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EFFECT OF CONSTRUCTION LABOUR GROUP COMPOSITION ON OPTIMAL FIELD LABOUR'S PRODUCTIVITY IN MALANG – EAST JAVA

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ABSTRAK

Salah satu faktor utama yang menentukan produktivitas tenaga kerja adalah komposisi kelompok kerja. Di Indonesia, estimasi biaya tenaga kerja konstruksi menggunakan komposisi kelompok kerja produktivitas Standar Nasional Indonesia (SNI) 2002 dan modifikasinya. Namun penggunaan produktivitas ini tidak efisien dan efektif. Tulisan ini bertujuan untuk menentukan komposisi kelompok kerja yang ideal, koefisien penyetaraan serta perbedaan produktivitas aktual terhadap produktivitas SNI 2002. Metode penelitian yang dipakai adalah observasi lapangan dan wawancara terhadap 240 komposisi kelompok kerja pada pembangunan rumah menengah di Malang, Jawa Timur. Data diolah secara statistik deskriptif dan statistical test for a mean differences. Dari hasil penelitian ini diperoleh: komposisi kelompok kerja yang ideal untuk pasang tegel lantai, bekisting dan pengecoran beton adalah: 1 tukang tegel : 2 pekerja, 1 tukang kayu : 1½ pekerja dan 1 tukang batu : 4 pekerja. Diperoleh juga koefisien penyetaraan untuk berbagai komposisi kelompok kerja. Serta perbedaan produktivitas lapangan terhadap SNI 2002 untuk pekerjaan pasang tegel, bekisting dan pengecoran beton sebesar 286%, 114,8% dan 18%.

Kata kunci: *komposisi kelompok kerja, SNI 2002, produktivitas tenaga kerja lapangan, rumah menengah.*

ABSTRACT

One of the main factors which determines the labour productivity is the labour group composition. In Indonesia, the cost estimate of construction labour uses the labour groups of the productivities in Indonesian National Standard 2002 (SNI 2002) and its modification. However, using these productivities is not efficient and effective. This paper intends to determine the ideal labour group composition, the equivalent coefficient and the difference between the actual productivities and the productivities of SNI 2002. The research methodology used consists of field observation and interview with 240 labour groups of various compositions in the construction of middle-class houses in Malang,

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East Java. The data were processed by descriptive statistics and statistical test for mean differences. The result of this research shows that the ideal compositions for floor tile laying, sawn form work, and concrete pouring are: 1 tiler : 2 labours, 1 carpenter : 1½ labours, and 1 mason : 4 labours respectively. The equivalent coefficients for various labour group compositions are obtained. The differences between the field productivities and the productivities of SNI 2002 for tile laying, sawn form work and concrete pouring are 286%, 114.8% and 18% respectively.

Keywords: *labour group composition, SNI 2002, field labour's productivity, middle-class housing.*

INTRODUCTION

Background of the Study

A challenge faced by housing contractors in Indonesia post-recession of 2008 is creating a production cost efficiency in a construction industry (Sutoto, 2009). The cost efficiency can be obtained through increasing the labour productivity (Keegen, et al., 1995). So far, in Indonesia, a measurement for labour productivity in housing construction to calculate unit price from 1921 to 2000 is Construction Cost Analysis (*Analisis Biaya Konstruksi* /ABK) which is known as *Burgelijk Openbare Werken (BOW)* Analysis 1921. At this moment, the measurement of labour productivity according to BOW of 1921 Analysis is not appropriate anymore to use, as the methods, instruments, and human resources have changed (Suryanto and Pribadi, 1997).

From 2002 to now, the composition of a labour group used to determine labour productivity is a new labour group composition, based on an Indonesian National Standard 2002 (SNI 03-2835-2002) (Badan Standardisasi Nasional Indonesia, 2002). However, the labour productivity based on the composition of labour groups on the SNI 2002 does not fulfill the expectation of the developers/contractors in Malang – East Java as the use of labour productivity based on the SNI 2002 has no competitive advantage (Tjaturono, et al, 2009). In order to be efficient and effective in determining labour productivity used, developers/ contractors of housing construction apply a labour productivity based on their own "test" by determining a composition of various labour groups so that they have a different labour productivity. Practically, the productivity used by the developers is better than that of SNI 2002 (Rostiyanti, 2001; Tjaturono, et al, 2004). Nevertheless, the developers are still unsure whether the labour productivity obtained has reached the optimal productivity as it is expected. The change to the labour group composition is needed to obtain an optimal labour productivity of the SNI 2002, so that the obtained productivity is efficient and effective enough as it is expected by the contractors/developers.

Productivity of a labour is one of the basic factors influencing competitive ability in a construction industry (Ratnayanti, 2003; Tjaturono, et al. 2009). The productivity of an efficient and effective labour will reduce labour cost and time, so that the contractor/ developer would have a competitive advantage (Sutoto, 2009; Tjaturono, et al, 2009). It means that performance of the contractor/developer is higher than competitors in terms of saving time and lower selling price. Research on the labour productivity conducted by Ratnayanti (2003) and Tjaturono, et al. (2009) shows that the compo-sition of labour is one of the main factors determining/influencing the labour produc-tivity in the field. That is why a research in the measurement of labour productivity with various group labour in the field is needed to obtain an effective labour productivity from the cost as well as time point of view (Ratnayanti, 2003; Tjaturono, 2004). This research is conducted on three kinds of construction works with different labour groups, covering tile laying, sawn form work, and concrete pouring on a non-high rise

middle-class housing construction (Simanungkalit, 2004; Menteri Negara Perumahan Rakyat Republik Indonesia, 1995) as needed by the developers in Malang - East Java. By an effective productivity of the field labour, a developer/contractor of the middle class housing has a competitive advantage value (Hafid, 1995; John and Lowe, 1987; Sutoto, 2009).

