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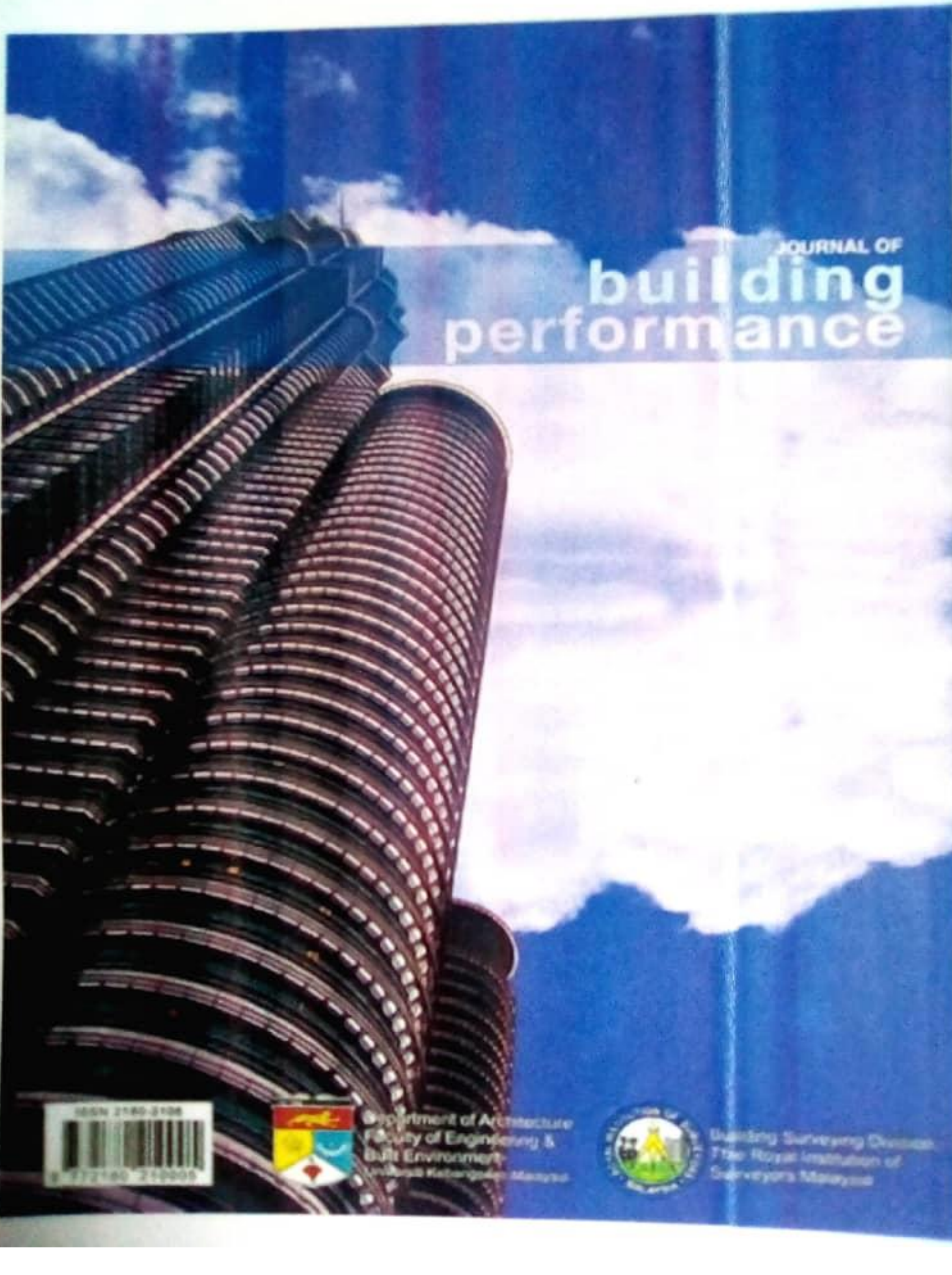
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A STRATEGY FOR LABOR PERFORMANCE IMPROVEMENT FOR FLOOR TILING WORK IN SINGLE STOREY BUILDINGS IN ABUJA, NIGERIA

