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PRACTICAL SOLUTIONS FOR IMPROVEMENT IN LABOR PRODUCTIVITY

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***Abstract* – Now a day's construction labour productivity plays very important role in all projects. Labour productivity effects on contractor, sub-contractor and owner also. There are number of factors affecting labour productivity on any construction sites. So in this project we have suggested number of practical solutions to increase labour productivity. Questionnaires survey was conducted for top ranked important factors which are affecting labour productivity and expert's solutions were collected from the survey to improve labour productivity on site. First of all, on site labour productivity is calculated; at the same time factors affecting labour productivity are identified. We found some practical solutions and these were implemented on site to improve labour productivity. After implementation of solutions, it was observed that, labour productivity is increased. Then we carried out comparative study of before and after labour productivity.**

Keywords - Labor Productivity(L.P), Relative Important Index(RII), Practical Solutions.

I. INTRODUCTION

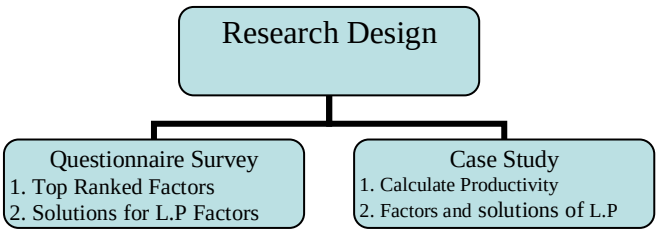
Construction industry is the world's largest and most challenging industry among all others. Today human resource has a strategic role to increase labour productivity in any organization and hence human resource plays superior role in industrial competition. Construction labour productivity is having critical importance, as it directly affects the competitiveness and profitability of construction companies. In India, there are many challenges faced by construction industries, but one of the most important is low labour productivity. Construction costs are constantly on the rise, as duration for completion of the project is substantially increasing and most projects are significantly overrunning considering their budgets. Higher productivity levels allow contractors to improve competitiveness, simultaneously increased profitability, so they pay higher wages to workers to complete activities in time. Economists defined the labour productivity as the ratio of total product output to total labour input or simply the ratio of output to input.[3] Construction is a labour-intensive industry and labour related costs in most countries often account for 30–60% of the total costs of a construction project.[4] The current traditional practice of estimating and scheduling relies on several sources to predict the productivity rates, which would include an estimator's personal judgment, published productivity data, and historical project data. The construction industry has progress last few decades through advances in heavy equipment, tools and materials. Nevertheless, labour productivity still needs improvements. Non-value-added activities spend 50–75% of the productive time on construction site.[5] Therefore maintaining and improving labour productivity is a key to making a construction project successful. The researchers have studied and analyzed construction tool time, labour productivity on construction sites and have investigated the real composition of the total time spent by construction labours on different activities. The general observation was that the real direct tool time was only 40–60% of the total time of activities.[13] In this study we analyzed factors affecting labour productivity and practical solutions were implemented on construction sites.

Productivity Formula:-Productivity is generally the ratio of the output to input. [10,11,12]

1. Productivity = Output ÷ Input
2. Labor Productivity (In terms of Cost) = {Output quantity cost ÷ Labor time cost}
3. Labor Productivity (In terms of Time) = {Output work ÷ Work hour}

II. RESEARCH DESIGN

Questionnaire survey was conducted for top ranked factors which are affecting labour productivity and practical solutions were collected. We calculated labor productivity in terms of time and cost on selected two construction sites for formwork, reinforcement work and concrete work activities. Factors were identified affecting labour productivity. Then practical solutions are found out to increase labour productivity. These solutions were implemented on sites for improvement in labour productivity. After implementation of solutions, again productivity is calculated to find out increase in the productivity. The detail of work was given below.



A. Data collection

Two construction sites were selected to calculate daily labour productivity. Fifty factors were collected from literature survey to prepare questionnaires survey.[1,2,7,9] These questionnaires were distributed to contractors, engineers and sub-contractors and responses were collected to improve labour productivity.