This paper intends to determine the ideal labour group composition for the three kinds of labour group, a coefficient of the equivalent factor for the composition of the labour group as well as the difference of productivity of actual labour from the study on those of the SNI of 2001. In order to achieve this, other factors affected labour productivity, besides labour compositions, were controlled and kept at a constant state. Those factors are; building site was in normal condition so that the implementation works without any constrain, standard labour force was available, good controlling, and materials and equipments needed for the construction process were assumed available.

Composition of The Labour Group

Productivity of field labour has an important role in a construction cost because the final product of a construction depends on the labour's performance in the field. In a construction field, a supervisor has a duty to give instruction, control the quality of work of another labour. A tiler is aided by some labours, which are called as a labour group (Soeharto, 2001). However, in reality, at a field, only prolific and supportive labours who make the tiler productivity achieved so that the tiler has an important role (Ratnayanti, 2003; Tjaturono, et al, 2009). The reason is the final product of a construction work depends on the performance of the labour in each field labour, so that the productivity of field labours will be determined by composition of its labour.

Here are examples on the difference productivity of a tile laying with a different group composition from various analyses as follows:

- Analysis of BOW from 1921 to 2000:
  Composition of labour/m^2: 0.15 supervisor; 0.1 leader; 0.25 tiler; 0.50 labour.
  Productivity : 4 m^2/day/labour group
- Analysis of SNI 2002 up to now:
  Composition of labour/m^2 : 0.03 supervisor; 0.035 leader; 0.35 tiler; 0.62 labour.
  Productivity: 3.43 m^2/day/ labour group
- Analysis of Tjaturono's research finding (2004):
  Composition of labour/m^2 : 0.01 supervisor; 0.073 tiler; 0.146 labour.
  Productivity: 13.70 m^2/day/labour group

Productivity of The Labours

Productivity can be defined as a ratio between output (result achieved) and input (resources used) or effectiveness with efficiency (Gasperz, 2005; Hafid, 1995; Tangen, 2002). In other words, productivity is an output produced in a unit input. In a construction, an output is a result of work consisting work quantity or work volume, such as the meter square of brick, cubic meter of concrete, etc. An input is the resources used to realize the result, such as labours, capital, machines, equipments, raw materials. Among the resources, human resources has an important role in achieving a certain productivity, as instrument and technology are only a masterpiece of human resources (Setyanto, et al, 1998). Even Suternaister (Siswanto, 1989) in his finding concluded that about 90% of labour productivity depends on the achievement of labours and 10% depends on the progress of technology and raw materials.

There are two concepts related to productivity, i.e. effectiveness and efficiency. Effectiveness is concerned with the outputs while efficiency is focussed on utilization of the inputs to achieve the goal. Thus, productivity of labour

is a quantity of time needed by a labour group or a labour team to produce a certain work volume.

RESEARCH METHOD

This section, describes the location of research, population, data sampling, and data analysis. Location of the research on the influence of labour composition to the productivity of field labour was in Malang (municipality and regency). Research was conducted from April 1, 2009 to September 10, 2009.

Population of the research was developers of middle-class housing, who have constructed at least 200 units of middle class houses in one location. Then sampling process was done in a simple random way: five developers from eight eligible developers, whereas unit analysis of the labour group sample was 20 (N) taken in a simple random way from 50 – 70 house units, which were constructed by developers and four groups are taken for each developer.

The data collection was conducted by direct observation on the field, interviewing or both methods. For example, composition of the tile laying labour was: 1 tiler : 1 labour; 1 tiler : 1½ labours; 1 tiler : 2 labours and 1 tiler : 2½ labours. For compositions of 1 tiler : 1½ labours are arranged by applying 2 tilers : 3 labours. It means that there are two groups of masons with composition of 1 tiler: 1½ labours. Furthermore, for composition of 1 tiler : 2½ labours by applying 2 tilers : 5 labours. It means that there are two groups of tilers with composition 1 tiler : 2½ labours.

Observation was conducted to 20 labour groups five times in an effective six-hour work in a day. Supervision was done in the morning, mid-day, and afternoon. The result of direct observation was data on productivity of each labour group composition.

Data that had been collected from field observation were set in a table and analyzed. The analysis was done by descriptive statistic method, a method used to describe a set of quantitative data. Furthermore, some of the data are analyzed by counting the mean ($\overline{X}$), variance (S^2), deviation standard (S), and statistical test for the mean difference was used to compare labour group composition productivity (Nazir, 2004). Then, the cost productivity is obtained for each composition of the labour group is described in a plot showing correlation between cost and productivity of the labour group composition to achieve an optimal productivity of the labour group (effective and efficient).

RESULT AND DISCUSSION

The result of treatment of the three kinds of labour with various labour groups in a same way is taken as an example, and its composition is: 1 tiler : 1 labour; 1 tiler : 1½ labour; 1 tiler : 2 labours and 1 tiler : 2½ labours. Data for two other works – composition of sawn form work and concrete pouring are processed in the same way.

From direct observation to the field for productivity of the tile laying with various labour groups, the result has been obtained, as seen in Tables 1, 2, 3, and 4.