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Abstract

This paper examined labor productivity of floor tiling works in selected construction sites. Sixty one (61) sites were visited for the purpose of collecting data. The construction sites chosen for this study were ongoing one storey buildings in Abuja, Nigeria. Data used for the study were obtained using daily method of data collection which has the advantage to capture both quantity and time inputs. A total of 737 data points were collected for the floor tiling activity in all the sites. From these data, the study variables (cumulative productivity, baseline productivity, coefficient of variation and project performance index) were computed using conceptual (site-based) model of labor productivity measurement and the results revealed that many of the projects studied had low performance rating while few of projects performed well. A simple regression and correlation analyses were used to determine relationships of the research variables. The result showed that the coefficient of correlation between coefficient of labor productivity variability and performance index was found to be 0.588 which is significant at 0.01 confidence level. The coefficient of determination (R) was calculated to be 0.44 This showed that 44% variation in crew performance is accounted for by variability in labor productivity. It was suggested that crew performance in tiling work can be improved by moderating or curtailing variability in labor productivity.

Key words: labor, performance, productivity, tiling, variability

Introduction

The low level of productivity in the building construction industry compared to the manufacturing industry world-wide has resulted in calls for improvement in performance in the construction industry (Lema, 1996). Drops in construction productivity have been tracked down to lack of upgrading in the construction process as a whole. The main performance lies in the knowledge of construction processes, process variables and process performance indicators. Process accomplishment improvement can be effected by changing the variable or set of variables that most influence the performance indicator. The primary step in searching for performance improvement includes the analysis of the scope of the process performance variability. This would uncover the extent of performance variance. One of the major performance indicators in the construction industry that can be examined to bring to light the extent of performance disparity is labor productivity (Lema and Price, 1996). Variability affects project performance and extends project cycle time thereby causing continuing widespread under-achievement of project objectives in many construction firms.

In Nigeria, there has been no attempt to measure the effects of variability on performance from labor productivity studies. A critical examination of previous studies (Olomolaiye *et al.*, 1989; Ayandele 1999; Ameh and Odusami, 2002) showed that the analyses were based on mere ranking of factors affecting labor productivity. Other studies showed that data sets used were inadequate and out of the range of normal distribution which may have rendered the results of these studies unreliable. Against this background, there is therefore, the need to adopt a method of using large productivity data sets from building trades to investigate the effects of variability on performance of local contractors within the study area.

Performance measurement

Construction jobsite performance can be measured (Alfeld, 1988). Performance measurement in any organisation is based on the assumption that there is a standard against which comparison can be made, this benchmark could be internally and externally based. Performance measurement has been described as the process of quantifying the efficiency and effectiveness of actions. For a performance measurement system to be regarded as a useful management process it should act as a means that enables assessment to be made, provides useful information and detects problems, allows judgment against certain predetermined criteria to be performed and more importantly, the systems should be reviewed and updated as an ongoing process. (Benon, and Milton, 2010).

Regular assessment of performance in an organization helps management with invaluable information to guide in decision making. The importance of regular performance cannot be overemphasized. The exercise makes management to be competent, transforms average site managers to performers and supplies management with the better information on which right decisions and actions are taken. According to Alfred (1988) contractors performance has two aspects, firstly accomplishment and secondly, method employed to accomplish the task.

Accomplishment here represents finished work of value to the job while method describes how the work was done for instance the total member of tiles laid is an accomplishment,; the number of labor man hours represents the method. Therefore, performance can be defined as the ratio of accomplishment to methods.

This is expressed by Alfred (1988) as:

$$Performance = \frac{Accomplishment}{Methods} \qquad (1.1)$$

$$Performance = \frac{QTY\ Total}{Manhours\ Cost} = \frac{Output}{Input} \qquad (1.2)$$

The above performance ratio reveals to us that a contractor can raise his competence by increasing the value of accomplishments while reducing the amount of time, energy and money spent on methods. Therefore "worthy performance occurs when the value of the accomplishment exceeds the cost of the method" (Alfeld, 1988). This means that contractors improve on their performance by investing resources in reducing the cost of the labor input (methods) required to accomplish a given tasks. The measurement of accomplishment helps to identify deficiencies in work methods. Construction performance is improved by management if such deficiencies are corrected. The definition of performance here is similar to that of productivity.

