Analysis of Critical Factors Affecting Labor Productivity of Construction Projects in Himachal Pradesh

Kaushal Kumar and Rishi Rana

Abstract The construction industry in India with Gross Domestic Product share of 8–10% is the second largest contributor in previous decade and it employs a large population. Construction is a labor-intensive industry. Decreasing construction productivity is a major concern faced by this industry. The loopholes in labor productivity sprang from various factors that are behind the labor inefficiency to complete the work at the desired rate. These factors are reviewed from different studies already conducted in the past to find the inefficacy of a project. In the present study, five construction sites of Himachal Pradesh, India have been taken into consideration. Firstly, the productivity of a construction site was checked using work sampling method which conforms to our assumption of decreased productivity. In the second phase, a questionnaire has been prepared where important attributes of labor productivity were stressed to find the significant factors affecting construction labor productivity. The methodology used was, (a) problem identification in labor's inefficiency, (b) getting questionnaire responses related to factors affecting labor's productivity from each site, and analysis of the data using Relative Important Index to get significant/critical factors. From this study, it was found that Rework, Efficiency of labor, Materials Availability, working without holidays, and safety having RII values as 0.88, 0.76, 0.52, 0.40, and 0.16 respectively were the important factors that are affecting the construction labor productivity in Himachal Pradesh. The results obtained from this study suggest that the management team needs to focus on more clarity of the task to be performed as improper supervision at the sites leads to an increase in the workload by redoing the same work again.

Keywords Construction · Labor productivity · Questionnaire · Work sampling · Relative important index

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1 Introduction

The construction industry is a labor-intensive industry, and in India, it provides employment to a large population. The contribution of construction industry plays a vital role in GDP growth of the country, and it is the second largest contributor of GDP (8–10%) [1]. Construction is one of the most challenging and mammoth industries. After having best labor, best equipment, and even high technology, the final productivity when evaluated comes out to be very low. So what would be the matter that even after having "the best" of everything hinders the way of 100% productivity and efficiency? The answer behind this difficult question is very simple and that is "labor productivity". The role of labor is a crucial factor to work upon for eradicating the inefficiency of the construction industry in our country. The reasons behind why we need to focus on labor to boost our construction industry are (a) The contribution of the labor industry to our national growth and per capita growth is large. (b) Moreover, construction industry is contributing to a large extent towards providing employment to skilled and unskilled people. (c) Modern slavery is also one of the stigmas attached to the construction industry. By keeping all these factors in mind there seems to be an urgent need to look upon those factors in construction industry that are very sensitive towards overhauling the industry. By considering different factors like time, cost, workability, quality assurance at site, type of material to work with, it can be said that labor is the pioneering and the driving force which is responsible for handling or taking care of the above written factors [2–7]. Several factors contribute towards the efficient working of the labor under any contractor. These factors include economic factors, psychological factors, socio-cultural factors, and many more, and these factors are the main reasons behind the lag of labor efficiency [5].

In this paper, different factors were reviewed from various studies, their veracity in different situations, and delay of the project. Methods to find the factors or delay or productivity have been analyzed and a questionnaire was prepared and has been validated with the experts. Since there are a lot of factors for labor inefficiency, so the weightage of these factors and their ranking is also an important aspect to find out which factor is the most sensitive one. Different methods and tools are required to simulate the mammoth data to scrutinize it to the final fruitful conclusion. Various trends that could be followed in the industry like working in the shifts, use of Information and Technology in the construction field, making a database of all the projects are some of the new initiatives that can bring a boost to this industry [2, 5].

1.1 Need of Labor Productivity Study for Construction Project in Himachal Pradesh

To understand the status of an ongoing project, an ongoing project site data (construction of a residential building in Palampur, Himachal Pradesh) has been made to enter