Table 1. Composition of Labour Group, Daily Productivity, Mean of Productivity, Deviation Standard (S)

No	Labour Group Tile Laying	Composition	Labour Group Productivity (m^2 / day)					Mean Group (m^2/day)	Mean Total Productivity (m^2/day)	Deviation-Standard (S)
			1	2	3	4	5			
1	Group 1		9.00	9.20	8.90	9.30	9.60	9.20		
2	Group 2		9.10	9.30	9.00	8.70	9.00	9.02		
3	Group 3		10.10	9.90	9.70	10.50	10.70	10.18		
4	Group 4		10.30	10.10	9.80	9.70	9.30	9.84		
5	Group 5		8.90	9.30	11.10	10.30	10.10	9.94		
6	Group 6		8.70	9.10	8.80	9.10	8.90	8.92		
7	Group 7		9.50	10.50	10.30	9.80	9.10	9.84		
8	Group 8		9.30	9.10	9.50	8.90	9.70	9.30		
9	Group 9		10.70	10.90	10.10	10.20	11.10	10.60		
10	Group 10	1 tr : 1lb	8.80	9.10	9.50	9.50	9.40	9.26	9.63	0.64
11	Group 11		9.10	9.50	9.30	9.70	9.00	9.32		
12	Group 12		8.40	8.30	9.40	9.10	8.50	8.74		
13	Group 13		10.90	11.10	10.70	10.40	10.90	10.80		
14	Group 14		10.10	10.50	10.00	10.10	10.40	10.22		
15	Group 15		9.90	9.30	10.10	10.60	9.80	9.94		
16	Group 16		8.60	9.10	8.70	9.30	8.50	8.84		
17	Group 17		10.00	9.30	10.10	10.50	9.70	9.92		
18	Group 18		9.50	9.10	9.50	8.90	10.10	9.42		
19	Group 19		10.70	10.10	10.40	10.90	10.40	10.50		
20	Group 20		8.70	9.10	8.90	8.50	8.70	8.78		

tr = tiler, lb = labour

Table 2. Composition of Labour Group, Daily Productivity, Mean of Productivity, Deviation Standard (S)

No	Labour Group Tile Laying	Composition	Labour Group Productivity (m^2 / day)					Mean Group (m^2/day)	Mean Total Productivity (m^2/day)	Deviation-Standard (S)
			1	2	3	4	5			
1	Group 1		11.10	11.50	11.30	10.90	11.50	11.26		
2	Group 2		9.90	11.10	10.90	10.50	11.00	10.68		
3	Group 3		12.60	12.40	12.00	12.90	13.00	12.58		
4	Group 4		12.80	12.45	12.40	12.10	11.80	12.31		
5	Group 5		11.10	11.80	13.10	12.80	12.60	12.28		
6	Group 6		9.90	11.10	10.30	10.90	10.30	10.50		
7	Group 7		11.10	13.00	12.60	12.80	11.40	12.18		
8	Group 8		11.40	12.30	11.40	11.00	11.80	11.58		
9	Group 9		13.10	14.10	13.10	13.50	14.10	13.58		
10	Group 10	1 tr : 1½ lb	11.40	11.20	11.45	12.00	11.80	11.57	11.96	1.01
11	Group 11		11.60	12.00	11.30	12.40	12.00	11.86		
12	Group 12		9.70	9.90	11.10	10.90	9.90	10.30		
13	Group 13		13.60	13.80	13.50	13.30	13.60	13.56		
14	Group 14		12.40	13.30	12.90	13.30	12.80	12.94		
15	Group 15		11.60	12.00	12.60	12.10	12.40	12.14		
16	Group 16		10.80	11.40	10.80	11.40	10.60	11.00		
17	Group 17		12.70	12.15	13.30	13.80	13.50	13.09		
18	Group 18		11.60	11.20	12.40	11.30	12.65	11.83		
19	Group 19		13.20	13.00	12.80	13.50	13.70	13.24		
20	Group 20		10.40	10.90	11.10	10.80	10.40	10.72		

tr: tiler. lb : labour

Table 3. Composition of Labour Group, Daily Productivity, Mean of Productivity, Deviation Standard (S)

No	Labour Group Tile Laying	Composition	Labour Group Productivity (m^2 / day)					Mean Group (m^2/day)	Mean Total Productivity (m^2/day)	Deviation-Standard (S)
			1	2	3	4	5			
1	Group 1		13.30	13.80	13.60	13.10	13.55	13.47		
2	Group 2		12.10	13.60	13.40	13.20	13.40	13.14		
3	Group 3		15.10	14.90	14.60	15.40	15.50	15.10		
4	Group 4		15.20	15.10	15.20	14.80	14.60	14.98		
5	Group 5		13.60	14.40	14.90	15.40	15.20	14.70		
6	Group 6		12.40	13.50	13.90	13.70	12.60	13.22		
7	Group 7		13.60	15.40	15.20	15.40	14.20	14.76		
8	Group 8		14.10	14.90	14.00	13.90	14.35	14.25		
9	Group 9		15.70	17.00	16.00	16.20	17.00	16.38		
10	Group 10	1 tr : 2 lb	14.00	13.70	14.10	14.50	14.30	14.12	14.51	1.03
11	Group 11		13.90	14.40	13.90	14.90	14.60	14.34		
12	Group 12		12.50	12.70	13.80	13.70	12.45	13.03		
13	Group 13		16.10	16.50	16.40	16.20	16.50	16.34		
14	Group 14		15.20	16.10	15.80	15.20	15.70	15.60		
15	Group 15		14.20	14.60	15.20	14.80	15.10	14.78		
16	Group 16		13.20	13.80	13.40	13.90	12.90	13.44		
17	Group 17		14.90	14.40	15.30	16.00	15.80	15.28		
18	Group 18		14.20	13.90	15.10	14.00	15.20	14.48		
19	Group 19		15.90	15.20	15.40	15.30	15.90	15.54		
20	Group 20		12.95	13.60	13.80	13.40	12.90	13.33		

tr: tiler. lb : labour

Table 4. Composition of Labour Group, Daily Productivity, Mean of Productivity, Deviation Standard (S)