However, performance engineering defines productivity in a narrower context as jobsite labor man hours divided by quantity of work produced which is an important and very useful measurement of jobsite performance. This is a measure of only one performance dimension. Alfeld (1988) suggested that performance measurement should be related to a baseline or exemplar performance. This assertion was corroborated by Thomas and Zavrski (1999a), 1999b) and Enshassi *et al.* (2007) that performance should be measured in relation to baseline productivity.

Lean concept identifies project management index (PMI) or project waste index as useful tool to measure jobsite performance. According to Thomas and Zavrski (1999a) and Abdel Hamid *et al.* (2004), PMI (Performance) is expressed mathematically thus:

$$PMI\ (Performance) = \frac{Cumulative\ Productivity - Baseline\ Productivity}{Expected\ Baseline\ Productivity} \qquad (1.3)$$

This is defined as the ratio of the difference between the cumulative productivity and Baseline Productivity over expected Baseline Productivity.

Project Management Index (PMI)

The project management index sometime referred to as project waste index (PWI) is a dimensionless parameter that reflects the influence that project management has on the cumulative labor operations. It is expressed as the ratio of the difference between the cumulative productivity and baseline productivity over expected baseline productivity (Thomas and Zavrski, 1999a, 1999b). According to Abdel – Razek *et al.*, 2007. PMI is a measure of the difference between the actual and baseline productivity, it provides a measure of the impact of poor material, equipment and information flows, and inadequate planning. This makes it a measure of waste, which is one of the issues being addressed by lean construction. Reduced waste can lead to better flow and productivity. The lower the PMI value the better is the project management's influence on overall operation (Thomas and Zavrski, 1999b). Mathematically, the PMI eliminates the productivity influence of complex design.

Reduce variability in labor productivity

Thomas *et al.* (2002) stated that different strategies for managing construction variability emerge from lean thinking. Some focus on reducing work flow variability with the intention of improving project performance by increasing throughput, while others employ the strategy of capacity management that is, using flexibility in responding to variability which has the capacity to improve operation by permitting rapid changes as needed.

Thomas and Zavrski (1999b) concluded in their study that the variability in daily labor productivity is highly correlated to project performance. Also that variability in productivity appears to be a good determinant of good and poorly performing project. Thus the goal of lean construction should be to improve performance by reducing variability in labor productivity. This variability in the daily labor productivity was computed using the developed mathematical equations by Thomas and Zavrski (1999a) adopted in Idiake and Bala (2014).

Research methodology

Data collection

The data collection for on-site productivity study was conducted on floor tiling activity. The research procedures involved the engagement of ten research assistants, who were trained to observe the workmen and record observations in terms of input and output. Data collection covers floor tiling work of 61 projects from building contractors selected randomly within the study area. Daily visit method of observation of labor productivity was adopted. This involved personal observation of labor activities on the selected live projects. The strategy adopted was to interact with the foremen and workers in order to record the dates, number of workers, starting time, closing time and measurement of length/breadth of work done (quantities) of each worker. The information gotten was recorded on research instrument collection sheet designed for this purpose. The daily visit method of collecting data is a simple and effective method of monitoring productivity on building construction sites. It has the advantage of being used to measure multiple gang size. It is used to collect productivity data on labor inputs and outputs. The figures collected were weighted and analysed to determine the research variables.

The population of the study was drawn from contractors handling building projects in the study area. The builders were involved in different types of construction activities such as mass housing projects of bungalow category, storey building housing projects and infrastructures. In order to meet the objectives of the study, the research samples were drawn from contractors constructing single storey buildings for the purpose of homogeneity. The research team was able to collect data from sixty one (61) construction sites, randomly drawn from the available list of builders. A total of 737 data points were obtained for floor tiling work activity from the 61 projects. This is on the average about 12 observations per site. Data were gathered at various stages of job execution.