B. Questionnaire survey

Questionnaire survey was preferred as the best effective and suitable data-collection technique for the study. Questionnaires were collected by personally from

respondents in Sangli district (Maharashtra, India). First, pilot survey was conducted by 8 experts and then questionnaire were collected by 50 engineers, contractors and construction companies. By using Relative Important Index (RII) method [8] top 25 factors were selected (Table No.1) from the data collected by Questionnaire survey. In questionnaire, respondents suggested number of solutions for improvement in labour productivity. (Table No.2)

- Ranges:- 1 – Does not affect it, 2 – Somewhat affect it, 3 – Directly affect it.
- Relative Important index (RII) = [Sum weights] / [Total No. of Respondents* Highest Range (3)]
- Sum Weights ranges [1 – Does not affect it, 2 – Somewhat affect it, 3 – Directly affect it]
  * Number of respondents for each Factor

TABLE NO.1 RELATIVE IMPORTANCE INDICES AND RANKS OF ALL PRODUCTIVITY FACTORS

Sr. No.	Factors	Relative Importance Index (RII)	Rank
1	Morality (alcohol influence)	0.94	**1**
2	Availability of materials	0.92	**2**
3	Rain	0.89	**3**
4	Work planning and scheduling	0.86	**4**
5	Availability of workforce	0.86	**5**
6	Economic conditions	0.86	**6**
7	Payment delay	0.85	**7**
8	Safety	0.84	**8**
9	Availability of tools and machinery	0.81	**9**
10	Specification and drawings	0.81	**10**
11	The level of management control	0.77	**11**
12	Quality experience and training	0.77	**12**
13	The incompetence of site supervisor	0.76	**13**
14	Sequence of work	0.74	**14**
15	Design requirement	0.74	**15**
16	Disturbance	0.74	**16**
17	Site access	0.73	**17**
18	Inclement weather	0.73	**18**
19	The professionalism of the design team	0.72	**19**
20	Frequent changes in labours	0.72	**20**
21	Payment terms	0.70	**21**
22	Order variations	0.68	**22**
23	Subcontract	0.63	**23**
24	Overtime	0.58	**24**
25	Development and research	0.52	**25**

TABLE NO.2 QUESTIONNAIRE SURVEY – FACTORS AFFECTING LABOR PRODUCTIVITY AND SOLUTIONS

Sr. No.	Factors and Solutions	Sr. No.	Factors and Solutions
1	Payment delay 1) Weekly payment 2) Proper planning and provision 3) Payments as per schedule	2	The level of management control 1) Maintain proper communication 2) Experienced project manager 3) Arrange weekly meeting
3	Work planning and scheduling 1) Planning and scheduling should be done properly 2) Keep daily attention on bar chart of project and Re-scheduling 3) MSP, Primavera software used	4	The professionalism of the design team 1) Expert design team required 2) Better communication between site engineer and design team, Monthly meetings 3) Prepare design before execution 4) Experienced designer appointed in team
5	The incompetence of site supervisor 1) The advice was taken from senior 2) Experienced supervisor appointed 3) Training for the site supervisor	6	Availability of materials 1) Making proper scheduling of work material 2) Stock in advance 3) Material available before work starts
7	Payment terms 1) Maintaining proper payment schedule 2) As per measurement	8	Inclement weather 1) Have to consider prior base 2) Take advice from a senior engineer
9	Availability of workforce 1) Maintained as per required 2) Manpower as per schedule 3) Sufficient of labour force should be arranged 4) Resource planning necessary	10	Availability of tools and machinery 1) Should be present on site before work starts 2) Modern tools and machinery available on site and As per quantity of work requirement 3) Extra standby machinery and tools
11	Sequence of work 1) As per proper planning 2) Sequence of work should be the plan before work starts, With bar chart 3) According to schedule 4) Penalty to sub-contractor	12	Design requirement 1) Priority has to be given designer and communicate, Design in advance 2) Before site start all design required 3) Available before of work
13	Overtime 1) As per planning 2) Give them some expense to labour 3) Allow but in less extent	14	Development and research 1) Use some new techniques 2) Promote development and research department organization for the company
15	Specification and drawings 1) All Specification and drawings should be made available before the work start 2) Specification and drawings should be correct and proper 3) Drawing should be easy to read	16	Rain 1) Concrete and fabrication work care is taken and Rainy season planning 2) Provide raincoat, gumboots and plastic paper on site 3) Concreting should do before rain season 4) See forecast and after making the plan
17	Site access 1) Site layout is necessary 2) Site access should be done before starting of work 3) Proper house-keeping required 4) Site access details should be displayed on site	18	Subcontract 1) Selection of subcontractor as per rules and regulations 2) Subcontractor should be appointed to speed up the work and Proper agreement 3) Proper handled subcontract problems and solve it
19	Morality (alcohol influence) 1) Should not allow on-site 2) Taken strictly fine and action 3) Organize campaign for healthy labour production	20	Safety 1) Labour indication is necessary 2) Should provide safety equipment's 3) Safety training required for labour and Organize campaign for safety

