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# Improving Labour Productivity in Construction Industries

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## ABSTRACT

Construction productivity has become such a buzz word and one of the most frequently researched topics. In most countries, labour cost comprises 30 to 50% ofthe overall project's cost, and thus is regardedas a true reflection of the economic success ofthe operation. There are many challenges facing the construction industry but one of the most important is low productivity. There aremany challenges facing the construction industry in Kerala, but one of the most important, the writers debate, is low productivity. Despite all the technological advancements, abundance of construction materials, tools, and financial means available to local contractors, construction costs are constantly on the rise, completion durations ofprojects are substantially increasing, and mostprojects are significantly overrunning their budgets. The objective of this research,therefore, is to identify and rank the factors that affect the labour productivity on construction sites. To achieve this objective, a statistically representative sample of contractors was invited to participate in a structured questionnaire survey, comprising 30 productivity factors, classified under the following five primary groups: (1) manpower; (2) external; (3) communication; (4) resources and (5) miscellaneous. The main aim and objective of this study focuses on views fromthe construction industry about various factorsaffecting labour productivity, analyses factorsaffecting the labour productivity impact, and suggests appropriate measures that can be taken to improve labour productivity.

## 1 Introduction

### 1.1 General Background

Construction productivity has become such a buzz word and one of the most frequently researched topics. In most countries, labour cost comprises 30 to 50% ofthe overall project's cost, and thus is regardedas a true reflection of the economic success ofthe operation. There are many challenges facing the construction industry but one of the most important is low productivity. There aremany challenges facing the construction industry in Kerala, but one of the most important, the writers debate, is low productivity. Despite all the technological advancements, abundance of construction materials, tools, and financial means available to local contractors, construction costs are constantly on the rise, completion durations ofprojects are substantially increasing, and mostprojects are significantly overrunning their budgets. The objective of this research,therefore, is to identify and rank the factors that affect the labour productivity on construction sites. To achieve this objective, a statistically representative sample of contractors was invited to participate in a structured questionnaire survey, comprising30 productivity factors, classified under the following five primary groups:

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(1) Manpower
(2) External
(3) Communication
(4) Resources
(5) Miscellaneous.

Among the factors explored, the subsequent 10 are discerned to be the most significant in their effects on labour productivity:

(1) Clarity of Technical Specifications
(2) The Extent of Variation/Change OrdersDuring Execution
(3) Coordination Level Among DesignDisciplines
(4) Lack of Labour Supervision
(5) Proportion of Work Subcontracted
(6) Design Complexity Level
(7) Lack of Incentive Scheme
(8) Lack of Construction Manager'sLeadership
(9) Stringent Inspection By The Engineer

### 1.2 Aim and Objectives

The main aim and objective of this study focuses on views from the construction industry about various factors affecting labour productivity, analyses factors affecting the labour productivity impact, and suggests appropriate measures that can be taken to improve labour productivity. Other objectives websites which emphasize building construction's labour productivity. A survey

### 1.3 Survey Planning

For the research study, collecting general information on various factors affecting labour productivity in building construction all over Kerala was the basic aim of the survey. The purpose and approach used in the survey was fully explained to the respondents. Guidelines were provided to the respondents to ensure that the procedure was followed properly to reduce errors. During the survey period, some oversights were provided to help ensure the process was going smoothly and consistently. The data were stored in order to maintain confidentiality, which included raw data sheets, summary sheets, and of this study are following: Analyzes and quantifies previous studies in depth, to identify the key factors affecting the labour productivity, to find the relation between the factors, conduct the comparison and significance between the factors, to rank the factors based on their intensity.

### 1.4 Research Methodology

Survey research is defined as collection of different data by asking people questions. The data collection process used in this research had the option of two basic methods: questionnaires and personal interviews. A questionnaire was preferred as the best effective and suitable data-collection technique for the study. It was concluded that the questionnaire was described as a

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self- administered tool with web-design questions,an appropriate response. A questionnaire in a field survey format comparatively requires less duration and saves cost for the researcher while permits respondents to response the questionnaire at their personal ease. However, for this approach the reply rate is usually higher as compared to web surveys. Data wascollected from literature reviews from books, journals, articles, seminar conferences, and was given to employees from different trades involved with the construction project. Computer databases. Results included the overall statistics as well as individual statistics.