Conversion factor for tiling work

During the tiling operations, the crew worked with different sizes of tiling material ranging from 600 x 600mm to 250 x 250mm. The size of tile affected output rates for the gangs. The type of tile for which outputs were greatest was the 300 x 300mm tiles. Therefore, this size of floor tile was taken as the common unit/baseline for computing the tiling conversion factor. It should be noted that the calculation of converting factor for tiling trade is similar to that of concrete trade except that the data used for computation were not obtained from existing manual. This was due to the fact that the floor tiles have different countless sizes which are not common and thus output rates were not available in the estimating manuals. Therefore, the conversion factors were calculated from the data collected as shown in Table 1 this approach of calculating mensuration indices may likely be susceptible to imprecision in instances when the data sample contains a small proportion of data points in which work was done with one material type (Noor, 1992). Having a large data set tends to check inaccuracy.

Table 1. Converting factor for computing equivalent quantities of tiles

S/N	Type and Size of Tiles	Area of Tile (m^2)	Output per Square metre	Conversion Factor
1	600 x 600mm	0.360	2.77	0.25
2	600 x 300mm	0.180	5.55	0.50
3	450 x 450mm	0.203	4.93	0.44
4	300 x 300mm	0.090	11.11	1.00
5	250 x 250mm	0.063	15.87	1.43

Source: Author's analysis of data

$$CF_{ft} = \frac{\text{Output of non common tiles}_{nt}}{\text{Output of common tiles}_{ct}} = \frac{P_{nt}}{P_{ct}} \quad (1.4)$$

Where CF_{ft} = Conversion factor of floor tiles.

P_{nt} = Output of Non common tiles.

P_{ct} = Output of common tiles.

Analysis and discussion of results

The normal probability plot of labor productivity data for floor tiling activity used for the study is shown in Figure 1. A sample size of 737 observations was used for the investigation as against 357 found to be adequate from sample size calculation. Normality test was carried out, the mean of the sample was found to be 1.216whr /m^2 and the median was determined to be 1.134whr /m^2 which means that frequency distribution is not symmetrical, since the mean of the estimate was higher than the median. It is a skewed distribution as shown in Box and Whisker's Plot Figure 1. Also the distribution is positively skewed having a skewness value of 0.336 and standard deviation of 0.443.

The distribution of the sample variable was slightly normally distributed. The measure of variability was determined from the normal probability statistics computed. The range was found to be 1.70 which is the difference between the highest and the lowest scores in the distribution.

The average coefficient of variation for all the projects which is a measure of the standard deviation and the mean was calculated as 36.43%.

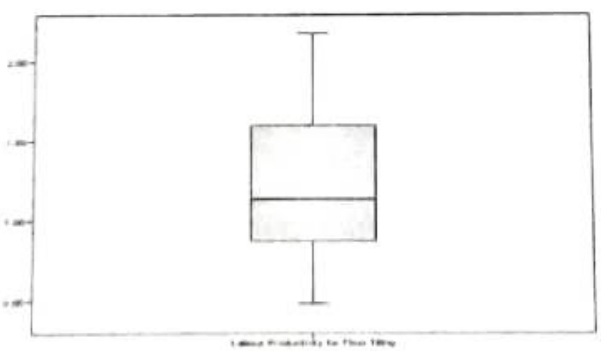

Figure 1: Box and Whisker's plot for labor productivity of floor tiling activities

Variability in daily labor productivity for the selected site activities

The variability in daily labor productivity of floor tiling task for project 5 is shown in Figure 2. The variability computation was performed for each of the projects examined see Table in appendix I. It was determined from input to output relationship. The computed values of coefficient of variation for floor tiling activity range from 0.108 to 0.576 for all the six one projects examined. This is similar to the earlier computation which is the product of the standard deviation divided by the mean of the estimate.