21	Quality of experience and training 1) Before the start of work experience supervisor required 2) Quality experience and training to company staff 3) Training arranged new labours and experienced labour for new work	22	Frequent changes in labours 1) Resource planning 2) Re-scheduling the work 3) Do not change the labour force 4) To give work perfect contractor 5) Another arrangement of labour should be their
23	Disturbance (Social issue, water, light) 1) Solved by mutual understanding 2) Controlled by site engineer 3) Keep communication with all agency involved with the project	24	Economic conditions 1) Maintain proper cash flow 2) Ensure proper funding for smooth progress of work 3) Arrangement of finance and provide time to time money as per requirement to site
25	Order variations 1) The order should not be repeated and subsequent, As per plan calculate quantity before the order 2) Stock maintain and Variation should be minimized 3) Proper communication between supplier and engineer 4) Daily update of available material and material required and As per estimation		

C. Objectives of Case Study

1. Calculate labour productivity before implementation of solutions.
2. To analyze factors affecting labour productivity.
3. To develop solutions to overcome factors affecting labour productivity.
4. To implementation of solutions on sites and after calculate labour productivity.
5. To perform comparative analysis among productivity prior and after implementation of solutions.

D. Case Study

The labour productivity was calculated and factors regarding labour produtivity were analyzed on selected sites. Site details are as follows, Site1- Shri Ladage Apartment, Sangli.
Site2- Shri Om Residency Apartment, Sangli. These sites were located in Sangli city, Maharashtra, India at different locations. Construction companies for these sites are also different. Similarly, construction design, cost, labours for both the sites are different. Both sites are having Labour Contract.

We calculated actual daily labour productivity for one floor only and we analyzed which factors are affecting labour productivity. Afterwords we developed solutions for factors affecting labour productivity and then these solutions were implemented on both sites. Then we calculated labour productivity for next floor. We found that, labour productivity was increased than previous floor. This labour productivity was calculated in terms of cost and time.

E. Calculation of labour productivity before implementation of solutions on sites.

First of all we prepared a Labour Productivity Chart for formwork, reinforcement work and concrete work activities. Every day we noted down the quantity of work completed on site. Then produtivity for each day is calculated. Also we found factors affecting produtivity of labours. We calculated daily labour productivity for Skilled and unskilled labours. Labour productivity is calculated only for one-floor; before and after implementation of solutions on sites. This skilled, unskilled and daily productivity less than 1 in terms of time is less productivity and higher than 1 is high productivity.[6] The labour productivity in terms of cost is depends on labour rate and work order rate, so project to project labour productivity change.
For calculation of labor productivity, following formulae are used. The labour productivity charts making in excel sheet and set formulae's to sheet. (Table No. 3) Sites reading was putting into chart after give automatic results of labour productivity. The sum of labor productivity for all activities were calculated from start to end for one floor and these total labor productivity for activities are written in following tables and Figures. Results of table No. 4 was indicated the total labour productivity of all activities in terms of time and cost before implementation of solutions on sites. Fig. 1,2,3,4,5,6 was indicated the separate labour productivity of activities and total productivity of activity, skilled and unskilled also.