### 1.5 Introduction to Software SPSS

(Statistical Package for Social Science) software is used in this study for analyzing the data from the field survey. The SPSS Statistics Base program covers all basic statistical needs. It includes crosstabs,frequencies, descriptive statistics, correlations, and all comparisons of mean scores (e.g., t---tests, ANOVAs). It also includes the ranking methods of factors and cluster analysis, linear and ordinal regression analysis, etc.

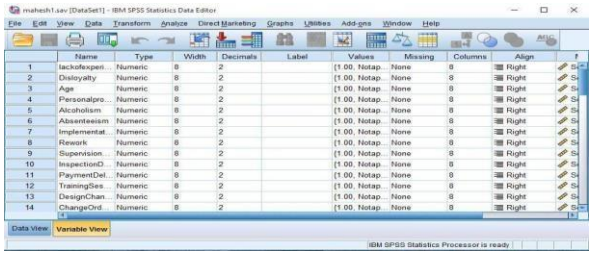


**Figure 1:** *Interface of the SPSS openingwindow in variable view.*

In the variable view (Figure 1.1), the logic behind each variable is stored. Each variable has a name (in the name column), a type(numeric, percentage, date, string etc.), a label(usually the full wording of the question), and the values assigned to the level of the variable 'values' labelled in the column.

### 1.6 Scope of the Research

The scope of the project is; thedistribution of the questionnaire and its study are limited with in Kerala and the data used inthis study is from small companies executing small building projects. The duration of the survey and its responses limited to four months.

## 2 Literature Review

### 2.1 General

A literature review is a comprehensive summary of previous research on a topic. The literaturereview surveys scholarly articles, books, and other sources relevant to a particular area of research. The review should enumerate, describe, summarize,objectively evaluate and clarify this previous research. It should give a theoretical base for the research and help you (the author) determine the nature of your research. The literature review acknowledges the work of previous researchers, and in so doing, assures the reader that your work has been well conceived. It is assumed thatby mentioning a previous work in the field of study, that

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the author has read, evaluated, and assimilated that work into the work at hand. Just like most academic papers, literature reviews also must contain at least three basic elements: an introduction or background information section; the body of the review containing the discussion of sources; and, finally, a conclusion and/or recommendations section to end the paper. A literature review creates a "landscape" for the reader, giving her or him a full understanding of the developments in the field. This landscape informs the reader that the author has indeed assimilated all (or the vast majority of) previous, significant works in the field into her or his research. A literature review is the writing process of summarizing, synthesizing and/or critiquing the literature found as a result of a literature search. It may be used as background or context for a primary research project.

## 2.2 Literature Review

**Rowlinson, Proctor et al,1999**. Productivity is generally defined as the average direct labour hours required to install a unit of material. It is said that perfect productivity (1.0) can be achieved with a 40-hour work week, with people taking all the holidays and vacation days as planned all of the engineering drawings would be 100% complete there would be no delays of any kind during construction; everyone would work safely; everything would fit perfectly the first time; the weather would be 700 F; and there would be no litigation at the end of the project.

**Borcherding and Liou, et al, 2002**. Output and input differ from one industry to another. Also, the productivity definition varies when applied to different areas of the same industry. Labour is one of the basic requirements in the construction industry. Labour productivity usually relates manpower in terms of labour cost to the quantity of outputs produced.

**Drewin, 2008**. In other words, the definition of labor productivity is the amount of goods and services produced by a productive factor (manpower) in the unit of time.

