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Analysis of Key Factors Influencing Labour Productivity in Construction Projects

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Abstract: Labour is one of the major resource in this labour intensive Indian construction industry. Due to the transient nature of our industry therefore there are no universally accepted standards to measure factors causing labour productivity loss in construction projects. Objective of this paper is to study factors affecting labour productivity of Autoclaved aerated concrete block masonry activity at construction site in Delhi/NCR, India. The identification and prioritization of the critical factors which affects labour productivity of blockwork activity will assist the project management team to leverage the limited resources at their disposal to improve the labour management on construction site, in order to improve labour productivity. Total 40 factors were identified with the help of work study method and divided into 8 main group as Material, Equipment, Tools & accessories, Labour, Site, Design, Management, and others factors group. The analysis of those 40 factors is considered in a questionnaire survey indicates the 10 most critical factors among all which are negatively affecting the labour productivity are : Inefficient crew composition, Design Complexity, Inexperienced or unskilled worker, no proper Supervision, Non availability of vertical shifting equipment, Unavailability of required material, Poor management of working space, Unclear or inadequate instructions to workers, Unavailability of required tool and No proper or safe scaffolding arrangement. Reliability analysis and validation of the acquired results is done with the help of live construction site in Delhi.

Index Terms **– Labour Productivity, Influencing Factors, Work Study, Productivity Improvement.**

I. INTRODUCTION

Indian construction industry is one of the fastest-growing and gives the second largest employment after agriculture. It relies on the skills of its most valuable asset that is labour, as most of the construction projects here are labour intensive with the basic use of hand tools and equipment's and in which labour resource cost around 25 to 40 percent of the cost of the construction (H. Alinaitwe et al., 2005). There are many challenges that are faced by Indian construction industry, but one of the significant challenge is of labour productivity. It is necessary to improve the efficiency of production by improving the productivity of labour.

There are many factors which influence labour productivity in construction projects. Various external and internal factors which are never constant and are very difficult to anticipate. This results to a continuous variation in labour productivity we achieve at sites. It is necessary to make sure that a reduction in productivity does not affect our project schedule and cause delays (Gundecha, 2012). It is essential to identify, analyze and prioritize the factors that influences labour productivity at construction sites that will help management team to develop the most effective methods and strategies to improve construction labour productivity in the upcoming time.

II. LITERATURE REVIEW

2.1 Labour Productivity:

Productivity can be defined in many ways. (Oglesby et al., 1988) mentioned that considerable amount of effort has been put to understand the concept of productivity which resulted into wide variety of productivity definitions by various researchers. The term productivity expresses the correlation between the outputs and the inputs. (Liou & Borcherding, 1986) According to them outputs and inputs both differ from one industry to other. Also sometimes the productivity definition varies when applied to various areas within the same industry as well.

Definition

Productivity is defined as the ratio of the output to all or one class of input which are used in producing the output. Input can be single factor for example: labour, material, machine, capital, energy etc. or multifactor in which input is a holistic measure that takes into consideration the joint and simultaneous impact of all the inputs used. 'Labour productivity' is widely used to simplify the measurement, in which input is taken in terms of man-hour contributed to produce the output.

Labour Productivity = $\frac{Output\ Produced}{Man-hour}$

2.2 Factors affecting construction productivity

There are number of factors which influence construction productivity and those have been the subject of inquiry for many years and by many researchers. In order to improve labour productivity, a study on the factors affecting it, weather positively or negatively, is necessary. Thus making use of identified positively effecting factors and eliminating (or controlling) negatively impacting factors will ultimately improve the productivity. If all the factors influencing productivity are known, it will also be possible to forecast productivity (Lema, 1996).

Serval researcher investigated factors affecting labour productivity, few significant one are mentioned here. (Olomalaiye et al., 1998) concluded that factors affecting construction productivity are rarely constant and vary depending upon geographical location, typology of project and even sometimes within the same project, depending upon the circumstances. They classified factors into two categories: external and internal factors, mentioning external factors which are the ones outside the control of the organization management for example nature of the industry, client knowledge, weather, economic development level etc. and internal factors related to the productivity factors originating within the organization such as management, technology, labour etc.