1. Productivity = Output ÷ Input
2. Labor Productivity (In terms of Cost) = Output quantity cost ÷ Labor time cost
3. Labor Productivity (In terms of Time) = Output work ÷ Work hour

TABLE NO.3 FORMAT OF LABOUR PRODUCTIVITY CHART

Date	10/23/2017 to 12/18/2017	Unit	Total Quantity	Work done				Achieved	Productvity Per Day in (Time)	BOQ Rate	Total Amount in Rs.	Productvity Per Day in (Cost)	Factors affecting Labor Productivity
	Activity			No	L	B/W	D	Qty.					
24-Oct-17	C1 to C6 columns starter and lift shuttering work	sqm	152.10					10.318	0.34	279	2,878.72	2.13	Labour force, Material availability, Non tool time
28-Oct-17	C11 to C22 columns suttering,scaffolding,lining,material shifting	sqm	125.00					19.5469	0.28	279	5,453.59	1.76	Non tool time, Work Planning and Scheduling
31-Oct-17	Deshuttering of columns and lift and material shifting	sqm	105.45					46.6539	1.17	139	6,484.89	3.71	-
1-Nov-17	staircase and 1 feet upper columns shuttering and scaffolding	sqm	58.80					18.55	0.88	279	5,175.45	5.48	Non tool time
										TOTAL	116,906.68		

Date	Activity	Unit	Labour (WORK TIME:Day Shift:9.00 A.M to 7 P.M)				Total time (in Hours)	Sikkled Labour Rate (550)	C-Productivity in Cost	Unsiklled Labour Rate (400)	H-Productivity in Cost	Total Labour Amount(Rs.)	Difference Amount
			Carpenter in Time (hrs)	C-Productivity in Time	Helper in Time(hrs)	H-Productivity in Time		Total cost Carpenter in Rs.		Total cost Helper in Rs.			
24-Oct-17	C1 to C6 columns starter and lift shutering work	sqm	9	1.1	18	0.6	30	495	5.82	720	4.00	1,350.00	1,528.72
28-Oct-17	C11 to C22 columns suttering, scaffolding, lining,material shifting	sqm	18	1.1	45	0.4	70	990	5.51	1800	3.03	3,100.00	2,353.59
31-Oct-17	Deshuttering of columns and lift and material shifting	sqm	9	5.2	27	1.7	40	495	13.10	1080	6.00	1,750.00	4,734.89
1-Nov-17	staircase and 1 feet upper columns shuttering and scaffolding	sqm	6	3.1	12	1.5	21	330	15.68	480	10.78	945.00	4,230.45
											TOTAL	20,365.00	80,301.68

TABLE NO.4 SITE1 AND SITE 2 - TOTAL FLOOR WORK LABOR PRODUCTIVITY BEFORE IMPLEMENTATION OF SOLUTIONS

	Labor Productivity	
Site No.	Labour Productivity Before Implementation of Solutions	
1	Total Labour Productivity For All Activities in terms of Time (1st Floor)	(1830.92/2651) = 0.68
1	Total Labour Productivity For All Activities in terms of Cost (1st Floor)	(5,26,883.45/1,16,610) = 5.07
2	Total Labour Productivity For All Activities in terms of Time (1st Floor)	(1020.75/2080) = 0.50
2	Total Labour Productivity For All Activities in terms of Cost (1st Floor)	(327489/94900) = 4.01

F. Site 1 and site 2 - factors affecting labour productivity and implementation of solutions

Factors affecting labour productivity are found out from the calculations. The day which is having less productivity shows there are some problems. Then problems are analyzed and solutions for these factors were implemented on site, which shows the increase in labour productivity. It means solutions applied are correct and are useful to contractors, engineers and sub-contractors.