**Jarkas, 2010**. In 1883, Littre defined productivity as the "faculty to produce," that is, the desire to produce.

**Sumanth, 2012.** 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

**Adrian, 2007.**Depending on measurement objectives and the availability of data, several productivity definitions are encountered. The U.S. Department of Commerce defined productivity as "dollars of output per person-hour of labour input"

**Hendrickson, 1998.** Construction requires extensive manual labour. Human performance and productivity are reliant on one another. Therefore, the most commonly used measure of productivity is the constant contract dollars of new construction work per work hour

**A study by 'Teicholtz' (2004)** revealed that over 40 years (1964-2003) the construction industry lags compared to all other non-farm industries in developing and applying labour saving techniques and substituting equipment for labour. Figure 2.1 depicts construction

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labour productivity Changes as opposed to all non-farmindustries from 1964-2003.

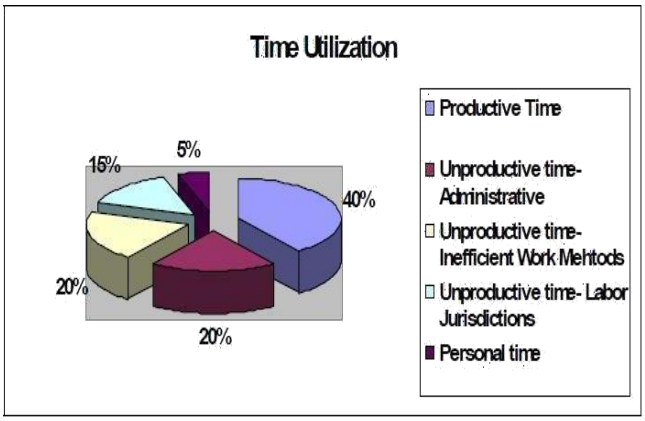



**Figure 2:** *represents construction labor productivity changes as opposed to all non- farm industries from 1964-2003 (Teicholtz2004)*

**A study by Hendrickson (1998)** addressed the time utilization of the average construction worker. Only 40% of a workers time is considered to be productive, with 55 % unproductive time, and 5 % personal time. Figure 2.2 shows a breakdown of the average workers time utilization.

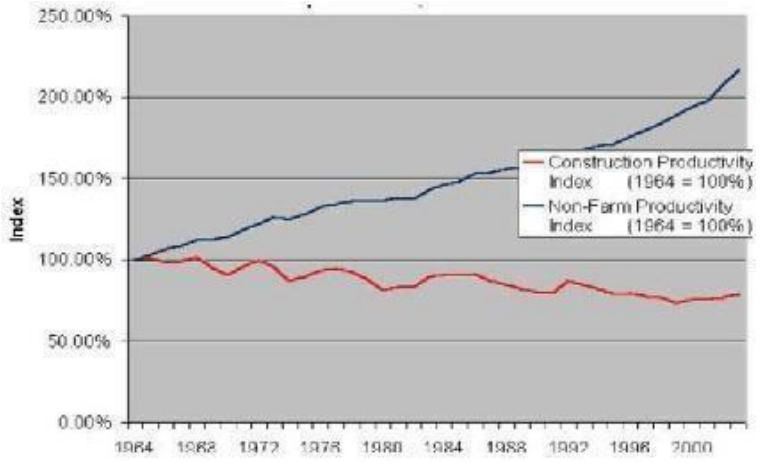



**Figure 3:** *Breakdown of the average workers time utilization (Hendrickson,1998)*

Productivity has a great significance in construction. Labour productivity constitutes a significant part of production input for constructionprojects. 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 labour productivity. It is necessary to make sure that a reduction in productivity.