No	Labour Group Tile Laying	Composition	Labour Group Productivity (m^2 / day)					Mean Group (m^2/day)	Mean Total Productivity (m^2/day)	Deviation-Standard (S)
			1	2	3	4	5			
1	Group 1		13.80	14.20	14.00	13.60	14.00	13.92		
2	Group 2		13.25	14.50	14.45	14.30	14.20	14.14		
3	Group 3		15.80	15.40	15.20	15.90	16.20	15.70		
4	Group 4		15.90	15.70	15.90	15.50	15.30	15.66		
5	Group 5		14.30	15.10	15.40	15.90	15.75	15.29		
6	Group 6		13.40	14.50	14.00	14.60	13.60	14.02		
7	Group 7		14.10	15.90	15.80	16.00	14.70	15.30		
8	Group 8		14.40	15.10	14.30	14.10	14.60	14.50		
9	Group 9		16.20	17.40	16.70	16.75	17.60	16.93		
10	Group 10	1 tr : 2½lb	14.30	14.20	14.50	13.90	14.70	14.32	15.06	1.05
11	Group 11		14.30	14.90	14.20	15.40	14.90	14.74		
12	Group 12		13.20	13.30	14.60	14.60	13.30	13.80		
13	Group 13		17.30	17.60	17.50	16.40	17.70	17.30		
14	Group 14		15.20	16.30	15.90	16.40	15.80	15.92		
15	Group 15		14.60	15.40	15.70	15.30	15.60	15.32		
16	Group 16		13.65	14.30	13.90	14.25	13.40	13.90		
17	Group 17		14.95	14.80	15.40	16.10	16.00	15.45		
18	Group 18		14.70	14.40	15.60	14.50	15.70	14.98		
19	Group 19		16.20	16.00	16.40	16.10	16.80	16.30		
20	Group 20		13.20	13.90	14.00	13.75	13.20	13.61		

tr: tiler. lb : labour

Subsequently, for tile laying group with various labour groups, 20 sample data (N) are taken for each group, and if it is determined with 95% confidence level and 5% degree of accuracy. The test for data sufficiency can be seen by the following Groeneveld (1988) formula:

$$n^* = \left[\frac{Z_{\alpha/2}\, S}{e}\right]^2 \quad \text{.....(1)}$$

which:
$Z_{\alpha/2}$ = 1.96
S = Deviation standard;
e = 0.05 x mean productivity.

A result of the test for data sufficiency can be seen in the following Table 5.

Then statistical test of mean difference in the Table 6 indicated that these were significant differences of labour productivity among group composition of 1 tiler : 1 labour, 1 tiler : 1½ labour, 1 tiler : 2 labour ($p < 0.05$), but no significant difference between 1 tiler : 2 labours and 1 tiler : 2½ labours ($p > 0.05$). The effective labour productivity is shown on the group composition of 1 tiler : 2 labours.

Table 5. Labour Group Composition, Mean Productivity, Deviation Standard (S), Data Sufficiency

No.	Kind of Labour Group	Composition	Mean Labour Group Productivity (m^2/day)	Deviation Standard (S)	Condition of Data Sufficiency (n^*)
1	Tile laying	1 tiler: 1 labour	9.63	0.64	6.68
2	Tile laying	1 tiler : 1½ labour	11.96	1.01	11.05
3	Tile laying	1 tiler : 2 labour	14.51	1.03	5.34
4	Tile laying	1 tiler : 2½ labour	15.06	1.05	7.44

Table 6. Difference Mean Among Labour Composition Productivity

(I) Composition	(J) Composition	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 tr : 1 lb	1 tr : 1.5 lb	-2,33100*	,29993	,000	-2,9284	-1,7336
	1 tr : 2 lb	-4,88500*	,29993	,000	-5,4824	-4,2876
	1 tr : 2.5 lb	-5,42600*	,29993	,000	-6,0234	-4,8286
1 tr : 1.5 lb	1 tr : 1 lb	2,33100*	,29993	,000	1,7336	2,9284
	1 tr : 2 lb	-2,55400*	,29993	,000	-3,1514	-1,9566
	1 tr : 2.5 lb	-3,09500*	,29993	,000	-3,6924	-2,4976
1 tr : 2 lb	1 tr : 1 lb	4,88500*	,29993	,000	4,2876	5,4824
	1 tr : 1.5 lb	2,55400*	,29993	,000	1,9566	3,1514
	1 tr : 2.5 lb	-,54100	,29993	,000	-1,1384	,0564
1 tr : 2.5 lb	1 tr : 1 lb	5,42600*	,29993	,000	4,8286	6,0234
	1 tr : 1.5 lb	3,09500*	,29993	,000	2,4976	3,6924
	1 tr : 2.5 lb	,54100	,29993	,000	-,0564	1,1384

* : The mean difference is significant at the .05 level.