(H. M. Alinaitwe et al., 2007) mentioned that the productivity efficiency is essential in developing countries, where most of the building construction work is still done on the manual basis. He identified the factors for building projects in Uganda, categorizing 36 identified factors into 5 groups: design, manpower, management, environment, and others. The ten most significant problems which were affecting labour productivity in their projects were identified as 1) incompetent supervisors, 2) lack of skills of workers, 3) rework, 4) lack of tools/equipment, 5) poor construction methods, 6) poor communication, 7) inaccurate drawings, 8) stoppages of work by consultants, 9) political insecurity and 10) harsh weather conditions. On the other hand in same year (Enshassi et al., 2007) studied Palestinian construction industry and identified that the problems of material supply and project scheduling techniques are very common there. Apart from them they also identified ten most critical factors which are influencing labour productivity specifically in the Gaza strip are 1) working labour force, 2) governance, 3) factors associated with work, 4) inspiration factor with regards of time, 5) materials resources and machinery, 6) inadequate supervision, 7) project related specifications, 8) protection, 9) quality of the worked achieved and 10) other factors of the project.

(Soekiman et al., 2011) studied Indonesia, Found 113 factors that are having an impact on labour productivity and these factors are further assembles into 15 sets of factors as per their features. Observed and classified that the groups of factors that give high impact are: supervision, material, execution plan, and design. The most influencing factors came out to be 1) Lag of material, 2) Delay in arrival of materials, 3) unclear instruction to labour, 4) Labour strikes, 5) financial difficulties of the owner, 6) High absenteeism of labour, 7) No supervision method, 8) Supervisors absenteeism, 9) Design changes, 10) Non-availability of definite schedule.

(Gundecha, 2012) Identified factors affecting labour productivity in building construction projects in USA. 40 factors, categorized into 5 groups, were analyzed and ranked. It was concluded, that the 1) lack of required construction material, 2) shortage of power/water supply, 3) accidents during construction, 4) Lack of required construction tools/equipment, 5) insufficient lighting, 6) Poor site condition, 7) Weather condition, 8) differing site conditions from plan, 9) Material storage location, 10) working overtime were identified as the major factors affecting the productivity of an individual labour.

(Patel & Pitroda, 2015) classified 46 factors affecting labour productivity in 10 groups for building construction projects in central Gujrat, India. The top ten factors influencing labour productivity rated by their level of impact and frequency of occurrence are 1) Frequent changes in the design, 2) Poor resources management, 3) Lack of communication between stake holders, 4) Too much work load, 5) Lack of training, 6) Lack of equipment and tools, 7) Delays in decisions making, 8) Shortage of material, 9) Effect of bad weather (rain, wind, high/low temperature etc.) and 10) Inspection and instruction delay.

These dissimilarities in identified factors indicated that the factors affecting labour productivity in construction changes based on the geographical location and on project type. However, there are some common factors are also observed among the studies.

III. PROBLEM STATEMENT

Several researchers investigated this topic of productivity, despite of such intensive research, none of them agreed upon a common set of factors with significant influence on labour productivity or any agreement has been reached on the classification of these factors. Various approaches and methods have been adopted to classify but due to the transient nature of construction projects, therefore there are no universally accepted standards to measure factors causing labour productivity loss in construction industry.

IV. RESEARCH OBJECTIVE

This study mainly aims to investigate critical factors affecting labour productivity of Autoclaved aerated concrete(AAC) block masonry work in building construction projects of National Capital Territory of Delhi and NCR. Study aiming at finding out the factors affecting an important construction activity of Autoclaved aerated concrete(AAC) Blockwork. The identification and prioritization of the critical factors which affects labour productivity of blockwork activity will assist the project management team to leverage the limited resources at their disposal to improve the labour management on construction site, in order to improve labour productivity. Work study method has adopted to identify various factors and improve the labour productivity effectively while focusing on crucial areas in activity.
This study is conducted to achieve the following objectives:

- To identify factors affecting labour productivity of Autoclaved aerated concrete block masonry work with Work study.
- To rank identified factors by calculating their relative importance index and analyzing the critical factors influencing productivity of labour.
- Validate the acquired results and make recommendations to improve labour productivity in construction projects.