**Ms.P.Jeevitha, Mr.T.Sathieshkumar et al (2018)**proposed theoretical model of this study proposed fifteen independent groups affecting the variation of Labour Productivity in the construction projects namely Labour factors , Supervision factors , External factors , Owner/consultant factors, Execution plan factors , Designer , Working time factors , Equipment factors , Financial factors , Quality factors , Project factors , Organization factors , Leadership and coordination factors , Health and safety factors. This research is intended to identifythe causes of probable factors affecting labour productivity in building construction.
This study investigates all possible factors through a structured questionnaire administered all over Coimbatore. The survey results are subjected to analysis, and the ranking of factors is calculated using the Relative Important Index. The basic ideas of the research is to study various factors affecting labor productivity on construction. The target groups in this study were construction professionals. Total of 125 questionnaires were distributed, and 83 questionnaires (66.4 % response rate) were returned. Because project engineers, project managers have vast experience in construction, their adequate experiences were a proper suggestion to study about thevarious construction factors affecting labor productivity.
**Archit Jain , 2 Nasir Ali Lone,Abhishek Sharma et al (2020)** Investigate does not affect the plan and schedule ofthe work and does not cause delays. Theconsequences 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 labourcost.
**Thomas, 1991** today's world the construction industry is rated as one of the key industry. It helps in creating and accomplishing the objective of society. Earlier information of work efficiency during development can set aside cash and time. Ventures for these tasks are extremely high and on account of the multifaceted nature in development, different variables can very influence generally speaking profitability, hence the undertaking can wind up including considerably additional time and cash so as to be finished. From these previous studies, we getthe key factors that affect labour productivity. The following are the factors, which are used in the survey; (1) Age, (2) Disloyalty, (3) Lack of experience, (4) Personal problems, (5) Alcoholism, (6) Absenteeism, (7) Implementation of government laws, (8) Rework, (9) Supervision delays, (10) Inspection delays from the authorities, (11) Payment delays, (12) Training sessions, (13) Design changes, (14) Change orders from designers, (15) Change order from the owners, (16) Disputes with owner, (17) Disputes with designer, (18) Increase in the price of materials, (19) Lack of required tools, (20)Poor site conditions, (21) Poor access within construction job site, (22) Violations of safety laws, (23) Insufficient lighting, (24) Inadequate transportation facilities for workers, (25) Material storage location, (26) Shortage of water and/or power supply, (27) Working overtime, (28) Weather conditions, (29) Accidents during construction, (30) Project objective is not well defined. The above factors are used for the generation of the questionnaire.

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### 2.3 Litrature Summary

1. Productivity is generally defined as the average direct labour hours required toinstall a unit of material, when all otherfactors are perfect. ie, the time required to complete a task from its beginning to end without any faults.
2. Productivity is said to be the exact relation between input and output of a task. What matters is the degree ofoutput to the efforts of input.
3. Productivity is expressed in terms of cost of labour to the output of what activity labour has gone through.
4. Productivity is defined as the amount or service we got as an effort of manpower spend on it. ie, the actual efforts of labour to do a particular activity.
5. Productivity can simply explained as one's desire or willingness to producea certain output and it fully depends onthe labour's mind.
6. Productivity is a relative factor of output when compared with its degreeof output.
7. Productivity can be expressed or defined as the money spend for a certain activity and is expressed in terms of cash as per the country. Eg: Dollar for USA.
8. Productivity is found to be major factor and is noted as the cost spend onwork per hour.
9. Productivity can be increased by substituting human with equipment. Itwill save money, quick results with maximum satisfaction.
10. Productivity is addressed as time spend by workers will not be same as a whole. Only 40% is of high productivity, 55% is of unproductive & 5% of whole working hours is spendfor personal purposes. So 100% productivity cannot be practical.

## 3 Methodology

### 3.1 General

Project methodologies are set of guiding principles and processes used plan, manage, and execute project. These approaches to managing work are all about specifying the best way to initiate.

### 3.2 Problem Statement

In the construction industry productivity loss is one of the greatest and severe problems. Present constructioncontracts lack enough to classify recompense for productivity loss due to field factors (Construction Industry Institute [CII], 2000; National Electrical Contractors Association [NECA], 1999). Of various project-costs components such as labors materials and equipment's, labor component is considered the most risk. Whereas others components (equipment and material) are determined by the marketprice and price and 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. 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 laborcost in a direct proportion. It can eitherbenefit or reduce a project's profit, making it of

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vital interest to the construction industry for its success. 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 fieldmanagement, and extreme climatic conditions. 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 hoursnecessary to accomplish the task.