Furthermore, cost calculation needed to achieve productivity of the labour group each day is done by using existing daily cost at the time of study conducted, i.e. supervisor Rp. 50,000,- per day, mason Rp. 40,000.- per day, and labour Rp. 25,000.- per day.

The calculation is based on the reality in the field that the supervisor's duty is ordering instructions, controlling tiler and labour's works. Whereas one yielding productivity is a tiler assisted by labours supporting their works.

Then the cost for each group composition can be seen in Table 7.

From Table 5 on the Labour Group Composition and Productivity Mean and Table 7 on the Labour Group Composition with Labour Productivity Cost per day, there are two plots, i.e. one represents a relationship between a tile laying group composition and productivity per day, and the other between a tile laying group composition and productivity cost per m2 (unit) can be seen in Figure 1 and 2, respectively.

Table 7. Labour Group Composition. Labour Group Production Cost day, Productivity Cost per unit, Productivity per day, Productivity Cost per unit.

No	Labour Group Composition	Cost Detail (Rp.)	Labour Group Production Cost per day (Rp.)	Productivity Per day (m^2/day)	Productivity Cost per Unit (Rp./m^2)
1	1 tiler : 1 labour	0.1supervisor : 5,000.- 1 tiler :40,000.- 1 labour :25,000.-	70,000.-	9.63	7,269.-
2	1 tiler : 1½ labour	0.1 supervisor : 5,000.- 1 tiler :40,000.- 1½ labours :37,500.-	82,500.-	11.96	6,898.-
3	1 tiler : 2 labour	0.1 supervisor : 5,000.- 1 tiler :40,000.- 2 labours :50,000.-	95,000.-	14.51	6,547.-
4	1 tiler : 2½ labour	0.1 supervisor : 5,000.- 1 tiler :40,000.- 2½ labours :62,500.-	107,500.-	15.06	7,138.-

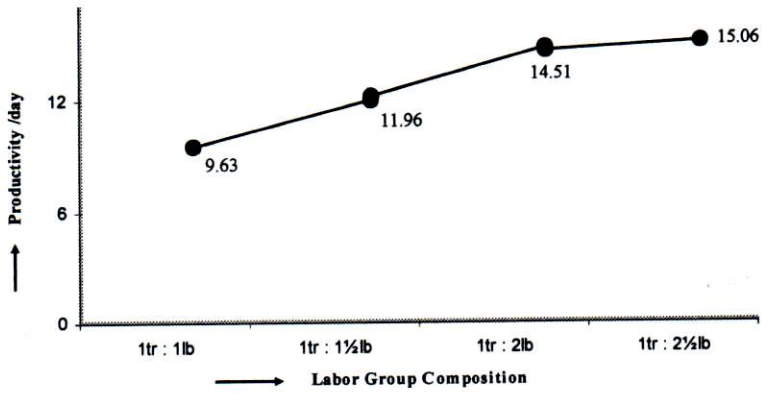

Figure 1. Plot between Tile Laying Group Composition and Productivity per day

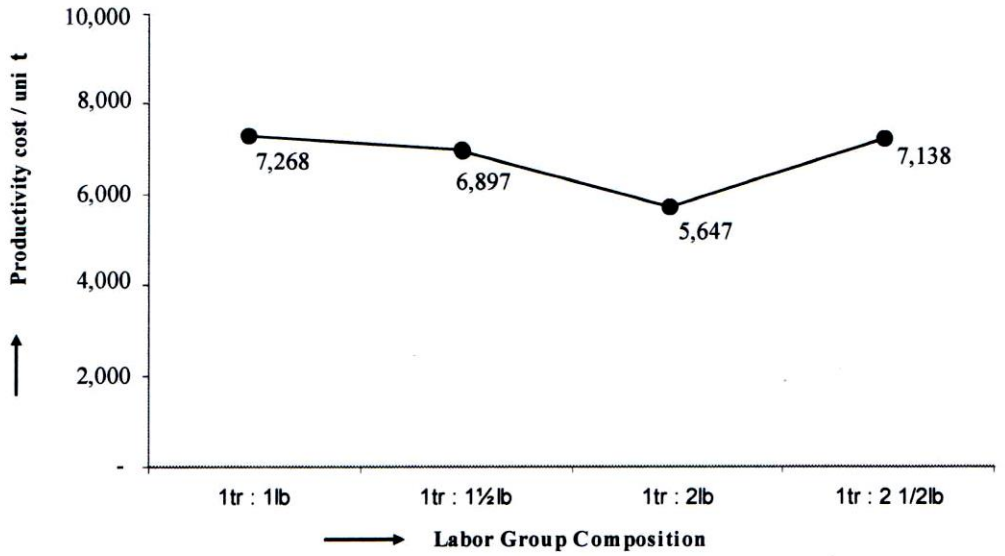

Figure 2. Plot between Tile Laying Group Composition and Productivity Cost

Table 8. Kinds of Labour Group Composition, Mean Productivity, Conditions for Data Sufficiency, Productivity Cost per unit.