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish	Total Float
assignment building estimate wbs		121	121	0%	03-May-17	02-Sep-17	0
SUBSTRUCTURE		19	19	0%	03-May-17	22-May-17	0
Foundation work		19	19	0%	03-May-17	22-May-17	0
A	Excavation	7	7	0%	03-May-17	09-May-17	0
C	first class brickwork	6	6	0%	16-May-17	22-May-17	0
B	Lime concerete	6	6	0%	10-May-17	15-May-17	0
D	reinforcement	4	4	0%	16-May-17	20-May-17	2
SUPERSTRUCTURE		102	102	0%	23-May-17	02-Sep-17	0
Concrete work		62	62	0%	23-May-17	24-Jul-17	0
F	brickwork	32	32	0%	29-May-17	29-Jun-17	0
E	DPC	5	5	0%	23-May-17	28-May-17	0
G	Plastering	25	25	0%	29-Jun-17	24-Jul-17	0
Steel work		15	15	0%	29-May-17	12-Jun-17	17
I	MS work	6	6	0%	29-May-17	03-Jun-17	26
H	RCC work	15	15	0%	29-May-17	12-Jun-17	17
Finishes		40	40	0%	25-Jul-17	02-Sep-17	0
M	Floor finish	20	20	0%	14-Aug-17	02-Sep-17	0
J	panels and hold fastings	7	7	0%	25-Jul-17	31-Jul-17	0
K	pipe fittings	5	5	0%	25-Jul-17	29-Jul-17	2
L	white washing	13	13	0%	01-Aug-17	13-Aug-17	0

Fig. 1 Analytical tool (Primavera Contractor) worksheet

in the analytical tool, **Primavera Contractor**. By analyzing and comparing the data for the project completion as shown in Fig. 1, a difference of 59 days had been found as that of the original time taken by the laborers on site was 180 days and with an analytical tool, it was 121 days. This was done to have an idea about the delay in terms of time.

1.2 Labor Productivity in Construction Project

Productivity can be defined as the output of any industrial process. It gives the rate at which a company produces goods and services with buffer available. But technically productivity can be given as the "ratio of the quantity of Output to the quantity of inputs" as given by Eq. 1.

$$\text{Productivity} = \text{quantity of output}/\text{quantity of input} \tag{1}$$

where Output is in terms of installed quantities at the end of the project; Input is in terms of labor hour. Productivity is basically labor intensive. It is measured as the labor hours per unit of the work. The significance of productivity lies in the fact that it measures the industrial trend, helps in comparing performance, and to see the effect on scheduling of different activities in a project.

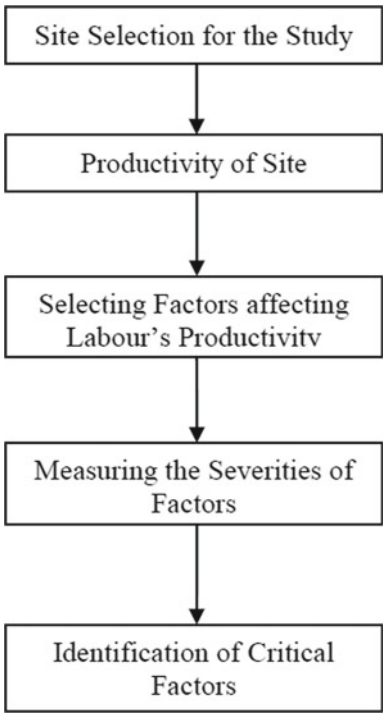

Fig. 2 Flowchart of the methodology followed for the study

2 Methodology

For finding the significant factors associated with labor productivity of construction projects in hilly terrain of HP, the methodology adopted has been shown in the flow chart, Fig. 2.

3 Site Selection

To study the overall trend of attributes affecting labor productivity pertaining to the locations in HP, five sites were chosen. The sites were chosen on the basis of the demography of the location, i.e., in these areas construction activities employ a lot of skilled and unskilled laborers and sites have been taken into consideration as these sites were having active projects and reliable data (like work schedule, progress report, etc.) were available. Following are the five sites taken into consideration in our study:

1. Construction of a Residential building in Palampur, district Kangra (Site 1)
2. Roadside construction building in district Kangra (Site 2)
3. Riverside construction of Building, Rajgardh, district Sirmour (Site 3)

4. Residential building in plain region of Kasauli, district Solan (Site 4)
5. Building construction in Urban area of Solan, district Solan (Site 5).