### 3.3 Research Contribution

The research study investigates important factors affecting labour productivity in building construction. Understanding these factors is helpful for the construction professionals who work on the initial phases of construction planning in order to efficiently deliver the project plan. The main goal of the research study is to provide essential information about factors affecting labour productivity to the project management teams who enable the project's success. Generally, the factors which affect construction productivity are a lack of required materials, disputes between the major parties, weather, and changes during the construction, accidents, and others.

For building construction, extra care must be taken when developing the project time schedule, which is possible only with prior knowledge of factor causes. The research study aims to provide knowledge of building construction-related factors that affect the project's success.

### 3.4 Organization of theQuestionnaire

One of the biggest concern of the research study was about number of responses with complete information.Recognition of respondents about the benefits and uses of this research study was also of great concern. The model of the questionnaire was adopted from the researcher 'Mahesh M. Gundecha, North Dakota State University, U.S.A'. Following criteria was used to begin the questionnaire design process: for Questionnaire: Exactness, Applicable, Completeness, Understanding were required. For Response Rate: Duration, Ease of Completion are applicable.

### 3.5 Data Measurement

It is commonly believed, while performing different task on construction projects, disturbances can existent with diverse degrees of danger. In order to overcome with these different degrees, it was decided to consider four condition levels: not applicable, does not affect it, somewhat affects it, and directly affects it. A clear specification of the standard conditions was necessary to enable respondents to clearly distinguish the degree of each adverse condition level. Standard conditions discussing to four different degrees of severity for each field were recognized (Eric Asa 2012). The concept of different degrees of severity for productivity factors was previously used in other studies (Neil and Knack 1984). Slight modifications were made to the typical conditions after they were reviewed by the participants. Further, detailed questionnaire was developed to calculate the factors affecting

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labour productivity in building construction. In order to select the suitable technique of study, the level of measurement is to be studied. For each measurement type, there is (are) (an) appropriate method(s) that can be applied. In this research, ordinal scales were used. An ordinal scale, as shown in Figure 3.1, is a ranking or a rating of data that normally uses integers in ascending or descending order. The numbers assigned (1, 2, 3, 4) neither indicate that the intervals between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels. Based on “Likert scale”.

**3.6 Likert Scale**

A Likert scale is a psychometric scale,which is commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research, such that the term (or more accurately the Likert-type scale) is often used interchangeably with ratingscale, even though the two are not synonymous (Wikipedia 2012).

The scale is named after its inventor, psychologist Renisis Likert. Likert distinguished between a scale proper, which emerges from collective responses to a set of items (usually eight or more), and the format in which responses are scored along a range. Technically speaking, a Likert scale refers only to the latter. The difference between these two concepts has to do with the distinction Likert made between the underlying phenomenon being investigatedand the means of capturing variation those points to the underlying phenomenon.

Provide answers that when responding to a Likert item, respondents specify their level of agreement or disagreement on a symmetric agree- disagree scale for a series of statements. Thus, the range captures the intensity oftheir feelings for a given item.

A scale can be created as the simple sum of questionnaire responses over the fullrange of the scale. In so doing, Likert scaling assumes distances between each item are equal. Importantly, "All items are assumed to be replications of each other or in other words items are considered to be parallel instruments". By contrast, modern test theory treats the difficulty of each itemas information to be incorporated in scalingitems.

Likert scales may be subject to distortionfrom several causes. Respondents may:

- Avoid using extreme responsecategories, especially out of a desire.
- To avoid being perceived as having extremist views. For questions earlyin a test, an expectation that questions about which one has stronger views may follow, such that on earlier questions one "leaves room" for stronger responses later in the test, which expectation creates bias that is especially pernicious in that its effects are not uniform throughout the test and cannot be corrected for through simple across-the-board normalization;
- Agree with statements as presented,with this effect especially strong among persons, such as children, developmentally disabled persons, and the elderly or infirm, who are subjected to a culture of institutionalization that encourages and incentivizes eagerness to please;
- Disagree with sentences as presented out of a defensive desire to avoid making

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erroneousstatements and/or avoid negative consequences that respondents mayfear will result from their answers being used against them, especially if misinterpreted and/or taken out of context;

- They believe will be evaluated asindicating strength or lack of weakness/dysfunction ("faking good"),
- Provide answers that they believewill be evaluated as indicating weakness or presence of impairment/pathology ("faking bad"),
- Try to portray themselves or their organization in a light that they believe the examiner or society to consider more favorable than theirtrue beliefs.