TABLE NO.5 ON-SITES FACTORS AFFECTING LABOR PRODUCTIVITY AND SOLUTIONS

Sr. No.	Factors affecting labour productivity	Implementations of Solutions on sites
1	Non-tool time	Supervisor to control labours and Motivate to labours towards the completion of the project
2	Site access	Proper site access clear as per site layout
3	Safety	Safety tools and equipment, Insurance Provided to labours
4	Lack of Material Transportation	Formwork – Use Extra Unskilled Labors Concrete work – Use Lift Machine or RMC Pump
5	Housekeeping and cleaning	Weekly
6	Availability of Material	Maintained Stock of Material on site
7	Availability of workforce	As per Requirement Activity of work
8	Work planning and scheduling	1. Primavera P6 Software used for Planning and Scheduling, monitoring of work 2. As per Resource Planning and scheduling of work
9	Sequence of work	
10	Frequent changes in labours	
11	Communication problems between Site Management and Labor	Every day communicate between site engineer and labour contractor
12	Communication break between labour and supervisor	Every day communicate with supervisor and labours, labour contractor
13	Site Supervisor Difficulties	Daily communicate with the senior engineer and project manager
14	Quality of Supervision	One week basic training of site work was given to supervisor from Project Manager
15	Finance Management	The owner was taken the loan from national and local banks

G. Calculation of labour productivity after implementation of solutions on sites.

Implementation of solutions on sites, after labour productivity were calculated on sites. The labour productivity charts making in excel sheet and set formulae's to sheet. (Table No. 3) Sites reading was putting into chart after give automatic results of labour productivity. The sum of labor productivity for all activities were calculated from start to end for one floor and these total labor productivity for activities are written in following tables and Figures. Results of table No. 6 was indicated the total labour productivity of all activities in terms of time and cost after implementation of solutions on sites. Fig. 1,2,3,4,5,6 was indicated the separate labour productivity of activities and total productivity of activity, skilled and unskilled also.

TABLE NO.6 SITE1 AND SITE 2 - TOTAL FLOOR WORK LABOR PRODUCTIVITY AFTER IMPLEMENTATION OF SOLUTIONS

	Labor Productivity	
Site No.	**Labour Productivity Before Implementation of Solutions**	
1	Total Labour Productivity For All Activities in terms of Time (3rd Floor)	(1,909.66/1,604) = 1.25
1	Total Labour Productivity For All Activities in terms of Cost (3rd Floor)	(5,43,785.05/58,485) = 8.99
2	Total Labour Productivity For All Activities in terms of Time (2nd Floor)	(1018.36/1283) = 0.94
2	Total Labour Productivity For All Activities in terms of Cost (2nd Floor)	(342403.76/56675) = 8.31

H. Labour Work-Time Difference Amount

The "labour work-time difference amount" is the cost for work completed by labours and cost of time required to complete work. The total labour-time difference amount is calculated separately for formwork, reinforcement work and concrete work activities on Labour productivity charts before and after implementation of solutions on both the sites. (Table No.7)

TABLE NO.7 TOTAL LABOR WORK-TIME DIFFERENCE AMOUNT

Total labour-time Difference Amount Before Implementation of Solutions				
	Form work (Rs.)	***Reinforcement work (Rs.)***	***Concrete work (Rs.)***	***Total work Amount (Rs.)***
Site 1 (1st Floor)	80,301.68	96,995.74	2,21,173.85	**3,98,471.27**
Site 2 (1st Floor)	45,833.60	52,185.41	1,10,705.76	**2,08,724.77**
Total labor-time Difference Amount After Implementation of Solutions				
Site 1 (3rd Floor)	1,35,638.61	60,314.28	2,63,361.08	**4,59,313.97**
Site 2 (2nd Floor)	73,857.62	66,427.29	1,21,718.76	**2,62,003.67**

III. RESULTS AND DISCUSSION

After implementation of solutions, from calculated data for formwork, reinforcement work and concrete work on both sites it is observed that labour productivity in terms of time and cost increases. Detail comparison of labour productivity for both sites as shows in the following figures.