V. SIGNIFICANCE OF STUDY

Productivity is considered as a measure of the efficiency of production. High productivity can lead to greater cost and time saving, also greater profits and greater income for individuals. Since Indian construction is a labour intensive, this clearly implies that labour power is the most productive resource in construction projects. Cost contribution of blockwork in comparison to other building activities is significantly high. Study of Blockwork activity provides various opportunity in terms of diverse nature of factors, most of its inputs and outputs are easily quantifiable and also it is a relatively easy activity to observe and quantify because of its intensity (Abo Mostafa, 2003).

VI. RESEARCH METHODOLOGY

The research methodology used in this study is shown in Figure 1

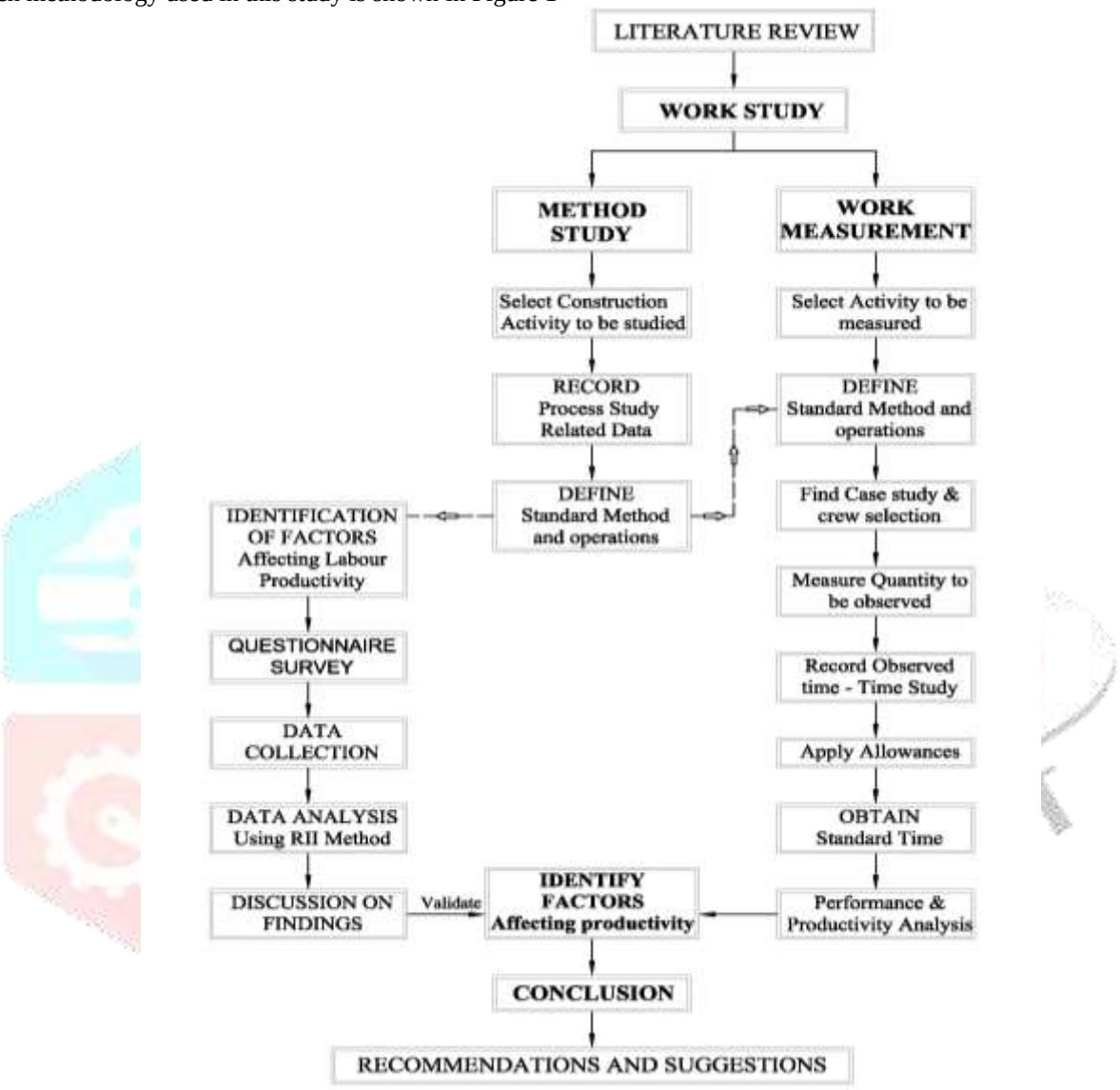

Figure 1- Research Methodology

4.1 Work Study

Work study is powerful tool for management to achieve higher productivity. It aims at examining the method of carrying on activity, simplifying them into operations to reduce or remove unnecessary or excess work during execution making it efficient. It is related to manpower, method and standard of performance aims at improving the existing or proposed ways of executing work. It a direct means for improving efficiency and effectiveness of labour work. Work study comprise of method study and work measurement.