Designing a scale with balanced keying (anequal number of positive and negative statements and, especially, an equal numberof positive and negative statements regarding each position or issue in question) can obviate the problem of acquiescence bias, since acquiescence on positively keyed items will balance acquiescence on negatively keyed items, but defensive, central tendency, and social desirability biases are somewhat more problematic.

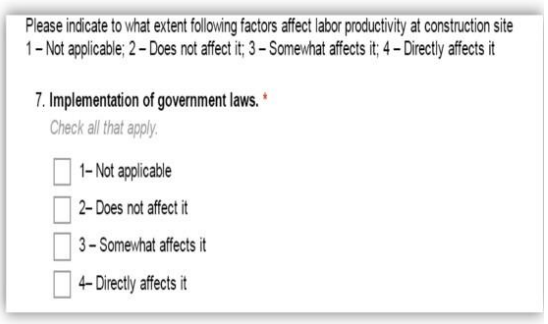



**Figure 4:** *Likert ordinal scale used inthis survey*

A Likert scale measures attitudes and behaviors using answer choices that range from one extreme to another (for example, not at all likely to extremely likely). Unlikea simple “yes / no” question, a Likert scale allows you to uncover degrees of opinion. This can be particularly helpful for sensitiveor challenging topics or subject matter. Having a range of responses will also help more easily identify areas of improvement (Survey Monkey 2015).

Following are the main criteria, which is used for the data measurement. Criteria for Data measurement.

- Keep it labeled: Numbered scales, or scalesthat are marked from 1 to 4, for instance, have also proven to give survey respondent’s trouble, since they might not immediately know what end of the spectrumskews positively versus negatively. Instead,use words to label your scales, i.e. ‘poor’ ranging to ‘excellent’ (Wikipedia 2016).
- Keep it unipolar**:** Whenever possible, try touse a “unipolar” scale that ranges from “extremely” to “not at all,” rather than extremely one thing to extremely another. Unipolar scales are just easier for people tothink about, and you can be sure that one end is the exact

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opposite of the other, whichmakes it methodologically more sound as well.

- Keep it continuous: Response options in a scale should be equally spaced from each other. (The distance between scale points should be the same throughout the scale, which makes the scale clear and less ambiguous.) This can be tricky when usingword labels instead of numbers.
- Keep it inclusive: Scales should span the entire continuum of responses. For example, if a question asks how hot your coffee was and the answers range from “extremely hot” to “moderately hot”, respondents who think the coffee wasn’t hotat all won’t know what answer to choose.
- Keep it logical: Add question logic to save your survey takers some time! For example, let’s say you want to ask how much your patron enjoyed your restaurant, and then get more details only if they were unhappy with something. To do this, just add question logic so that only those who are unhappy skip to a question asking for improvement suggestions.
- Keep it interrogative: Ask questions whenever possible instead of using agreement with statements. Avoid scales of agreement / disagreement whenever possible as they are subject to an acquiescence bias. This means that survey takers are more likely to agree with statements no matter what they say, and lesslikely to read the question carefully.

### 3.7 Questionnaire Distributions

The target groups in this study wereprofessionals from the construction industry. A list of 100 building-construction organizations was obtained from the Lensfed (Licensed Engineers Federation). The sample size can be calculated with the following equation for a 94% confidence level (Al-Shahri, M et al., 2001; Israel, 2003; Moore et al., 2003)

$$\mathbf{n = n'/ [1+(n'/N)]}$$

Where, n= Total number ofpopulation

N = Sample size from a finitepopulation

n’ = Sample size from an infinitepopulation = $S^2/V$

$S^2$= the variance of the populationelements and

V = a standard error of the sampling population. (Usually, S=0.5, and V = 0.06.)

