factors Affecting Construction Labour Productivity (cont'd)

Attributes	I.I.	Rank	Attributes	F.I.	Rank	Attributes	S.I.	Rank
Craftsmen turnover	0.682	29	Site congestion	0.405	29	Slow response on doubts arising from the drawings	0.278	29
Disputes with consultants/ owner causing stoppage of work	0.681	30	Slow response on doubts arising from the drawings	0.404	30	Poor quality of tools provided /used	0.278	30
Lack of adequate space for storage of materials	0.670	31	Design difficult to construct	0.404	30	Accidents causing stoppage of work at the site	0.276	31
Lack of interaction among the site community	0.668	32	Disregard of craft worker suggestions/ideas	0.404	30	Disputes with consultants/ owner causing stoppage of wwork work	0.272	32
Poor temporary facilities at the site	0.642	33	Poor temporary facilities at the site	0.402	33	Lack of interaction among the site community	0.272	33
Site congestion	0.622	34	Disputes with consultants/ owner causing stoppage of work	0.400	34	Interference from other trades or other crew members	0.271	34
Lack of monetary incentives	0.621	35	Communication problem among craftsmen and supervisors	0.400	34	Lack of periodic meeting among the management, site personnel and the contractors	0.271	35
Interference from other trades or other crew members	0.619	36	Poor pay	0.400	34	Lack of weekly project evaluation meetings	0.267	36
Lack of periodic meeting among the management, site personnel and the contractors	0.619	36	Inadequate instructions provided by supervisor	0.398	37	Lack of monetary incentives	0.266	37
Design difficult to construct	0.618	38	Poor quality of materials	0.395	38	Unrealistic project goals and deadlines	0.259	38
Lack of recognition of good and efficient workers	0.618	39	Unsafe working conditions	0.395	38	Poor temporary facilities at the site	0.258	39
Supervisor absenteeism	0.617	40	Supervisor absenteeism	0.391	40	Site congestion	0.252	40
Unrealistic project goals and deadlines	0.615	41	Unavailability of tools on time at the worksite	0.386	41	Design difficult to construct	0.250	41

Table 1. Results of The Ranking of Factors Affecting Construction Labour Productivity (cont'd)

Attributes	I.I.	Rank	Attributes	F.I.	Rank	Attributes	S.I.	Rank
Lack of weekly project evaluation meetings	0.615	42	Poor quality of tools provided /used	0.386	41	Disregard of craft worker suggestions/ideas	0.246	42
Disregard of craft worker suggestions/ideas	0.609	43	Accidents causing stoppage of work at the site	0.369	43	Supervisor absenteeism	0.241	43
Excessive overtime	0.505	44	Labour strikes	0.369	43	Excessive overtime	0.219	44

I.I. – Importance index
F.I. – Frequency index
S.I. – Severity index

In order to test the agreement among the respondents on ranking of attributes, Spearman's rank correlation test was used (table 2). The Spearman rank correlation coefficient was statistically significant among all the groups of respondents for all the indices, with project managers and site engineers having the strongest degree of agreement. The project managers and craftsmen differed slightly on the ranking of the issues based on the severity index, with the correlation coefficient being significant at the 5% significance level. Due to good agreement among the respondents on the ranking of issues based on the importance index, all responses were considered together for further analysis on importance of the factors.

Table 2: Results of The Spearman Rank Correlation Test between Groups of Respondents on The Factors Affecting Construction Labour Productivity

Respondents	Spearman rank correlation		
	Importance index	Frequency index	Severity index
Project Managers – Site Engineers	0.846**	0.632**	0.751**
Site Engineers – Craftsmen	0.666**	0.465**	0.541**
Project Managers – Craftsmen	0.606**	0.595**	0.381*