Application of the work study: To analyze the work flow/work content of AAC blockwork activity. Dividing it into smaller operations.

Advantages:

- Direct means of improving productivity
- It helps in eliminating waste and unnecessary operations.

There is a linkage between method study and work measurement. Method study reduces the work content whereas work measurement reduces the ineffective time associated with required work content.

4.1.1 Method Study

"Method study is a systematic recording and critical examination of existing and proposed ways of doing work" (Kanawaty, 1992). It is concerned with the reduction of work content by eliminating unnecessary operations from the activity making it efficient. Objective of work study to involves detailed process and operation analysis such as work operations and their sequence, materials, tools and accessories, layout of work place, movement of material and labour, work environment etc. Recording all the related facts about the activity, examine

them and develop best possible process considering all the circumstances. It will lead to improved layout and design of workplace, efficient work process, effective utilization of resources, improved final product.

4.1.2 Work Measurement

"Work measurement is the application of technique designed to establish the time for a qualified worker to carry out any specific operation at defined level of performance" (Kanawaty, 1992). It helps in investigating and reducing the ineffective time associated with it. It requires the familiarization of work content (from method study), Time required by each operation, rating to assess the worker being observed and building time standard by keeping the provision of appropriate relaxation and contingency allowances.

Procedure of Work Measurement: To calculate the standard time required for each operation these steps need to be performed - Selection of activity, defining operations, selection of crew for observing, Recording, measuring and compiling.

VII. AAC (AUTOCLAVED AERATED CONCRETE) BLOCK MASONRY

7.1 Process and Operation Analysis

AAC Blockwork activity includes various site activities and operations in the entire process, starting from pre-construction stage which includes: material selection, material procurement, material handling & management, material shifting arrangements, tools, Accessories and equipment, crew composition and job assignment etc., During construction stage: execution of blockwork and Post construction stage: quality check. After a thorough study a detailed standard work flow is recorded and defined with the help of various literature, process analysis, site observations, photographs and videos.

On projects using AAC masonry units for masonry work, consists of five major operations: 1) Material Handling, 2) Layout work. 3) Block laying, 4) RCC Work, 5) Scaffold erection and dismantling.

1. **Material handling:** This operation involves preparation, procurement and distribution of required material at required locations.
2. **Layout work:** In this operation the lines and location of the walls to be build are measured and marked including all the joints, doors, windows according to the given drawings or instructions.
3. **Block Laying:** This operation involves measuring, block cutting, mortar spreading, block laying, levelling and aligning.
4. **RCC Work:** This operation is crucial which help in reinforcing the block wall by providing RCC bond beams and lintels at required interval. Providing bond beams which includes – formwork installation, placing reinforcement, casting and curing.
5. **Scaffolding:** This operation required when working on height involves erection and dismantling of scaffolding arrangement.

7.2 Labour Involved

Different roles being played by blockwork labour. There are three major roles in a masonry crew:

a) **Direct Labour** - The crew responsible for masonry production. Skilled Labour – Mason and Unskilled – Collie & Bhisti.

b) **Supporting Labour** – The crew responsible to provide supporting elements. Such as Reinforcement cutting, Equipment operators etc.

The crew responsible for masonry production can be classified into Skilled and Unskilled labour. Skill labour is usually associated with Productive activities – those which are value adding to the activity. For example- Spreading mortar, Cutting blocks. Laying blocks. Raking and pointing. Unskilled labour is associated in Contributory activities. For example - Making mortar, Ancillary work, distributing blocks or mortar, Cleaning, scaffolding and other work relevant to block work (CPWD, 2018). This study is focused on analyzing the productivity of direct labour only.

VIII. DATA COLLECTION

Data collection has been done in two phases: questionnaire survey to identify the impact level of identified factors and personal site visit for the selected case study at the time of activity getting performed to perform work measurement.