No	Kinds of Labour Group	Labour Group Composition	Mean Productivity (Unit)	N* (Conditions for Data Sufficiency)	Productivity Cost per unit (Rp/unit)	N (sample amount)
1	Sawn Form Work	1 carpenter : ½ labour	6.38 m^2	12.93	9,012/m^2	
		1 carpenter : 1 labour	8.96 m^2	8.65	7,812/m^2	20
		1 carpenter : 1½labours	11.78 m^2	10.38	7,003/m^2	
		1 carpenter : 2 labours	12.34 m^2	8.75	7,698/m^2	
2	Concrete Pouring	1 mason : 2 labours	1.77 m^3	4.68	53,672/m^3	
		1 mason : 3 labours	2.48 m^3	4.87	48,387/m^3	
		1 mason : 4 labours	3.42 m^3	15.39	42,397/m^3	20
		1 mason : 5 labours	3.79 m^3	12.09	44,854/m^3	
		1 mason : 6 labours	4.04 m^3	13.58	48,267/m^3	

From Figures 1 and 2, it can be obtained an optimum point, a point showing the most efficient cost of the tiler labour group with an effective productivity of working group composition. So that it can be concluded that the most efficient cost of tile laying is Rp. 5,647.- per m^2 with the effective productivity is 14.51 m^2/day and the labour group composition is 1 tiler : 2 labours. Furthermore, the same data processing is conducted also for two other construction labour groups on the sawn form work and concrete pouring, which its result can be seen in Table 8.

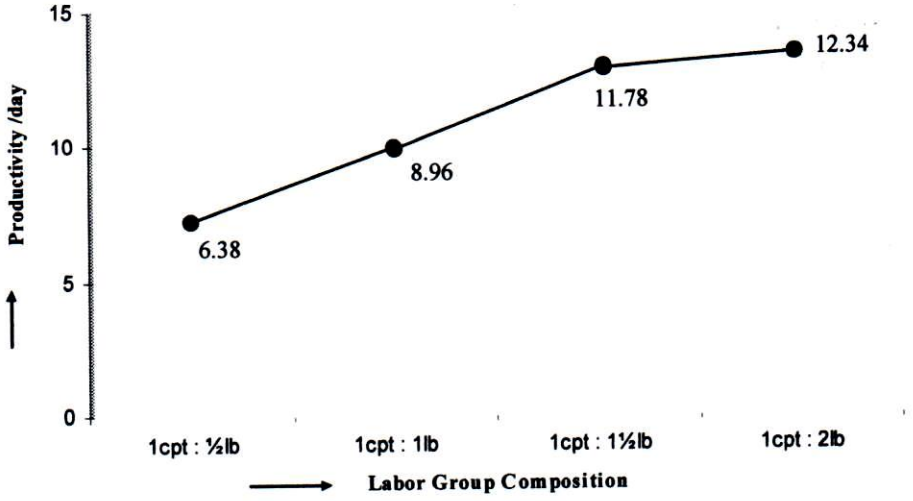

Figure 3. Plot between Sawn Form Work Group Composition and Productivity per day

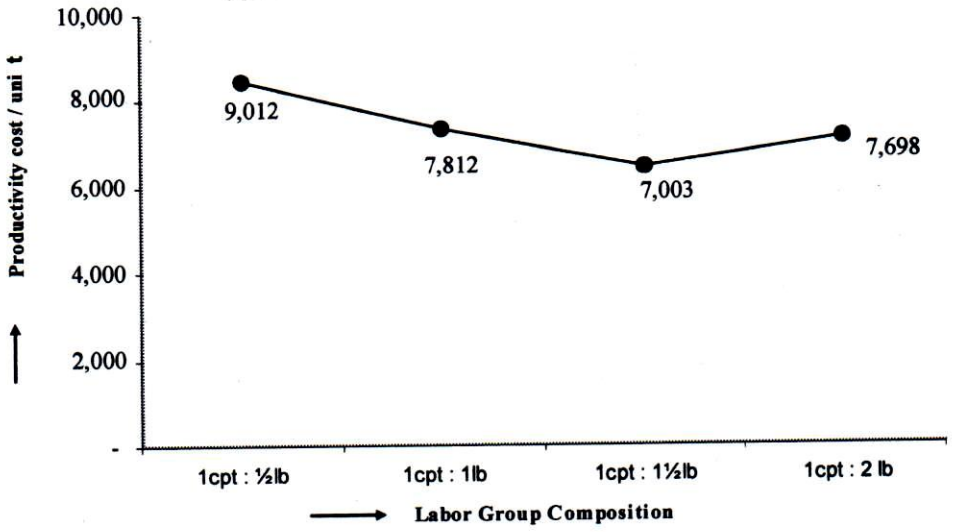

Figure 4. Plot between Sawn Form Work Group Composition and Productivity Cost

From Table 8 on the composition, productivity mean, and cost per day for sawn form work and concrete pouring, we have four plots. It can be seen in Figures 3, 4, 5 and 6 respectively.

Based on Figures 3 and 4, it is obtained an optimum point, showing the minimum cost of sawn form work is Rp. 7,000,- per m^2 with the effective productivity is 11.78 m^2 per day and the labour group composition is 1 carpenter : 1½ labours.

Statistical mean test of productivity was also found significantly different ($p<0.05$) between 1 carpenter : ½ labour, 1 carpenter : 1 labour, 1 carpenter : 1½ labours, and 1 carpenter : 2 labours. All was found significantly different at $\alpha = 5\%$. The higher composition of carpenter and labour, the more productive they are. The effective labour productivity is shown on the group composition of 1 carpenter : 1½ labours.