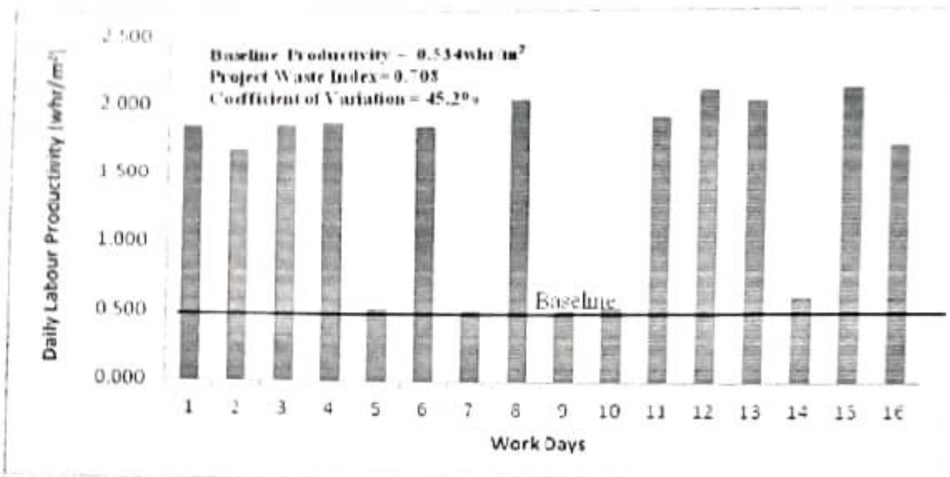

Figure 2: Relationships of the research variables (daily labor productivity, baseline productivity and performance Project 5)

The days observed for floor tiling activity is illustrated in Table 2 which showed, the gang size, work hours, daily quantity, daily labor productivity and baseline days. The floor tiling task observed in the project was done for sixteen days. The total crew size utilized to accomplish 587.55 square metre of floor tiling work was 94work men with a total work hours of 679hrs. This indicates that the construction firm used one site worker to achieve approximately 6.25m^2 of floor tiling. The daily productivities ranged from 0.506 to 2.107whr/m^2. The floor tiling work has a cumulative productivity of 1.156whr/m^2.This indicates that labor input was fairly low since this cumulative productivity is greater than unity. The following days 5, 7, 9, 10, and 14 were selected because of their high productivity scores as baseline days for floor tiling task. These are the highest productivity scores that were considered to define the baseline subset for floor tiling activity. The average of these five figures (0.525, 0.506, 0.506, 0.533, and 0.600whr/m^2) represents the expected benchmark for the project which is calculated to be 0.534whr/m^2.

The project waste index which provides a measure of labor performance was found to be 0.708 which is the worst pwi of all projects investigated. The pwi figure is high therefore showing a poor labor performance for project 5. A close look at Figure 2 also showed some level of gap between daily labor productivities and the baseline productivity which was found to be 45.20% coefficient of variation. This level of variation shows some level of improvement on labor performance. There is disparity in the values of daily labor productivity and the baseline productivity resulting in poor labor performance. Project 54 in Figure 3 for floor tiling activity shows a better performance with daily productivity close to the baseline productivity value. The baseline productivity for the project was calculated to be 1.011whr/m^2.

Also it was observed that the gap between the daily productivities and the baseline productivity provided a coefficient of variation of 10.80% which produced a better labor performance (pwi) of 0.122 compared to 0.708 found for project 5. This goes to support the lean theory which says that reducing variability enhances labor performance.

Table 2: Data presentation and analysis of site floor tiling work collected from Project 5

Day	Crew Size	Work hours (h)	Daily Quantities (m^2)	Labor Daily productivity (wh/m^2)	Baseline days and productivity
1	4	32	17.34	1.845	
2	6	48	28.78	1.668	
3	7	40	21.67	1.846	
4	7	56	29.98	1.868	
5	3	21	40.00	0.525	*
6	4	32	17.45	1.834	
7	5	40	79.00	0.506	*
8	7	56	27.67	2.024	

9	5	40	79.00	0.506	*
10	6	48	90.00	0.533	*
11	7	56	29.45	1.902	
12	7	56	26.67	2.100	
13	7	56	27.89	2.008	
14	7	18	30.00	0.600	*
15	5	40	18.98	2.107	
16	7	40	23.67	1.690	
SUM	94	679	587.55	1.156	0.534

Source: Researcher's data analysis, * Used in the computation of baseline productivity