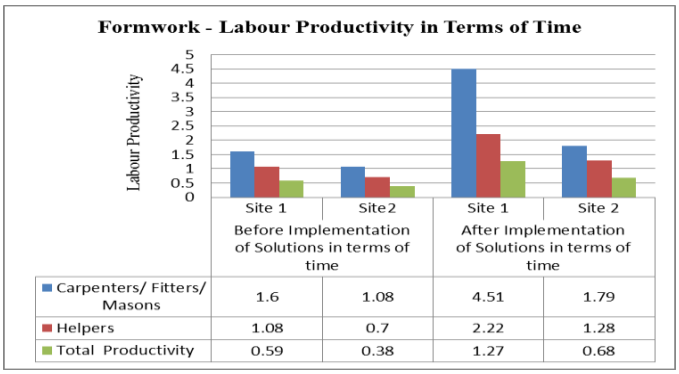


Fig.1:- Site1 and 2 - Formwork Labour Productivity before and after Implementation of Solutions in terms of Time

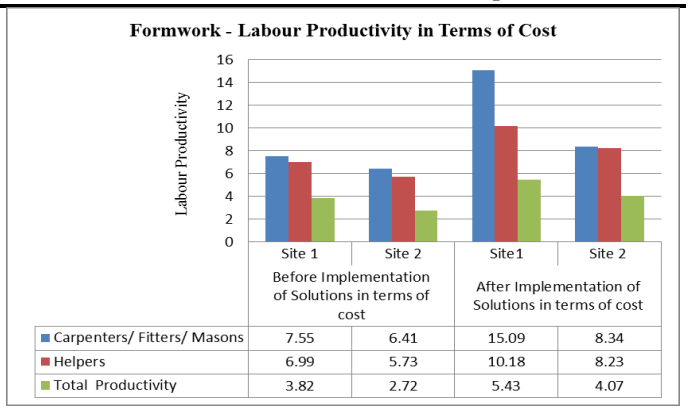


Fig.2:- Site1 and 2 - Formwork Labour Productivity before and after Implementation of Solutions in terms of Cost

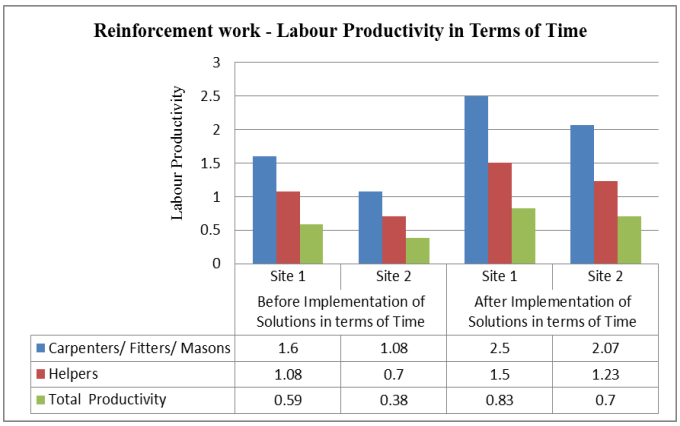


Fig.3:- Site1 and 2 – Reinforcement work Labour Productivity before and after Implementation of Solutions in terms of Time