**Correlation significant at 0.01 level
* Correlation significant at 0.05 level

FACTOR ANALYSIS ON IMPORTANCE OF THE FACTORS

Factor analysis is a technique used to condense the information in a large number of variables into a smaller set of new, composite dimensions known as factors (Hair et al., 2011). Factor analysis was performed by using the importance scale. To test the appropriateness of using factor analysis for the data, two tests were conducted, Kaiser- Meyer- Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO measure of sampling adequacy compares magnitudes of correlation coefficients to the magnitude of partial correlation coefficients (Malhotra and Dash, 2011). The KMO value ranges from 0 to 1 and a minimum value of 0.5 is specified as an acceptable threshold for proceeding with factor analysis (Hair et al., 2011; Malhotra and Dash, 2011). In the present research, the KMO measure of sampling adequacy was 0.902 which is well above the acceptable value of 0.5 and is interpreted as 'meritorious' (Hair et al., 2011). The Bartlett's test of sphericity tests the hypothesis that the correlation matrix is an identity matrix, which implies that the variables are uncorrelated (Chan et al., 2012; Field, 2005; Malhotra and Dash, 2011). The value associated with the Bartlett's test of sphericity was large (approximate chi-square statistic = 4323.419) and the observed significance level small ($p<0.001$). Thus, both the tests indicated factor analysis to be an appropriate technique for the present research. The attribute 'excessive overtime' had very low correlation with the other attributes and hence was not included in the analysis.

Principal component analysis was used for factor extraction and the criterion of an eigen value greater than one was used to determine the number of factors to be extracted. An eigen value represents the amount of variance associated with the factor (Field, 2005). Figure 1 represents a plot of the eigen values against the number of factors in the order of extraction. The plot, known as the scree plot, shows a steep

descent in the curve followed by a gradual trailing off called the scree. (Malhotra and Dash, 2011) Ten factors were extracted based on the eigen value criterion and the extracted factors account for 65.6% of the total variance which is above the minimum limit of 60% recommended by Hair et al. (2011) and Malhotra and Dash (2011). Varimax orthogonal rotation was performed to improve the interpretability of the factors. Table 3 represents the factor loadings of the variables on the 10 factors extracted. Hair et al. (2011) recommends factor loadings above 0.50 for practical significance and hence all factor loadings below 0.50 have been suppressed in the present study. The 43 factors/attributes used for factor analysis were thus grouped into ten factors namely, (1) tool and equipment issues; (2) poor labour motivation; (3) improper supervision; (4) poor material planning; (5) poor site management; (6) improper drawing management; (7) project management incompetency; (8) craftsmen issues; (9) lack of meetings and (10) lack of communication.

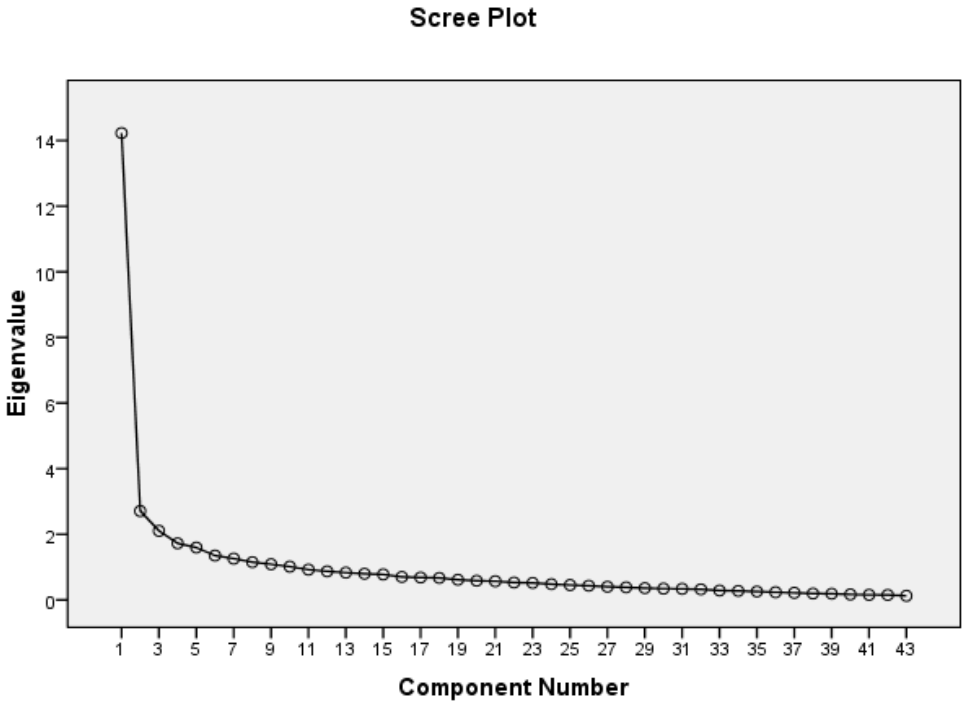

Figure 1: Scree Plot of The 43 Factors Affecting Construction Labour Productivity

