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Productivity Analysis of Small Construction Projects in India

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ABSTRACT

The construction industry in India has a share of about 8% of its GDP and provides employment to around 35 million people. A lot of research has been done to find and analyse workers productivity in Indian construction industry. Research on workers' productivity in construction related activities were limited to large and medium sized projects. This study aims at analysing labour productivity and relation between direct work and their productivity in small construction projects. This industry of small construction projects is labour intensive. The studies incorporated interviews with on-site personnel, work sampling, work measurement and direct observations of different activities. Productivity of different activities was measured directly by measuring actual works at site. Work sampling was used to measure percentage of direct work. The study shows that the percentage of direct work, indirect work and no work was varying between 32-44.6, 40-44 and 15-20%, respectively. It was also found that productivity was higher for the sites where percentage of direct work was higher. The study reveals a huge scope in productivity improvement by reducing no work and indirect work proportion of workers effort at site.

Key words: Productivity, direct work, construction waste, work sampling

INTRODUCTION

India has entered a phase of unprecedented economic growth. To sustain this growth good infrastructure is a prerequisite. As a result of this a large number of construction projects have been undertaken. These are divided into few very large projects, some medium scale projects and many small construction projects. The Indian construction industry is one of the fastest growing construction industries globally and it is the second largest employer in India. It gives employment to around 35 million people in India. The share of the construction industry in India is about 8% of its GDP.

The Indian construction industry is divided into three major segments e.g. large projects which are being undertaken by major contractors, medium scale projects are being undertaken by both major as well as medium contractors and small scale projects which are being undertaken by small contractors. Classification of contractors as major, medium and minor contractors is done by Indian Construction Industry according to the number of people they employ. Small contractors are classified as those which employ less than 200 people, medium contractor employs 200-500 people and those which employ more than 500 people are classified as major contractor. Small contractors constitute more than 96% of the total number of contractors in India (CIDC, 2007).

The sector of small construction projects is labor intensive. Small contractors use less equipment because it is not economic to them because of the smaller value and scope of work. The area of

research was focused on workers, their activities and productivities in small construction projects in Thanjavur and Tiruchirappalli Districts of Tamil Nadu State. The same concept can be used in different places of India to get the reflection of workers productivity of small construction industry in India. The study was focused on construction of building e.g., apartments, hospitals, hostels and individual houses. The study also emphasizes upon the factors on which productivity depends upon. Work sampling was used to analyze the activities of workers and results are discussed.

Effectiveness with which labour is used in the construction process and the relative efficiency of labour are two most important measures of labour productivity (Dozzi and AbouRizk, 1993). Measurement of productivity is not new to the construction industry. Drewin (1982) defined productivity as “amount of goods and services produced by a productive factor in a unit time”. Measurement of goods produced and human effort is two basic elements of labour productivity. Gouett *et al.* (2011) has described the ratio of work hours to units of output as labour productivity, the ratio of labour cost to units of output as unit rate and the ratio of scheduled or planned to actual work hours as productivity factor. AACE (2004) defines productivity as “rate of output per unit of time or effort usually measured in labour hours”. By this definition more productivity is being better. Trends of productivity in US were studied by Allmon *et al.* (2000). Ahmed (2011) found that there was no improvement in labour productivity during the period 1995 and 2009 in North America.

Work sampling was developed by Leonard Tippett in (1927) and has been used by many researchers. Gouett *et al.* (2011) have used this technique for measuring standard work times in industrial processes. Liou and Borcharding (1986) used work sampling to establish direct, support and delay (ineffective) work time and analysed how workforce used its work time. Work sampling has been used to measure and improve labour productivity at different time and places (Thomas *et al.*, 1984, 1990; Enshassi *et al.*, 2011; Handa and Abdalla, 1989). Augustinus and Siringoringo (2007) tried to compare work sampling with conventional, self assessment and continuous monitoring method. Though work sampling does not give accurate productivity, it is widely accepted as a tool to measure worker time for direct, support and idle conditions with ease and at less cost and in no time. Gong *et al.* (2010) have used work sampling to find direct work percentage. Tsehayae and Fayek (2012) have prepared a research framework for work sampling and its applications for comparative studies on time spent on direct and support activity by crews. Labour productivity have been measured and compared with waste in construction in Swedish construction (Forsberg and Saukkoriipi, 2007).