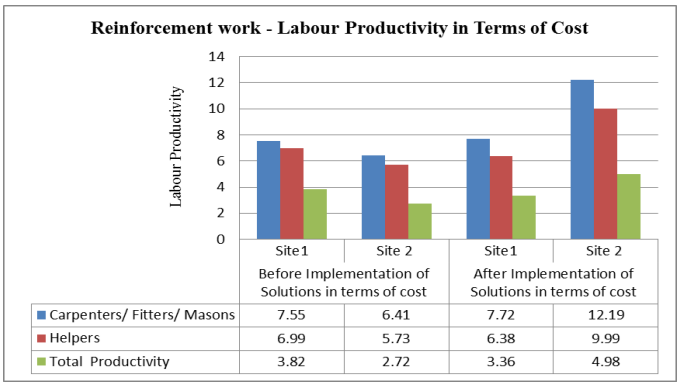


Fig.4:- Site1 and 2 – Reinforcement work Labour Productivity before and after Implementation of Solutions in terms of Cost

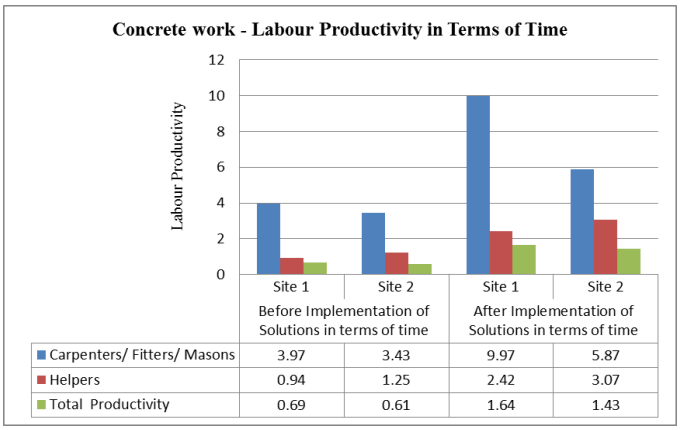


Fig.5:- Site1 and 2 – Concrete work Labour Productivity before and after Implementation of Solutions in terms of Time

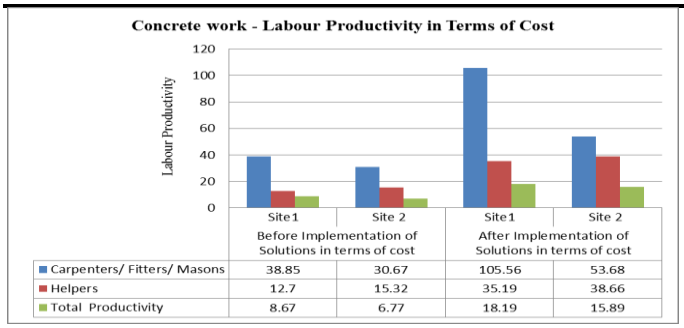


Fig.6:- Site1 and 2 – Concrete work Labour Productivity before and after Implementation of Solutions in terms of Cost

IV. CONCLUSION

1. The 25 top factors affecting labour productivity and solutions were collected through questionnaire survey from Sangli area. These factors and solutions will be used in future to increase the labour productivity for engineers, contractors, sub-contractors and construction companies in many types of construction work. (Table No.1, 2)
2. Labour Productivity for two sites is calculated for formwork, reinforcement work and concrete work in terms of time; before and after implementations of solutions and it is found that labour productivity for site 1 is increased by 83.82% and for site 2 by 88%. (Table No.4, 6)
3. Before and after implementations of solutions the labour productivity for formwork, reinforcement work and concrete work has increased in terms of cost for site 1 by 77.31% and for site 2 by 107.23%. (Table No.4, 6)
4. Total work cost and time cost amount difference (Profit) was increased for site 1- Rs.60,843/- (15.27%) and site 2- Rs.53,279/- (25.52%). (Table No.7)
5. The factors which are affecting on labour productivity were identified for the activities formwork, reinforcement work and concrete and practical solutions for these factors were found out. The practical solutions were implemented on sites to increase labour productivity. The increase in labour productivity shows that solutions implement on both the sites are correct and useful for engineers, contractors, sub-contractors and construction companies in many types of construction work. (Table No. 5)

References

[1] Abdulaziz M. Jarkas. (2015). "*Effect of Buildability on Labor Productivity: A Practical Quantification Approach*" J.Constr.Eng.Manage.,10.1061/ (ASCE) CO.1943-7862.0001062.