8.1 Questionnaire Survey

Factors affecting the labour productivity of AAC blockwork activity were identified through literature study, detailed process and operation analysis. A total 40 factors were identified and divided into 8 groups. A questionnaire survey approach has been adopted to find out the impact of each identified factor on the labour productivity of AAC blockwork in construction projects in Delhi/NCR area. Target Respondents are various professionals associated with the industry and having an exposure of construction projects including: Project managers, planning managers, Contractors, Site engineers, Site supervisors. Respondents are required to rate the factors according to the level of impact they have on labour productivity using their own experience on construction sites situated in Delhi/NCR area.

A 5-point Likert scale was used for measuring of the level of impact of factors. A Likert scale is a type of psychometric response scale often used in questionnaires, and is the most widely used scale in survey research. When responding to a Likert questionnaire item, respondents specify their degree of impact to a statement with the help of given rating from 1 to 5, representation of each is mentioned in ***Table 1***.

Likert Scale Index	Impact on Productivity
1	Not much impact
2	Slight Impact
3	Moderate Impact
4	High impact
5	Very Critical

Table 1- Likert scale index

8.2 Case Study- Site Visit

The selected case study is a State Government Boy's School located in Timar Pur, Delhi, India. The project comprises of single building having ground plus 4 story having the plot area of around 5 acres. The study performed during the execution of the activity of AAC block

masonry at site. The data is collected in the form of time study table for all the operations involved while execution of the activity with the help of stop watch. The time noted in the sheet under the category of observed time.

IX. DATA ANALYSIS APPROACH

Data collected from the questionnaire survey and site recordings was analyzed using Microsoft excel. A total of 41 responses were receive from the total of 70 distributed among the target respondents. Response rate for the survey is 59%. Among the received 41, 7 responses were rejected on the basis of non-validity of project location which were not Delhi or NCR area.

9.1 Relative Importance index (RII)

The data from the questionnaire were analyzed using the relative importance index method for determining the ranking of each identified factor form the perspective of various professionals and experts. Respondents were asked to rank factors impacting productivity of labour according to the degree of importance (1 = Not much impact; 2 = Slight impact; 3 = Moderate Impact; 4 = High Impact; 5 = Very critical). For analyzing data by ordinal scale, a relative importance index (RII) was used by following equation:

Relative Importance Index(RII) $= \frac{\sum_{i=1}^{5} Wi}{A*N}$ …….(Equation 1)

where: Wi = the rating given to each factors by the respondents ranging from 1 to 5
A is the highest weight = 5
N is the total number of responses collected for the ordinal scale.

The RII value has a range from 1 to 5, higher the value of RII, more is the importance of those factors relating to labour productivity.

9.2 Reliability Analysis

Cronbach's alpha is used to test the reliability of data received from questionnaire survey. Reliability Analysis is used to identify Cronbach's alpha coefficient and item total correlation. The reliability coefficient of Cronbach's alpha also examines how relation of the items in a set which are significantly correlated from one to other. For reliability analysis following equation is used:

$$\alpha = \left(\frac{k}{k-1}\right)\left(1-\frac{\sum_{i=1}^{k}\sigma_{y_i}^2}{\sigma_x^2}\right)$$

……(Equation 2)

where:
k - Refers to the number of scale items
σ_{yi}^2 - Refers to the variance associated with item iσ2xσx2 refers to the variance associated with the observed total scores
σ_x^2 - Refers to the variance associated with the observed total scores

If all of the scale items are entirely independent from one another (i.e., are not correlated or share no covariance), then α = 0; and, if all of the items have highly correlated then α will approach 1.

X. RESULTS OF DATA ANALYSIS AND DISCUSSION

10.1 From Survey

Relative Importance index(RII) is calculated for each factor and average RII of each factor group. From the analysis, we can observe that among 8 groups of factors that give high impact on labour productivity of AAC blockwork are: Tools and accessories factors, Labour factors, Management Factors & Equipment Factors. While other groups of factors give moderate to slight affect.
The calculated RII results shown in ***Table 2*** below for all 40 factors.