4 Factors Affecting the Labor Productivity in Himachal Pradesh

To find the factors affecting labor productivity, a questionnaire was devised by reviewing literature and then was updated according to the study objective to get the responses [8]. Factors of the questionnaire were cross-checked by experts from the field of construction management. After which a list of important factors affecting labor productivity in Himachal Pradesh was prepared and the questionnaire was sent to different sites to get the responses to find the most critical ones. List of the factors are as follows:

1	Environmental factors	9	Frequent revision of drawing (rework)
2	Material availability	10	Lack of locally available labor
3	Safety	11	Financially weakness of a contractor
4	Quality	12	Scanty financial policies of the government
5	Manpower	13	Waging seven days without holidays
6	Time available	14	Availability of equipment/tools
7	Motivational leadership	15	Miscommunication b/w contractor and labor
8	Strikes caused by political parties	16	Unskilled labors

5 Work Sampling Method [7]

Work sampling technique determines the percentage of occurrence of certain activity by statistical sampling and random observation. The percentage of observations so calculated for specific work or delay is the measure of percentage of time during which that works or delay occurs because of the workers.

To make it happen, the following approach is to be adopted:

1. Categorize the worker's activities as productive, semi productive, and nonproductive.
2. Take the random observations of workers at the site who are involved in a given operation in a field (random means choosing without any bias as to who is being observed).
3. Jolt down all observations so formed. Enter the checkmark under the appropriate mode.
4. Add up all the checkmarks and calculate the quantity as percentage.

Table 1 Productivity of site 1

S. No.	Productive (direct work)	Semi productive (support work)	Nonproductive (delay)
1	*		
2	*		
3			*
4		*	
5		*	
6		*	
7	*		
8	*		
9			*
10	*		
Total	**5**	**3**	**2**
Productivity	**50%**	**30%**	**20%**

The work sampling procedure is being applied at all the sites to check the productivity at each site. Site-1, i.e., Construction of a Residential building in Palampur, district Kangra, productivity data of site is being analyzed and given in Table 1, subsequently, all sites are being evaluated for the productivity and have been shown in Fig. 3.

Table 1, and Fig. 3, amount to the fact that with the operation of work sampling tool that each of the sites is lacking complete productivity. The productivity of each site is coming out to be 50%, 40%, 70%, 30%, and 40% for site 1, site 2, site 3, site 4, and site 5, respectively. This infers to the fact that at all the sites; there was a need to study the reasons responsible for a decline in productivity and how the labor's factors affecting construction productivity.

As we have seen that the productivity of construction sites is not optimum, there could be many reasons associated with it, but we will be focusing on the human factor

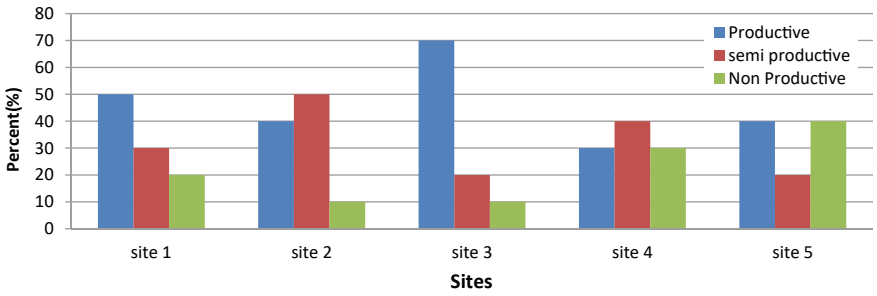

Fig. 3 Histogram of productivity of different sites in percentage

associated with declined productivity at construction sites. To evaluate the human factor, i.e., the construction labor productivity, we will be applying the questionnaire technique and looks for the factors responsible for the decline in labor productivity.

6 Questionnaire Survey

The work sampling method described above gives efficiencies at the site but was unable to identify the major cause for the efficiency. On-site surveying and questionnaire surveys were used for the site evaluation and were used to increase the efficiency at site. For evaluating the present scenario of the site, probable queries of the questionnaire were prepared from the many studies and were reviewed carefully. The questionnaire was evaluated by experts in the field of construction management and planning. After this, a final questionnaire was prepared to be circulated for the responses from each site. To effectuate the suitable objective the data for the work were collected through both online and offline modes. With the well-planned questionnaire survey and on-site data collection have been carried out a total of 87 valid responses (site 1–20; site 2–18; site 3–22, site 4–15, and site 5–12) from engineers and workers at respective sites were obtained. Validity of the data was being done using "**Test-retest Method**", i.e., a similar set of respondents were asked to fill the same questionnaire again after a duration of 1 month, and responses were cross-checked with the previous responses. Responses received from the 2nd questionnaire were same as that of the previous one implying the data received were reliable.