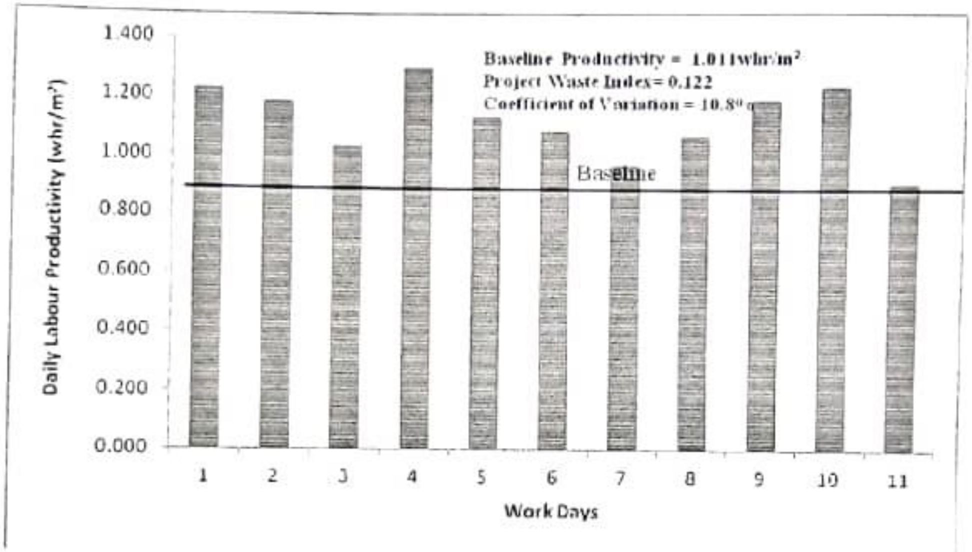

Figure 3: Relationships of the research variables (daily labor productivity, baseline productivity and performance Project 54)

Findings

1) Correlation result shows that there is a strong association between dependent variable project waste index (performance) and coefficient of variability for labor productivity which is the independent variable. The analysis yielded R value of 0.588. Therefore, the independent variable is thus found to be significant predictor of performance of site labor crew for floor tiling activity investigated.
2) It was found that the effect of labor productivity variability on performance of tiling activity is 44%. This means that variation in crew performance in floor tile laying is accounted for by variability in labor productivity.

Conclusions

The objective of this research is to determine the relationship between variability in job-site labor crew productivity and performance in the floor Tiling activity on selected sites. The effects of variability on jobsite performance were determined. The mean variability for each of the site activities for floor tiling was found to be 36.43%. The result is slightly higher than that of the previous study which was discovered to be 20% for floor tiling. This variation could be due to analytical approach and method of data collection. The level of variations in daily productivities of all site activities examined showed ample rooms for labor performance improvement. This means that the extent of gaps between the daily productivities and the baseline productivity were dependent on the level of the coefficient of variability. It was also found out that the closer the values of daily labor productivity to the baseline productivity the better the labor performance this was evident with some of the projects that performed well which had low project waste index (pwi) values. Which means reducing variability improves labor performance. Therefore, this supports the lean theory of improving performance by reducing variability in labor productivity.

It is therefore recommended that the impact of variability on performance of tillers on site be measured using labor productivity data. Also the effect of labor productivity variability on performance of tiling crew can be reduced by adopting any of the following:

i. Where Output decreases, the decrease in input should be proportionately greater than the decrease in output.
ii. For greater efficiency maintain same output with fewer inputs to reduce output variability.
iii. If labor input must be kept stable to increase output incentives plan must be in place.