1. **Material factor group:** Among all the factors "unavailability of required material" was ranked first in this material factor group and ranked 6th in overall list of factors. Which indicates that it is one of the factor which affects the labour productivity significantly. Justified because as availability of material is the necessary to proceed the construction work thus unavailability of material will critically impact the productivity or sometime lead to complete stoppage of the work. Other factors in this group are lying in low to moderate impact category.

2. **Equipment factor group:** "Non availability of vertical shifting equipment" was ranked 5th in overall list of factors indicating that it is one of the critical factor affecting labour productivity of blockwork. This result is justified as the construction depends heavily on equipment's these days. Being critical in AAC blockwork activity is again justified because of the quantity requirement of material on daily basis and it's not feasible for labour to handle and shift such huge quantity of blocks and mortar to upper floors manually. Thus, non-availability or any interruption in the use of the equipment leads to serious material-handling problems as well as a slowdown or a stoppage of operations.

3. **Tools & Accessories factors group**: "Unavailability of required tools" and "No proper or safe scaffolding arrangement at site" was ranked first in this group with both having same RII value and these factors were ranked 9th among all 40 factors. Indicating that both the factors are critical. Result is justified because in the activity of blockwork tools required are small and simple yet necessary for the activity to proceed. Also, Scaffolding is an essential component of most masonry activity, as after a certain height labour require a safe and stable working platform to proceed further. Working on unstable or unsafe platform can have various hazards and risks as activity involves repeated Lifting and carrying heavy loads, frequent bending or twisting, and heavy physical work.

Providing safe and steady scaffolding arrangement prevent excess physical exertion of labour and can improve productivity significantly.

4. **Labour factors group:** "Inefficient crew composition" is ranked first in the group as well as in the entire list of identified factor, making it the most critical factor which affects the productivity of labour in blockwork activity. In AAC blockwork major value added work has been done by skilled worker, the whole activity of blockwork depends upon the efficiency of mason and mason require certain helpers for necessary contributory activities. There is requirement for both skilled and unskilled for their defined typology of work and in defined proportion to achieve required output. Any inefficiency in the composition of crew will drastically impact productivity of activity. "Inexperience or unskilled worker" is ranked 3th rank in overall list. Implying that Lack of labour experience and skill has a great influence on productivity of AAC blockwork.

5. **Site Factors:** Most of the factors in this group lies moderate to slight impact category. Most significant factor in this group is "No space to keep enough material near work location" which ranked 14th on overall list. The space constraint for material near work location impacts the labour productivity because of the reason that labour is required to move to and fro from their work locations require extra time to shift required materials from inappropriate storage locations, thus resulting in productivity loss.

6. **Design Factors:** "Design complexity" from this group of factors is having significant impact on productivity securing 2nd rank among all factors, indicating that is one of the most critical factors which affects the labour productivity of blockwork, because of the reason that to understand drawing and specification requirements of complex design consequently reduce productivity as it requires more measurement steps (which has high potential for error), and more measuring and cutting of block. Another factor from this group which is critical is "excessive cutting of blocks" securing 9th rank in overall list, this result is justified because with regards to productivity, excessive block cutting would affect crew performance due to mistakes in cutting which increases waste of material and lead to rework as well.

7. **Management Factors:** "No proper supervision" is one of the critical factor in this group ranked 3rd in overall list, this result justified as work inspection by the supervisor is an essential process thus not having proper supervision will impact productivity significantly. According to various past studies good supervision was found to be the most significant motivator which results into improved productivity of labour. "Poor management of working space" and "unclear or inadequate instruction to workers" both having same RII value and on 7th rank among other 40 factors affecting productivity. Indicating that both the factors are critical. To avoid productivity losses due to unclear or inadequate instruction it is necessary to keep a close eye on labour daily work to make sure that they understand instructions and the work is proceeding in the required way to avoid any rework and loss of time of labour. If the workers space is managed poorly, then probability of interference and obstructions rises and productivity will be reduced significantly. "No daily target" provided to labour having 12th rank among 40 other factors indicating that it has a very high impact on productivity. Targets should be provided to labour on daily basis, they need to be achievable with a little extra effort, but never unachievable. With an impossible target, studies have shown that people give up trying and eventually it will impact significantly on overall output. Other factors from this group are having moderate to slight impact on productivity.