To achieve the objectives of this study, work was being divided into two stages. First stage is to prepare the questionnaire and distribute it to the respondent and the second stage was to evaluate the data using the relative importance index (RII). First stage was completed by fixating each factor and problems associated with it which are hindering construction labor productivity. In this study, we have fixated 16 questions for getting the major factors affecting on-field productivity. These factors have been zero-downed by taking into account vast studies on construction labor productivity. The statistical tests have been applied to the data collected from questionnaire survey: RII (relative importance index) for each factor has been calculated to highlight the total score responses received for each attribute. To be consistent with the preview of this study, the responses collected from all the sites were analyzed with the RII and find the ranking of the crucial factors to get the desire objectives. The RII method is explained below, and it will be used to find the ranking of the critical factors at each site.

Relative Important Index:

$$\mathrm{RII} = \Sigma \mathrm{W}/(\mathrm{A} * \mathrm{N}) \tag{2}$$

where W is the sum of score of all the weightage of each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e., 5 in this case), N is the total number of respondents.

Higher the value of RII, more important was the cause of delays. Ranking of the factors affecting labor productivity has been computed from site 1 and shown in Table 2.

From Table 4, the rankings for the factor affecting labor productivity have been evaluated based on the RII value. It was found out that the critical factors affecting labor productivity at site one were reworked, efficiency of labor, materials availability, safety, and Inefficient labor supervision having their respective RII as 0.85, 0.72, 0.7, 0.68, and 0.65 were critical factors.

The critical factors at all the sites by finding the RII of all the factors at all the five sites have been computed to find the critical factors at all the sites and have been shown in Table 3.

Table 2 Relative importance index and rankings of the factors for site 1

S. No.	Factors	Total score (W)	Max. weightage (A)	Total No. of respondents (N)	RII	Rank
1	Environmental	50	5	20	0.5	9
2	Material availability	70	5	20	0.7	3
3	Safety	68	5	20	0.68	4
4	Quality	58	5	20	0.58	8
5	Labor supervision	65	5	20	0.65	5
6	Time availability	64	5	20	0.64	6
7	Motivational leadership	40	5	20	0.4	13
8	Political strikes	44	5	20	0.44	12
9	Rework	85	5	20	0.85	1
10	Lack of locally available labor	32	5	20	0.32	15
11	Financial weakness of contractor	62	5	20	0.62	7
12	Inadequate financial policies of government	35	5	20	0.35	14
13	Working without holidays	50	5	20	0.5	9
14	Availability of tools	48	5	20	0.48	11
15	Miscommunication B/T contractor and labor	21	5	20	0.21	16
16	Efficiency of labor	72	5	20	0.72	2

Table 3 Relative important index for all the factors at every site

S. No.	Factors	Site 1	Site 2	Site 3	Site 4	Site 5
1	Environmental	0.50	0.5556	0.4545	0.67	0.4167
2	Material availability	0.70	0.7778	0.8000	0.77	0.5000
3	Safety	0.68	0.7556	0.6182	0.59	0.3333
4	Quality	0.58	0.6444	0.5273	0.67	0.2667
5	Labor supervision	0.65	0.7222	0.5909	0.27	0.3333
6	Time availability	0.64	0.7111	0.5818	0.35	0.6167
7	Motivational leadership	0.40	0.4444	0.3636	0.53	0.4333
8	Political strikes	0.44	0.7444	0.4000	0.59	0.2333
9	Rework	0.85	0.9444	0.6455	0.93	0.8833
10	Lack of locally available labor	0.32	0.3556	0.2909	0.43	0.3500
11	Financial weakness of contractor	0.66	0.7444	0.6545	0.76	0.6833
12	Inadequate financial policies of govt	0.35	0.3889	0.3182	0.47	0.4333
13	Working without holidays	0.50	0.5556	0.7727	0.84	0.7333
14	Availability of tools	0.48	0.5333	0.4364	0.64	0.3000
15	Miscommunication B/T contractor and labor	0.21	0.2333	0.1909	0.28	0.4333
16	Efficiency of labor	0.72	0.8000	0.6545	0.87	0.8333