Table 3: Results of Factor Analysis on The Factors Affecting Construction Labour Productivity

Grouped Factors	Factors/Attributes	Factor loading	Eigen value	Percentage of variance explained	Cumulative percentage of variance explained
1. Tool and equipment issues	1.1. Lack of maintenance of tools and plants	.730	4.053	9.426%	9.426%
	1.2. Poor quality of tools provided /used	.708			
	1.3. Equipment necessary to do the job not available on time	.681			
	1.4. Slow equipment repair in case of breakdown	.642			
	1.5. Unavailability of tools on time at the worksite	.576			
2. Poor labour motivation	2.1. Lack of monetary incentives	.727	3.351	7.794%	17.220%
	2.2. Lack of recognition of good and efficient workers	.691			
	2.3. Disregard of craft worker suggestions/ideas	.607			
	2.4. Poor pay	.576			
	2.5. Poor temporary facilities at the site	.554			
3. Improper supervision	3.1. Supervisor absenteeism	.681	3.295	7.663%	24.883%
	3.2. Lack of experience of supervisor	.645			
	3.3. Inadequate instructions provided by supervisor	.637			
	3.4. Lack of experience of craftsmen	.525			
4. Poor material planning	4.1. Unavailability of material on time at the workplace	.718	3.136	7.294%	32.177%
	4.2. Delayed material delivery by the supplier	.708			
	4.3. Craftsmen absenteeism	.546			
5. Poor site management	5.1. Site congestion	.679	2.713	6.310%	38.487%
	5.2. Interference from other trades or other crew members	.631			
	5.3. Disputes with consultants/ owner causing stoppage of work	.578			
6. Improper drawing management	6.1. Frequent revisions of drawing/design resulting in additional work/ rework	.683	2.473	5.750%	44.237%
	6.2. Slow response on doubts arising from the drawings	.593			
	6.3. Errors in the drawings	.586			
7. Project management incompetency	7.1. Improper project coordination	.771	2.467	5.737%	49.974%
	7.2. Poor project planning and scheduling	.651			
	7.3. Unrealistic project goals and deadlines	.582			
8. Craftsmen issues	8.1. Craftsmen turnover	.724	2.357	5.482%	55.456%
	8.2. Lack of team spirit among craftsmen	.648			
	8.3. Rework due to field errors committed by craftsmen	.545			
9. Lack of meetings	9.1. Lack of periodic meeting among the management, site personnel and the contractors	.818	2.331	5.421%	60.877%
	9.2. Lack of weekly project evaluation meetings	.744			
10.Lack of communication	10.1. Communication problem among craftsmen and supervisors	.628	2.035	4.731%	65.608%
	10.2. Lack of interaction among the site community	.600			

DISCUSSION OF THE EXTRACTED FACTORS

Tool and Equipment Issues

The first factor 'tool and equipment issues' accounts for 9.426% of the total variance and emphasizes the importance of timely availability and proper maintenance of tools and equipment. Improper maintenance schedule of tools and equipment can result in frequent breakdowns, forcing the site management to draw up alternative plans to prevent idling of the workforce. Quick repair of faulty tools and plants is also essential to avoid productivity losses. Construction productivity is severely impaired if proper resources are not available on time at the workplace, which in turn can have a long term impact on the cost and schedule performance of the construction projects. Lack of tools and equipment has been identified among the important problems affecting construction productivity by various researchers (Alinaitwe et al., 2007; Borcherding and Garner, 1981; Kaming et al., 1997; Makulsawatudom et al., 2004; Olomolaiye, 1988; Rivas et al., 2011). The study carried out by Dai et al. (2009) in the United States using factor analysis, identified tools and consumables and construction equipment as latent factors influencing productivity.

Poor Labour Motivation

The factor 'poor labour motivation' explains 7.794% of the total variance and reflects on the primary and secondary motivational needs of the workforce. Researchers have always recognised factors relating to pay and incentives as significantly affecting labour motivation. Monetary factors were found to be preeminent in influencing labour motivation in Turkey (Kazaz and Ulubeyli, 2007; Parkin et al., 2009), Iran (Zakeri et al., 1997) and Indonesia (Kaming et al., 1998b). In addition to satisfying the primary motivators related to pay and incentives, craftsmen also require their higher level motivational needs to be fulfilled. Lack of recognition of good and efficient workers and disregard of craftsmen suggestions can create negative motivational forces in the craftsmen which get reflected in the productive capacity of the workforce. Poor site facilities are a profound problem at most of the construction sites in Kerala and can be a demotivator to the workforce. The project management should realise the importance of maintaining workforce motivation in improving construction productivity and take necessary actions to satisfy the primary and secondary motivational needs of the workforce.