8. **Other factors:** Most of the factors in this group are having slight to not much impact on productivity of labour except the "unproductive movement of labor" which is on 14th rank and justified because unnecessary movement of people within a process reduce the productivity value significantly. As motion consumes time and no addition of value to work takes place.

Table 2- Overall ranking of the factors negatively affecting the labour productivity

GROUP	S. NO.	FACTORS	RII	RANK
MATERIAL FACTORS	1	Large size and weight of blocks	0.547	40
	2	Chemical Adhesive in place of Mortar mix for block bonding	0.612	36
	3	Poor Quality of material	0.671	22
	4	Unavailability of required material	0.776	6
	5	Poor handling of material	0.724	16
EQUPMENT FACTORS	6	Non availability of vertical shifting equipment	0.800	5
	7	Non availability of horizontal shifting equipment	0.606	37
TOOLS & ACCESSORIES FACTORS	8	Unavailability of required tools	0.765	9
	9	No proper or safe scaffolding arrangement for block work at heights	0.765	9
	10	Manual Cutting of blocks	0.688	20
LABOUR FACTORS	11	Inefficient crew composition	0.859	1
	12	Inexperienced or unskilled worker	0.806	3
	13	Language barrier between supervisor and workers	0.629	34
	14	Worker physical strength	0.671	22
	15	Working hours	0.659	26
SITE FACTORS	16	Site congestion and obstructions	0.682	21
	17	Large distance between material storage and work location	0.700	18
	18	No space to keep enough material near work location	0.729	14
	19	Poor or unsafe access at site	0.671	22
DESIGN FACTORS	20	Design Complexity	0.824	2
	21	Large wall height	0.647	32
	22	Too many Openings	0.606	37
	23	Quality of masonry required	0.712	17

	24	Excessive cutting of blocks	0.765	9
	25	Construction method employed	0.624	35
MANAGEMENT FACTORS	26	Poor management of working space	0.771	7
	27	Inefficient production planning & control	0.694	19
	28	Improper sequencing of tasks	0.735	13
	29	No or inadequate training provided at site	0.653	30
	30	Unclear or inadequate instructions to workers	0.771	7
	31	No proper Supervision	0.806	3
	32	No daily Target provided to labour	0.741	12
	33	Poor communication between workers	0.659	26
	34	Unavailability of safety measures	0.641	33
OTHER FACTORS	35	Rework	0.671	22
	36	Waiting or idle time	0.659	26
	37	Unproductive Movement of labour	0.729	14
	38	Extreme temperature	0.606	37
	39	Rains	0.653	30
	40	Strong winds	0.659	26

10.1.1 Reliability analysis

Cronbach alpha method was used for reliability analysis. The value to Cronbach's alpha is calculated applying ……(Equation 2 is 0.94 which indicates that the internal consistency of the data is excellent. A high level for alpha indicates that the items in the test were highly correlated.

10.2 From Case Study

Data collected for every operation involved during execution of AAC blockwork activity on site. The labour crew composition consists of 1 mason and 2 labour. Work location was at ground floor internal wall. After recoding the "observed time" at site time study calculation procedure followed to get the standard time as follows:

Observed time: The time measured from the stop watch is known as observed time.

Normal Time: Normal time is the time that a worker takes when working at normal pace. It is calculated as below:

$$\text{Normal Time} = \frac{Observed\ Time\ x\ Observed\ rating}{Standard\ Rating(100)}$$

Standard Time: The standard time is the sum of Normal time and allowances. Thus it is calculated as below:

$$\text{Standard Time} = Normal\ Time + Allowances$$

Allowances: A worker requires time for relaxation, fatigues, personal time, breaks etc. So some extra time is added to the normal time. The extra time is known as allowance.

Rating: It is a measure of efficiency to the worker being observed. The rating factor is used to convert observed time into normal time. There is predefined scale for rating in which provides 0-100 standard rating scale.

Table 3- Standard Time

S.No.	Operation	Normal Time	Allowances		Standard time
			Personal(5%)	Fatigue (4%)	
1	Material handling	01:03:32	00:03:11	00:02:32	01:09:15
2	Layout Work	00:02:20	00:00:07	00:00:06	00:02:33
3	Block Laying	00:51:37	00:02:35	00:02:04	00:56:16
4	RCC Work	01:16:00	00:03:48	00:03:02	01:22:50

After Calculating Standard time from the observed time for executing the block wall.