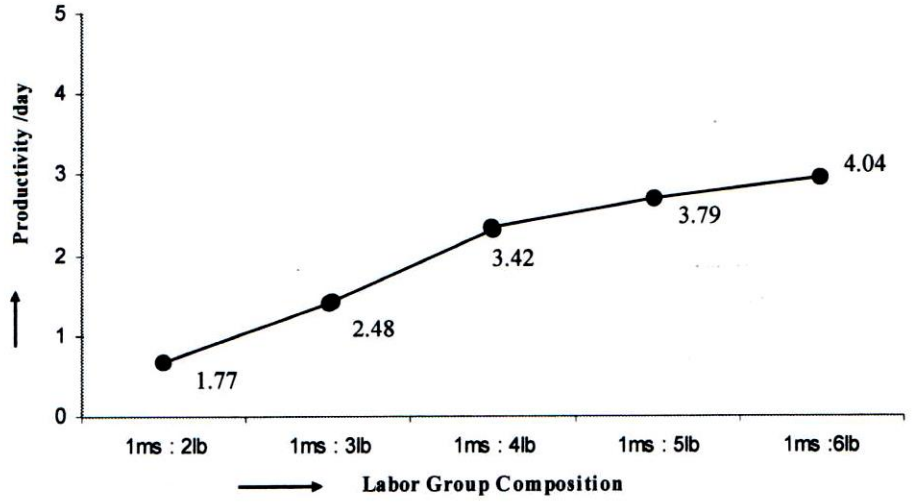

Figure 5. Plot between Concrete Pouring Group Composition and Productivity per day

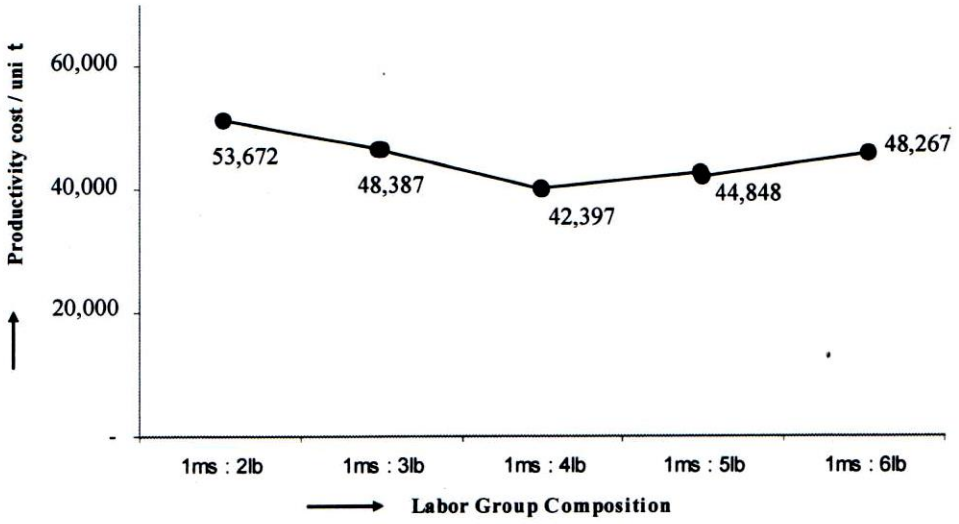

Figure 6. Plot between Concrete Pouring Group Composition and Productivity Cost

Moreover, Figures 5 and 6 indicate the optimum point showing the most efficient cost of concrete pouring is Rp. 42,397,- per m^3 with the effective productivity is 3.42 m^3 per day

and the group composition is 1 mason : 4 labour. Statistical mean test of labour productivity was also found significantly different ($p < 0.05$) between 1 mason : 2 labours, 1 mason : 3 labours, 1 mason: 4 labours, 1 mason : 5 labours and 1 mason : 6 labours. The higher composition of mason and labour, the more productive they are. The effective labour proactivity is shown on the group composition of 1 mason: 4 labours. These optimum points are ones that should be achieved by developers in a normal condition construction. Therefore, the developers are able to achieve the most efficient cost for labours with an optimal/fective productivity.

From the six figures above, it is achieved three optimal points for tile laying, sawn form work, and concrete pouring, respectively. Besides, it was also found some non optimal points which are higher labour productivity than the optimal one but the labour cost were higher than the minimum one so that they were not efficient. For example, the ideal composition of a concrete pouring is 1 mason : 4 labours with the most efficient is Rp. 2,397.- and the productivity is 3.42 m^3 each day. Comparing with composition of labour group 1 mason : 6 labours with productivity 4.04 m^3 each day and the cost of productivity is Rp. 48,267.-/m^3/day. This composition of a labour group can be used also when there is retardation or delay in work for this should be fastened. In spite of that, fastened project as a whole can be classified into activities, which are in a critical path; its duration is planned dependent to the labour productivity of the optimal labour group, substituted by productivity of larger labour based on a larger labour group composition. Although the cost for labour is larger than the efficient cost, but the precipitate can be obtained with a low additional cost. Hence a crashing or trade-off is unnecessary as these in general causes a higher cost of the precipitate by additional labour group, overtime, and shift (Alifen, 2000; Johan, 1998).

Based on the calculation of mean productivity for the three construction labour group with various compositions, the ideal labour group composition with a minimal cost of manpower is determined as a basis for equivalence by giving coefficient 1. For other compositions, equivalent coefficient is obtained by compaing labour productivity and productivity on the ideal labour composition. In doing so, the equivalent coefficient is obtained as shown in Table 9.

Table 9. Types of Labour Group, Productivity, and Equivalent Coefficient.