Many factors which affect construction productivity have been identified and methods suggested and implemented to improve productivity all over the globe. Questionnaire and interviews with project managers in Thailand indicates Lack of materials, incomplete drawings, incompetent supervisors, lack of tools and equipment, absenteeism, poor communication etc., as the major causes for poor productivity (Makulsawatudom *et al.*, 2004). Study in Afghanistan shows that lack of security, corruption, poor scheduling and co-ordination, low quality materials etc., affect productivity the most (Gidado and Karimi, 2012). Finding from Libyan construction industry show that productivity can be improved by analyzing entire construction process, better planning, training and regular meetings (Hammad *et al.*, 2011).

MATERIALS AND METHODS

The data for the study to analyse the productivity and factors on which it depends was collected through a variety of methods. Site visits were made to multiple building projects in various stages

of completion. Interviews and meetings were held with the project in-charge, engineers, architects and site supervisors. Foremen, supervisors and workers were interviewed to get a clear perspective of project execution at the operational level. Measurement of the site was done to find out the labour productivity for different activities. Productivity was calculated as ration between output and Input. The output being units of work completed and input as number of man days employed to complete these works.

Tour based work sampling (Liou and Borcharding, 1986) was conducted to find out the areas related to major workers and their activities. Crew work sampling was then done to study the workers' activity in detail. All activities were listed and categorized in three categories as direct work, indirect work and no work. Crew work sampling data was used to measure the time spent by labourers in these work categories. Interval of observation was reduced to 2 min for better reflection of actual work done by the crew. Comparisons were made between percentages of direct, indirect and no work and actual productivities found from measurement. Productivities were also compared with the degree of supervisions and educational qualifications of workers.

Details of workers age, educational qualification, daily wage and background were collected from various construction sites. Social aspects of workers were studied with the help of worker data.

WORK SAMPLING

Tour work sampling was done on every site to find out the different activities being carried out at different locations of the site. It was useful in finding out the number of workers working at different locations and the different activities they perform for any particular activity. Tour work sampling is done by making a tour of pre-defined path covering almost all activities of a project site at fixed regular interval and noting down the different activities being performed by each individual at any location. After listing of different activities for particular work, Crew work sampling was done for that activity. Crew work sampling is done for any particular crew doing any particular work at any location. At a fixed interval observations of activities being performed are noted for all members of the crew. Interval for crew work sampling was kept at 2 min and sampling was done for a period of 2 h. From crew work sampling data, percentage of direct, indirect and no work was calculated.

From tour work sampling each work was categorized in different activities. All activities were further categorized as direct work, indirect work and no work category. Table 1 shows the different activities and their categorization.

Table 1: Categorization of sub-activities of different trades into direct work, indirect work and no work

Work	Brick work	Plastering	Form work	Reinforcement
Direct work	Placing bricks	Placing mortars	Placing shutters	Placing bars
	Placing mortars	Finishing	Nailing/taping	Tying bars
	Finishing			
Indirect work	Mixing mortars	Mixing mortars	Scaffolding	Marking
	Transport	Transport	Transport	Transport
	Material handing	Material handing	Material handing	Material handing
No work	Idle	Idle	Idle	Idle
	Chatting	Chatting	Chatting	Chatting
	No contact	No contact	No contact	No contact

RESULTS

Percentage of direct work, indirect work and no work for brickwork, plastering, formwork and reinforcement was calculated from work sampling. Detailed result of work sampling is in Table 2 and summary is shown in Fig. 1. Productivity of different trades was measured at site and the results are shown in Table 3. Percentage of direct work was found to be varying from 32 to 44.6% whereas that of indirect work was varied from 40.4 to 44%. Percentage of no work was varying from 15 to 24%. Comparison of work sampling and productivity of each trade shows that the percentage that decrease in direct work component is caused by increase in no work and indirect work

Table 2: Result of work sampling: Percentage time spent by workers on direct work, indirect work and no work for various trades at different job site