Improper Supervision

The factor 'improper supervision' explains 7.663% of the total variance and stresses the importance of supervision in construction. Supervisor absenteeism during working hours can result in the craftsmen engaging in unproductive activities or idling time. Lack of experience of supervisor can be also a major problem at construction sites with the supervisor being unable to provide necessary guidance to the craftsmen, resulting in an increase of errors in construction. Inadequate and improper instructions provided by the supervisor can lead to faulty work, which may result in rework. Lack of labour supervision was identified as a besetting problem affecting labour productivity in studies carried out in the Gaza Strip and Kuwait (Enshassi et al., 2007; Jarkas and Bitar, 2012) whereas incompetent supervisors were found to significantly impair productivity in Uganda and Thailand (Alinaitwe et al., 2007; Makulsawatudom et al., 2004). Inexperienced craftsmen can slow down work thereby lowering labour productivity. Inexperienced craftsmen combined with improper supervision worsens the situation resulting in severe deterioration of productivity. Skills and experience of

the workforce have been identified as a major driver of productivity in various studies (Alinaitwe et al., 2007; Enshassi et al., 2007; Mojahed and Aghazadeh 2008).

Poor Material Planning

The factor 'poor material planning' with three items loading into it accounts for 7.294% of the total variance and is a factor that has a decisive effect on productivity. Lack of materials lead to idling time, as the workforce either has to wait for materials or shift to areas where materials are available. The craftsmen may slow down the work when sufficient quantities of materials are not available, so that the existing supply of materials is not exhausted. If lead time in material procurement is not taken into consideration, material delivery may be delayed by the supplier creating material shortages at the worksite. Delays in material delivery may also be due to unavailability of materials in the market or due to delayed payment for the materials. Crew sizes are also reduced when materials are short. Lack of material has been identified as the most important factor affecting construction productivity by various researchers (Borcherding and Garner, 1981; Enshassi et al., 2007; Kadir et al., 2005; Kaming et al., 1997; Makulsawatudom et al., 2004; Olomolaiye, 1988; Rivas et al., 2011). Dai et al. (2009) also identified materials as a latent factor impacting productivity.

Poor Site Management

This factor accounts for 6.310% of the total variance and reflects on the capability of the site management. When the work is not planned properly or when the schedule is accelerated by increasing the number of workers, congestion and interference results. Kaming et al. (1998a) reported that a labour density greater than one man per 30 m^2 results in loss of productivity, which intensifies with the degree of overcrowding and the number of men on site. Interference was an important problem influencing productivity in Indonesia and the United Kingdom (Kaming et al., 1997; Olomolaiye, 1988). Disputes with owners/consultants leading to work stoppage are another outcome of poor site management. The incompetency of the site management can create a hostile working environment and often ignite conflicts among the various project participants. The morale of the labourers is also affected by the disputes and work stoppages and thus productivity is severely impaired.

Improper Drawing Management

The sixth factor 'improper drawing management' explaining 5.750% of the total variance stresses the quality of the construction drawings. Frequent design/drawing revisions causing additional work/rework have a severe impact on productivity. Thomas and Napolitan (1995) observed, on an average, 30% loss of efficiency due to changes. Hanna et al. (1999) also reported a larger decrease in labour efficiency on mechanical construction projects impacted by changes when compared to unimpacted projects. The morale and attitude of project personnel are also adversely affected by lack of progress due to changes. Slow response on doubts arising from the drawings leads to idling of the workforce, whereas drawing errors if not corrected on time can result in erection of faulty work which later leads to rework. In a study carried out in Chile, the major reason for most of the rework was change orders, followed by design errors or lack of project definition, while only 20% of rework was linked to field errors or misunderstanding (Rivas et al., 2011). Drawing and specification alterations were identified as important factors influencing productivity in the Gaza Strip

(Enshassi et al., 2007). Jarkas and Bitar (2012) also reported the extent of variations/ change orders during execution as a significant cause of productivity loss in Kuwait. Engineering drawing management has been recognised as a latent factor influencing productivity in the United States as well (Dai et al., 2009).