No.	Kinds of Labour Group	Labour Group Composition	Productivity	Equivalent Coefficient
1	Tile Laying	1 tiler : 1 labour	9.63	0.663
		1 tiler : 1½ labours	11.96	0.824
		1 tiler : 2 labours	14.51	1
		1 tiler : 2½ labours	15.06	1.04
2	Sawn Form Work	1 carpenter : ½ labours	6.38	0.54
		1 carpenter : 1 labour	8.96	0.76
		1 carpenter : 1½ labours	11.78	1
		1 carpenter : 2 labours	12.34	1.05
3	Concrete Pouring	1 mason : 2 labours	1.77	0.52
		1 mason : 3 labours	2.48	0.725
		1 mason : 4 labours	3.42	1
		1 mason : 5 labours	3.79	1.11
		1 mason : 6 labours	4.04	1.18

Table 10. Productivity Difference of Tile laying, Sawn Form Work, and Concrete Pouring from Research Result of SNI 2002.

No.	Kinds of Labour Group	Mean Productivity of Research result	Mean Productivity after equivalence	Mean Productivity SNI 2002	Productivity Difference Volume	%
1	Tile Laying	14.51 m^2 1 tr : 2 lb	13.23 m^2 1 tr: 1.77 lb	3.43 m^2 1 tr : 1.77 lb	9.8 m^2	286%
2	Sawn Form Work	11.78 m^2 1 cpt : 1½ lb	9.88 m^2 1 cpt : 1.15 lb	4.62 m^2 1 cpt : 1.15 lb	5.26 m^2	114.8%
3	Concrete pouring	4.04 m^3 1 ms : 6 lb	4.04 m^3 1 ms : 6 lb	3.42 m^3 1 ms : 6 lb	0.55 m^3	18%

tr = tiler; cpt = carpenter; ms = mason; lb = labour
* The effective man-hour is 6 man-hours multiplied with 1,20 x standard of SNI 2002 (5 man-hour)

The coefficient is needed to keep pace with implementation of labour in different labour group compositions, because developers do not know the optimum point between an optimal labour composition with the most efficient cost and an effective productivity. So far, in doing their works in their field with labour group compositions, the developers make a composition according to their experience or based on "trial and error" which are deemed as the most efficient and effective way.

Furthermore, the result of calculation of the productivity and cost obtained from various group compositions. We are compared with the result of list analysis of labour cost of the SNI of 2001 by using the equivalent coefficient shown in Table 9. This step generates a productivity difference between mason in Malang and Productivity of labour of SNI of 2001 shown in Table 10.

As listed on Table 10, it is obtained the difference of productivity and labour group composition between the research and that of the SNI 2002. In order to achieve realistic difference of productivity, balancing of labour group composition between the research and the SNI 2002 is needed first as it is shown in Table 9. By balancing the labour group composition of tile laying, sawn form work, and concrete pouring, it is obtained 285.70%, 113.8%, and 18% productivity difference. It means that the productivity of the research for these three kinds of labour groups is higher than that of SNI 2002. Moreover, the productivity has a significant influence on costs and time of construction of the three kinds of works and the results are more efficient of costs and effective of time for housing construction.

CONCLUSIONS

After analyzing data of the field research and discussion of labour productivity for various team work compositions, the following conclusions are drawn:

Firstly, the ideal composition of labour group for tile laying is 1 tiler : 2 labours with the most efficient cost Rp. 5,647.- per m^2 and productivity 14,51 m^2 per day. The ideal composition for sawn form work is 1 carpenter : 1½ labours with the most efficient cost Rp. 7,003.- per m^2 and productivity 11.78 m2 per day. The ideal composition for concrete pouring is 1 mason : 4 labours with the most efficient cost Rp. 42,397.- per m^2 and productivity 3.42 m^2 per day.
Secondly, the research found an equivalent factor for various construction labour groups. These equivalent coefficients are based on ideal composition of labour groups with

minimum cost as the basis, and it is pointed out by 1 for technical calculation. The coefficient equivalencies for other compositions are based on a comparison between achieved productivity of each labour composition group and the productivity of the ideal ones. Based on the principle, the optimal labour composition for tile laying is 1 tiler : 2 labours so that equivalent coefficient for other labour composition groups is 0.66 for 1 tiler : 1 labour. 0.824 for 1 tiler : 1½ labours and 1.04 for 1 tiler : 1½ labours. The optimal sawn form work composition groups was 1 carpenter : 1½ labours so that equivalent coefficient for the other labour composition groups is 0.54 for 1 carpenter : ½ labours. 0.76 for 1 carpenter : 1 labour and 1.05 for 1 carpenter : 2 labours. The composition for concrete pouring is 1 mason : 4 labours, so that equivalent coefficient for the other labour composition groups are 0.52 for 1 mason : 2 labours, 0.725 for 1 mason : 2 labours, 0.725 for 1 mason : 3 labours, 1.11 for 1 mason : 5 labours, and 1.18 for 1 mason : 6 labours.

Finally, after balancing is done for labour composition of the research finding on SNI 2002 using the equivalent coefficient mentioned above, it was found that labour productivity is 13.23 m^2/day, 11.78 m^2/day, 4.04 m^3/day for tile laying, sawn form, and concrete pouring respectively. Therefore, the difference labour productivity between the research finding and SNI 2002 is 286% for tile laying, 114.8% for sawn form work, and 18% for concrete pouring.

SUGGESTIONS

Further research needs to be conducted to obtain actual labour productivity, and to determine the equivalent coefficient of labour productivity between Java and outside Java. So that the labour productivity standard (Standar Produktivitas Tenaga Kerja Nasional Indonesia – SNI) can be more realistic and applicable to each regional condition with its different human resources' capability.

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