[2] Abdulaziz M. Jarkas, Camille G. Bitar. (2012)."*Factors Affecting Construction Labor Productivity in Kuwait*" J. Constr.Eng.Manage.,10.1061/(ASCE)CO.1943-7862.0000501,811-820.

[3] Abraham Assefa Tsehayae, Aminah Robinson Fayek. (2016). "*Developing and Optimizing Context-Specific Fuzzy Inference System-Based Construction Labor Productivity Models*" J.Constr.Eng.Manage.,10.1061/(ASCE)CO.19437862.0001127.

[4] Bon-Gang Hwang, Chin Kiat Soh. (2013). "*Trade-Level Productivity Measurement: Critical Challenges and Solutions*" J.Constr.Eng.Manage.,10.1061/(ASCE)CO.19437862.0000761.

[5] Carlos H. Caldas, Jung-Yeol Kim, Carl T. Haas, Paul M. Goodrum, Di Zhang. (2014). "*Method to Assess the Level of Implementation of Productivity Practices on Industrial Projects*" J. Constr. Eng. Manage., 10.1061/(ASCE) CO.1943-7862.0000919.

[6] E.C. Lim. (March 1996). "*The Analysis of Productivity in Building Construction*" Loughborough University., https://dspace.lboro.ac.uk/2134/7150.

[7] Khaled Mahmoud El-Gohary, Remon Fayek Aziz, Hesham A. Abdel-Khalek. (2017). "*Engineering Approach Using ANN to Improve and Predict Construction Labor Productivity under Different Influences*" J. Constr. Eng. Manage.,10.1061/(ASCE)CO.1943-7862.0001340.

[8] Krishna P. Kisi, Nirajan Mani, Eddy M. Rojas, E. Terence Foster. (2016)."*Optimal Productivity in Labor-Intensive Construction Operations: Pilot Study*" J. Constr. Eng. Manage., 10.1061/(ASCE) CO.1943-7862.0001257.

[9] Rodrigo A. Rivas, John D. Borcherding, Vicente González, Luis F. Alarcón. (2011). "*Analysis of Factors Influencing Productivity Using Craftsmen Questionnaires: Case Study in a Chilean Construction Company*" J. Constr.Eng.Manage., 10.1061/(ASCE)CO.19437862.0000274.

[10] Sampada Khanapurkar, Pooja Gadekar, Nilesh Bawankukle, Saurabh Ingole, S. S. Sanghai. (2016). "*Analysis of Labor Productivity*" International Research Journal of Engineering and Technology (IRJET)., Volume: 03, Issue: 06.

[11] Prachi R. Ghate, Ashok. B. More, Pravin R. Minde. (2016). "*Importance of measurement of Labor Productivity in Construction*" International Research Journal of Engineering and Technology (IRJET)., Volume: 05, Issue: 07.

[12] Sudam Chavan, Hemant Salunkhe. (2016)." *A Study on Labor Productivity in Construction Industry*" International Journal of Engineering Research., Volume No.5, Issue Special 1 pp: 247-249.

[13] Upul Ranasinghe, Janaka Ruwanpura, Xin Liu. (2012)."*Streamlining the Construction Productivity Improvement Process with the Proposed Role of a Construction Productivity Improvement Officer*" J. Constr. Eng. Manage., 10.1061/(ASCE)CO.1943-7862.000046.