Activity	Share (%)	Site 1	Site 2	Site 3	Site 4	Site 5	Average
Plastering	Direct work	40	44	42	46	51	44.6
	Indirect work	50	43	36	38	35	40.4
	No work	10	13	22	16	14	15.0
Brick work	Direct work	38	36	44	40	37	39.0
	Indirect work	48	52	36	34	40	42.0
	No work	14	12	20	26	23	19.0
Form work	Direct work	36	32	38	42	37	37.0
	Indirect work	44	53	41	38	34	42.0
	No work	20	15	21	20	29	21.0
Reinforcement	Direct work	32	28	34	35	31	32.0
	Indirect work	43	52	49	42	34	44.0
	No work	25	20	17	23	35	24.0

Table 3: Result of direct workers' productivity measured at different job sites for various trades

Work	Unit	Productivity					
		Site 1	Site 2	Site 3	Site 4	Site 5	Average
Plastering	Sqm/man days	10.00	12.00	11.00	13.00	14.00	12.00
Brick work	Cum/man days	0.64	0.68	0.74	0.71	0.66	0.69
Form work	Sqm/man days	6.30	5.60	6.20	6.50	5.80	6.08
Reinforcement	Kg/man days	56.00	48.00	56.00	57.00	52.00	53.00

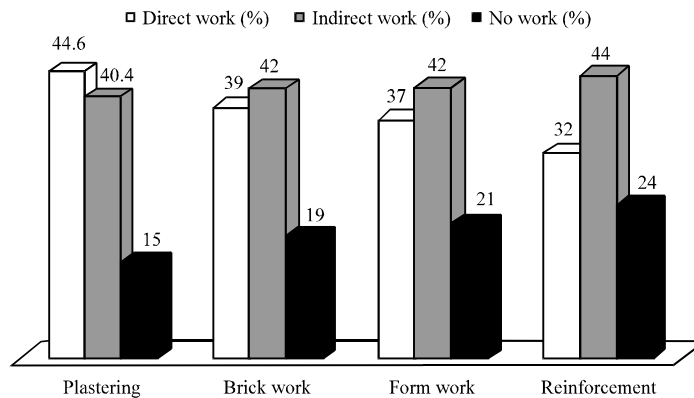


Fig. 1: Summary of work sampling: Average percentage time spent on various trades by workers on direct work, indirect work and no work

of direct work component influences the productivity directly. Summary of work sampling shows proportions. Main reason for higher no-work component is in-appropriate crew size ratio of skilled and unskilled workers. Higher indirect work component for some trades is due to inaccurate methodology and project layout.

From the interviews and meetings of the engineers, supervisors and discussions from the workers it was found that, out of 160 workers, average age of the workers was 32 years and maximum age was 43 years. More than 50% of the workers were illiterate whereas about 40% of workers had studied up to 5 to 8th standard. Male to female ratio of workers were 9:1 and almost all the female workers were unskilled. Ratio of skilled to unskilled workers was 1:1.5.

DISCUSSION

From the work sampling it was found that percentage of direct work was lowest in reinforcement work (32%) and highest in plastering (44.6%). Percentage of no work was highest in reinforcement (24%) and lowest in plastering (15%). A major percentage (more than 40%) of human effort was involved in indirect works which is necessary for the work but does not contribute directly in measurable end product. Percentage work in Productive, Contributory and Un-productive activities in block work in a building project in Gaza Strip was found as 48.2, 28.7 and 23%, respectively (Enshassi *et al.*, 2011). Average Direct work in the Austin, Texas (USA) during 1978-2008 was found almost stagnant at around 45% (Gong *et al.*, 2010). It is evident from the results of work sampling and productivity measurement that the site where percentage of direct work is higher, productivity is also higher. Effort should be made to optimize the percentage of human effort such that the share of indirect work remains only complementary to that of direct work. Any increase in direct work effort will directly increase the output and productivity. The result also shows that the work sampling result is in line with the labourers productivity. Root cause for the higher percentage of no work was found to be inconsistency in skilled to unskilled worker ratio. Component of No-work category can be reduced by maintaining appropriate ratio of skilled and unskilled workers at site. Component of indirect work will decrease with improved work methodology, site layout etc. and training and experience of workers and supervisors.

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