$n'=S^2/V^2= (0.5)^2/(0.06)^2= 69.44$ For N=100

n = 69.44/ [1+ (69.44 / 100)] = 41

To obtain 94% of confidence level, it was calculated to send the questionnaire to 41 organizations to accomplish a 94%. For getting more accuracy and precision for thestudy we take 80 respondents instead of 41.

## 4 Conclusion

### 4.1 General Conclusions

In today’s world, the construction industry is rated as one of the key industry. It helps in developing and achieving the goal ofsociety. Study and knowledge of constructionproductivity

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are very important because theycause losses to the governing agencies and also influence the economics of the construction industry. Prior knowledge of labour productivity during construction can save money and time. Investments for these projects are very high and because of the complexity in construction, various factors can highly affect overall productivity, thus the project can end up adding even more time and money in order to be completed, Gundecha*et.al* (2012). This research is intended to identify the causes of probable factors affecting labour productivity in building construction. This study investigates all possible factors through a structured questionnaire administered all over Kerala. The survey results are subjected to analysis, and the ranking of factors is calculated. Based on the correlation between the variables, many variables are positively correlated; some of them are negatively correlated; somevariables have no significant relation and thedata used in the study is from small companies executing small building projects .The basic ideas of the research are to study various factors affecting labour productivity on construction.

### 4.2 Recomendations

Construction tasks are expensive and frequently cause in arguments and claims, which generally affects progress of construction projects. The environment of construction organizations should be suitableto implement projects with successful completion, Adrian *et. al* (1990). In the construction industry, it is necessary to find the weaknesses of particular task in order to solve and overcome them. Mentioned below are the recommendations which were found to be important factors for improving labour productivity in the construction industry. Absenteeism at work site can be reduced withinclusion of appropriate paid time off and vacations to all employees. Strict drug and alcohol tests should be implemented in working hours at sites. Recruiting manager and project managers should recruit appropriate candidate to particular task. Friendly relations should be maintained with labours and made aware of their importance to the organization, Adrian *et. al* (1990). A detail schedule of material supply schedule for each project should be provided by the contractors. It should contain the time required to supply materials and the availability of the local market to furnish therequired materials in time.

Extra attention is required on quality of construction materials and tools used in their projects because usingsuitable materials and tools reduces both the time taken to finish the work and wastage of materials. Using suitable materials and toolsalso has a positive effect on the task and thus,better labour productivity can be achieved. Arbitration provided for disputes between theowners and builders. Organizations should make sure there is enough lighting present *at* the construction sites which can indirectlyreduce the number of accidents. Continuous safety training and meetings should bearranged to achieve better performance inlabour productivity. Purchased material should be stored at appropriate location and should be easily accessible and close to constructed buildings to avoid wasting labour time for multiple-handling materials. To achieve desired results, time required to implementing change orders and to

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make corrections in drawings and specifications should be estimated and scheduled without affecting the project-time completion. Regular meetings should be arranged with the project authorities. Various external and natural factor risk should be considered in the budget estimation to minimize delays due to closures and material shortages. There should be suitable emergency budget to cover cost of increased material. Haris*et. al* (1998).Incomplete drawings should be avoided and care should be taken to avoid confusion among the various construction agencies. Change orders and design error should be avoided as much as possible. These factors can be costly and time consuming if the work has been done. Work sequences canalso be affected due to rework.

### 4.3 Future Research

The distribution of the questionnaire and its study are limited with in Kerala and the data used in this study is from small companies executing small building projects. Future study could be done in other parts of the Country and could emphasize specific types of building construction, including commercial, education, government buildings, skyscrapers, etc. There is a need to study the productivity levels in other types of projects. Only a few studies are conducted in this area using SPSS and the output of the project is valuable for researchers as well as companies in this field. A study similar to the present research is needed for transportation projects to find factors that affect the productivity of highway construction, which will help departments of transportation to minimize unnecessary cost and project schedule delay.

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