Project Management Incompetency

This factor accounts for 5.737% of the total variance. Improper project coordination and poor project planning and scheduling can create a shortage of all resources needed for construction, thereby significantly affecting productivity. Doloi (2008) using analytical hierarchy process (AHP) identified pre–planning and programming to be the most critical factor in improving construction labour productivity. Unrealistic project goals and deadlines can also negatively impair productivity. In addition to causing time overruns, unrealistic schedules can also lead to mistakes and rework in construction (Doloi et al., 2012). The importance of proper management of construction projects has been stressed by various researchers who uphold that management should improve to achieve productivity enhancement (Mojahed and Aghazadeh, 2008; Rojas and Aramvareekul, 2003; Tucker, 1986). In the United States, project management was also identified as a latent factor influencing productivity (Dai et al., 2009).

Craftsmen Issues

The factor explains 5.482% of the total variance. Frequent craftsmen turnover can lower construction productivity with newer members of the crew being on the learning curve. Hinze (1978) pointed out that safety is affected by increased turnover. The degree of supervision required also increases with increased turnover. Lack of team spirit among craftsmen can affect the motivation of the labourers, thereby lowering productivity. Good relationship with workmates was identified as an important motivator of craftsmen in Indonesia and Iran (Kaming et al., 1998b; Zakeri et al., 1997). Rework due to craftsmen errors is a pertinent problem with inexperienced and unskilled labour. The actual work in the field is done by the craftsmen and hence it is essential that craftsmen are skilled and experienced enough to achieve good productivity.

Lack of Meetings

The factor ‘lack of meetings’ accounts for 5.421% of the total variance. Periodic meetings involving all the project participants are essential to the success of construction projects. Weekly project evaluation meetings provide feedback on work achieved during the week and help the project personnel to take corrective actions to rectify schedule and cost overruns. It is a venue where the project participants can voice out their problems faced during construction and seek redress. Lack of periodic meetings to assess project progress instigates schedule slippages and may trigger other productivity problems like excessive overtime, overcrowding, stacking of trades and resource shortages. A study carried out in Alberta, Canada, also identified lack of meetings among the major factors affecting construction labour productivity (McTague and Jergeas, 2002).

Lack of Communication

This factor explains 4.731% of the total variance. Ineffective and inadequate communications among the supervisors and craftsmen can affect craftsmen motivation and increase mistakes in construction causing detrimental effects to

productivity. Misunderstanding between labour and superintendents was a major factor impacting productivity in the Gaza strip (Enshassi et al., 2007). Lack of communication was also a factor affecting construction labour productivity in Alberta, Canada (Hewage and Ruwanpura, 2006). Construction involves a variety of tasks being carried out simultaneously engaging various specialists, consultants, contractors, subcontractors and trades. Poor communication among parties involved can spark off various other productivity problems, ranging from resource shortages to intractable disputes among the project participants. Effective interactions among all the people working on the site are a key to the successful completion of a construction project.

MATHEMATICAL VALIDITY AND RELIABILITY OF FACTOR ANALYSIS

Doloi et al. (2012) maintained that if the attributes explain the factor identified by factor analysis, they should exhibit significant correlations with one another. Validity of factor analysis was hence established by calculating the Pearson correlations among the factors/attributes. The values of Pearson correlation among the factors/attributes are tabulated in Table 4. The correlation coefficients show that the attributes were correlated, with all correlations being significant at the 1% significance level. Thus it may be concluded that the factors contain attributes that are related.

Table 4: Summary of The Correlation Coefficients between The Factors/Attributes Affecting Construction Labour Productivity

	Grouped Factor 1					Grouped Factor 2					Grouped Factor 3				Grouped Factor 4		
	1.1.	1.2.	1.3.	1.4.	1.5.	2.1.	2.2.	2.3.	2.4.	2.5.	3.1.	3.2.	3.3.	3.4.	4.1.	4.2.	4.3.
1.1.	1																
1.2.	.525	1															
1.3.	.553	.661	1														
1.4.	.596	.448	.527	1													
1.5.	.385	.653	.613	.416	1												
2.1.						1											
2.2.						.445	1										
2.3.						.333	.420	1									
2.4.						.528	.213	.353	1								
2.5.						.404	.346	.295	.442	1							
3.1.											1						
3.2.											.571	1					
3.3.											.581	.742	1				
3.4.											.498	.435	.474	1			
4.1.															1		
4.2.															.767	1	
4.3.															.536	.464	1