Table 4 Critical factors of the different sites

Site/Factors	Site 1	Site 3	Site 3	Site 4	Site 5
Factor 1	Rework	Rework	Material availability	Rework	Rework
Factor 2	Efficiency of labor	Efficiency of labor	Working without holidays	Efficiency of the labor	Efficiency of labor
Factor 3	Material availability	Material availability	Efficiency of the labor	Work without holiday	Working without holiday
Factor 4	Safety	Safety	Rework	Material availability	Financial weakness of contractor
Factor 5	Labor supervision	Political strikes	Financial weakness of contractor	Financial weakness of the contractor	Time availability

In Table 3, RII values of all the factors for all the sites have been evaluated. Ranking of all the factors has for all sites has been calculated and crucial factors responsible for the decline of labor's productivity have been assembled in Table 4.

For finding the significant factors responsible for reduced labor productivity in construction projects in HP, the top five contributors for each site have been identified

Table 5 Ranking of the critical factors taken from different sites

S. No.	Factors	Site 1	Site 2	Site 3	Site 4	Site 5	Avg. RII
1	Environmental	0.5000	0.5556	0.4545	0.6667	0.4167	**0.5187**
2	Material availability	0.7000	0.7778	0.8000	0.7733	0.5000	**0.7102**
3	Safety	0.6800	0.7556	0.6582	0.5867	0.6167	**0.6594**
4	Quality	0.5800	0.6444	0.5273	0.6667	0.2667	**0.5370**
5	Time availability	0.6400	0.7111	0.5818	0.5467	0.6167	**0.6193**
6	Rework	0.8500	0.9444	0.6455	0.9333	0.8833	**0.8513**
7	Financial weakness of contractor	0.6600	0.7444	0.6545	0.7600	0.6833	**0.7004**
8	Working without holidays	0.6200	0.5556	0.7727	0.8400	0.7333	**0.7043**
9	Efficiency of labor	0.7200	0.8000	0.6545	0.8667	0.8333	**0.7749**

as tabulated in Table 4. In the next step, all the factors from different sites have been tabulated in Table 5 and their respective relative importance is being calculated to find the most critical factors. The RII of the important factors as an average of all the RIIs from each site has been calculated. The avg. RII values of significant factors are given in Table 5.

From different sites, significant factors were selected based on their RII values, and for the considering factors related to Himachal Pradesh, Avg. RII values have been calculated to evaluate critical factors. Higher the value of RII, higher will be its impact on labor productivity. Rework, Efficiency of labor, and Materials availability are significant factors with RII 0.8513, 0.7749, and 0.7102 respectively.

7 Conclusions

The findings of the above studies are as follows:

- Higher values of RII imply that the factor is having higher impact on Labor productivity. The RII value of factors equal to 0.7 or above is considered critical [1]. Table 6 below shows all the critical factors along with their RII values and Ranks.
- The overall productivity of each site has been calculated from the work sampling method were 50% for site 1; 40% for site 2; 70% for site 3; 30% for site 4; and 40% for site 5. This indicates that each project which was studied is having very little productivity.
- Prior knowledge of labor productivity factors during the execution of the construction project can save money and will also improve project completion time.

Table 6 Critical factors affecting construction labor productivity in Himachal Pradesh

S. No.	Critical factors	Avg. RII	Rank
1	Rework	0.8513	1
2	Efficiency of labor	0.7749	2
3	Material availability	0.7102	3
4	Working without holidays	0.7043	4
5	Financial weakness of contractor	0.7004	5

- The results obtained were region specific as well as planning specific. For example, the productivity of site 3 (30%) is having the least productivity. Apart from labor productivity issues, technical issues may also be responsible for low productivity.

8 Limitations

- The total number of respondents at each site was not large, which increases the margin of error.
- Apart from construction laborers, other personals from construction industry like contractors, supervisors, etc. should also have been taken into consideration for the study.
- Other industry laborers like road and highways, hydraulic structures, etc. construction workers should also be taken into consideration for finding critical factors of overall construction industry labor.

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