Process performance analysis was performed calculating the processing time, resource capacity, Process capacity, Bottle neck, Flow rate, labour utilization, cycle time, Idle time, labour content and average labour utilization.

Process performance analysis results showed that:

- On Average only 66% of Labour Utilization happening at site. In which Mason is getting 100% utilized, Labour 1 is getting 60% utilized and Labour 2 is getting only 45% utilized at site.
- Among all the operations only 37% operations are generating value in activity. All other are non-value added but necessary to for the task.
- Result demonstrated that Mason's operations are the bottleneck which is having longest processing time and determines the process capacity.
- 46.4 % of total labour content is the idle time.

After identifying the reasons for the inefficiencies in labour utilization and productivity at that site. We have identified both positive impacting and negative impacting factors on labour productivity of blockwork at the site. Which are listed below:

Factors which were negatively affecting labour productivity are:

- Inefficient crew composition
- Inexperienced or unskilled worker

- Unavailability of required material
- Poor management of working space
- Unavailability of required tool
- Unproductive Movement of labour
- Poor handling of material
- Large distance between material storage & work location
- Inefficient production planning & control
- Manual Cutting of block
- Worker physical strength
- Waiting or idle time
- Rains
- Extreme temperature

Factors which were positively affecting labour productivity are:

- Availability of vertical shifting equipment
- Daily Target provided to labour
- Availability of horizontal shifting equipment

Out of 14 observed and identified reasons of negative impacting factors in project of Boys, School, Timar Pur, Delhi.
Comparing against the results of ranking and impact identified through survey analysis: 6 of them lie in critical to high impact on productivity, 4 of them have moderate impact on productivity and 1 of them lies in slight impact category and other 2 in not much impact category. And out of 3 observed and identified reasons of positive impacting factors in project comparing against the results of ranking and impact identified through survey analysis: 2 of them lie in critical to high impact on productivity and 1 of them have not much impact on productivity

Therefore, we can conclude that out of total 17 factors: 8 are those factor which we identified as the critical ones which affects the productivity negatively. Hence concluded that these factors have to be kept in mind while execution for the improved productivity in every project.

XI. CONCLUSION

The primary objective of this research was to identify, rank, assess the factors which affect labour productivity in the construction projects in Delhi/NCR area. The study of labour productivity carried out for the AAC blockwork because of its significance in building construction. Identification of factors that influence construction productivity of blockwork was done with the help of work study method. Forty factors were identified and considered for the study, which are categorized in 8 groups as Material, Equipment, Tools & accessories, Labour, Site, Design, Management, and others factors. The prioritization of the factors is done to determine the most critical factors affecting labour productivity which will enable the project team to improve the onsite labour management. Top ten factors influencing labour productivity of blockwork in construction projects are Inefficient crew composition, Design Complexity, Inexperienced or unskilled worker, no proper Supervision, Non availability of vertical shifting equipment, Unavailability of required material, Poor management of working space, Unclear or inadequate instructions to workers, Unavailability of required tool and No proper or safe scaffolding arrangement. This acquired result is validated with the help of live construction project, in which the factors affecting the labour productivity there are identified and listed down to compare against the list of critical factors analyzed through survey questionnaire responses. And observed that majority of factors critically affecting the productivity of labour at that site are from the identified list of critical factors concluded in the study. Hence conclusion of the study is that these critical factors have to be kept in mind while execution to achieve the optimal, more efficient and improved productivity in future projects.

XII. RECOMMENDATIONS

It is important aspect of management to assign or recruit the right people to do the job. To be productive in construction project the requirement of skilled labour is necessary. But the appropriate ratio of pairing the skilled to unskilled laborers for blockwork activity should be carefully planned by ensuring that both the mental and manual effort have been taken into account. Also it should keep a close eye on labour work to make sure that they understand instruction. Supervision is the important virtue of getting the work done in the proper speed, in the required quality and safely. It is also recommended that management team should keep an eye on the material supply schedule and its management as well to avoid any kind of delays. More attention towards the quality of construction materials and tools used in the projects proven to have positive effect on the quality of work which consequently improves labour productivity. At last but not least A quality jobsite which includes a defined and ample-sized area for materials and supplies, undisturbed and ample space for the mason to work and having easy access to the masonry supplies.

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