Table 4: Summary of The Correlation Coefficients between The Factors/Attributes Affecting Construction Labour Productivity (cont'd)

	Grouped Factor 5			Grouped Factor 6			Grouped Factor 7			Grouped Factor 8			Grouped Factor 9		Grouped Factor 10	
	5.1.	5.2.	5.3.	6.1.	6.2.	6.3.	7.1.	7.2.	7.3.	8.1.	8.2	8.3.	9.1.	9.2.	10.1.	10.2.
5.1.	1															
5.2.	.421	1														
5.3.	.488	.388	1													
6.1.				1												
6.2.				.592	1											
6.3.				.547	.595	1										
7.1.							1									
7.2.							.595	1								
7.3.							.517	.490	1							
8.1.										1						
8.2.										.426	1					
8.3.										.434	.437	1				
9.1.													1			
9.2.													.701	1		
10.1.															1	
10.2.															.540	1

Reliability of factor analysis was established by calculating the Cronbach's alpha reliability coefficient (α) (Chan et al., 2012; Choi et al., 2011; Doloi et al., 2012). The Cronbach's alpha coefficient was calculated for the attributes in each grouped factor, as well as on all the attributes, and the respective values are shown in Table 5. The lower threshold limit of Cronbach's alpha coefficient is 0.7 which may be reduced to 0.6 in exploratory research (Hair et al., 2011). The value of α for all attributes was 0.950 which is excellent (Doloi et al., 2012). The value of α of each factor was also high except for the two grouped factors 5 and 8 where the α values were very close to 0.7, and is hence within acceptable limits. The α values calculated therefore indicate good reliability of the attributes under factor analysis.

Table 5: Result Summary of Reliability Analysis for Grouped Factors Affecting Construction Labour Productivity

Attributes	Cronbach's alpha reliability coefficient
Attributes in factor 1	0.853
Attributes in factor 2	0.753
Attributes in factor 3	0.830
Attributes in factor 4	0.801
Attributes in factor 5	0.691
Attributes in factor 6	0.802
Attributes in factor 7	0.773
Attributes in factor 8	0.695
Attributes in factor 9	0.824
Attributes in factor 10	0.701
All attributes shown in Table 4	0.950

CONCLUSIONS

An empirical questionnaire survey was carried out to identify the factors influencing construction labour productivity in the state of Kerala in India. The survey results revealed material related problems to be the most critical factors influencing labour productivity in the state. This corroborates findings of other studies which also identified material problems to have the severest effect on productivity. The attributes of political strikes and hartals, harsh weather conditions, frequent drawing revisions, craftsmen turnover and craftsmen absenteeism have been identified as frequently occurring in construction projects in Kerala and hence were found to have a severe effect on productivity. Improper project coordination and poor project planning and scheduling have also been identified among the top ten severe factors. The Spearman rank correlation test revealed no significant differences among the respondents on the ranking of the factors, though some disagreements existed among the project managers and the craftsmen on ranking of the factors based on severity index. Factor analysis performed to understand the underlying relationships among the factors, grouped the factors into 10 latent factors, namely, (1) tool and equipment issues; (2) poor labour motivation; (3) improper supervision; (4) poor material planning; (5) poor site management; (6) improper drawing management; (7) project management incompetency; (8) craftsmen issues; (9) lack of meetings and (10) lack of communication. The factors identified reveal that the majority of the productivity problems faced by construction practitioners in the state are a result of poor

management of the construction projects, with the major factors entailing the need of implementing effective resource management practices on construction projects across the state. Proactive measures by the management to control the factors identified can achieve significant productivity improvement on the construction projects.

Poor labour productivity is a chronic problem in most of the construction sites in Kerala. However labour productivity is rarely measured on the construction sites and hence the losses are never identified. The lack of a systematic approach to managing construction projects in India has been observed by Doloi et al. (2012) and is true for construction projects in the state as well. The research has highlighted factors impacting productivity in the Indian context and the research findings can guide construction practitioners in their efforts to achieve productivity improvement. Future research efforts can be directed in replicating the study in other parts of the country to validate the findings of this research.

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