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Appendix I

Table1: Computation of research variables

S/N	Project code number	Coefficient of Variation Qty	Coefficient of Variation LP	Total Work days	Average daily output m^3	Cumulative Productivity whr/m^3	Baseline Productivity	Project waste index
1	Project 1	0.6173	0.440	15	29.1947	1.0573	0.6598	0.4531
2	Project 2	0.4962	0.410	10	36.2420	1.0237	0.7722	0.2867
3	Project 3	0.6483	0.434	14	39.3457	1.1074	0.6265	0.5482
4	Project 4	0.7417	0.461	14	33.3286	1.0373	0.5381	0.5691
5	Project 5	0.6425	0.452	16	36.7219	1.1556	0.5342	0.7084
6	Project 6	0.5594	0.384	18	50.4444	1.1129	0.7204	0.4474
7	Project 7	0.1459	0.150	13	23.7623	1.8630	1.6810	0.2075
8	Project 8	0.3025	0.241	10	51.5760	1.1517	0.9981	0.1751
9	Project 9	0.3642	0.220	10	56.1200	1.0798	0.9085	0.1953
10	Project 10	0.5248	0.576	10	68.2300	0.9028	0.5587	0.3923
11	Project 11	0.2697	0.142	10	65.1730	1.0679	0.9405	0.1453
12	Project 12	0.2841	0.229	9	64.2678	1.2915	1.1517	0.1594
13	Project 13	0.3445	0.174	10	56.3920	1.1704	1.0473	0.1403
14	Project 14	0.5458	0.476	10	79.5320	0.8590	0.6405	0.2490
15	Project 15	0.3919	0.253	10	69.9270	1.0511	0.8832	0.1914
16	Project 16	0.3373	0.164	11	67.7555	1.0050	0.8572	0.1684
17	Project 17	0.2828	0.124	10	65.3550	1.0267	0.9021	0.1420
18	Project 18	0.5805	0.453	10	81.0250	0.9059	0.7101	0.2232
19	Project 19	0.5818	0.534	10	31.5000	0.9079	0.6119	0.3374
20	Project 20	0.5189	0.567	14	37.1429	0.8769	0.5974	0.3186
21	Project 21	0.2674	0.148	10	19.1780	1.6529	1.4782	0.1992
22	Project 22	0.3661	0.139	10	10.7950	1.5841	1.4497	0.1532
23	Project 23	0.5890	0.497	10	20.1820	0.9266	0.6489	0.3165
24	Project 24	0.3002	0.256	9	22.5589	1.2609	1.0465	0.2444
25	Project 25	0.2826	0.213	11	10.3091	1.4815	1.2902	0.2181
26	Project 26	0.5815	0.497	11	21.7273	1.0167	0.8915	0.1427
27	Project 27	0.6244	0.324	10	21.8360	1.1632	1.0151	0.1689
28	Project 28	0.3827	0.185	21	27.4504	1.3097	1.1066	0.2315
29	Project 29	0.4370	0.335	13	29.7273	1.0336	0.8282	0.2342
30	Project 30	0.4203	0.235	20	26.6600	1.2847	0.8829	0.4580
31	Project 31	0.4161	0.205	20	25.2270	1.2982	0.9591	0.3866
32	Project 32	0.3197	0.338	11	17.2400	1.2392	0.8581	0.4344
33	Project 33	0.6581	0.266	10	38.4450	1.2745	1.0740	0.2286
34	Project 34	0.3287	0.481	12	63.9067	1.0510	0.7454	0.3484
35	Project 35	0.5448	0.494	10	58.3000	1.0257	0.6819	0.3920
36	Project 36	0.2940	0.113	10	53.7920	1.1005	0.9744	0.1438
37	Project 37	0.4084	0.229	10	56.2260	1.1240	0.9850	0.1585
38	Project 38	0.3967	0.190	10	56.5020	1.0814	0.9686	0.1285
39	Project 39	0.3363	0.462	10	58.5840	1.0959	0.7520	0.3920
40	Project 40	0.5285	0.451	10	58.4580	1.0366	0.7733	0.3002
41	Project 41	0.2661	0.136	10	61.0370	1.0272	0.9102	0.1334
42	Project 42	0.3702	0.485	10	56.5450	1.0187	0.7078	0.3543
43	Project 43	0.2201	0.190	10	59.3960	1.0304	0.9050	0.1429
44	Project 44	0.4220	0.479	10	59.0200	0.9997	0.7055	0.3354
45	Project 45	0.1802	0.155	10	59.3040	1.1955	1.0340	0.1842
46	Project 46	0.2813	0.137	13	19.4277	1.6273	1.4395	0.2141
47	Project 47	0.6384	0.342	20	25.9470	1.2526	0.7032	0.6262
48	Project 48	0.7280	0.545	9	48.8911	0.7931	0.6496	0.1636
49	Project 49	0.3522	0.397	19	41.4211	1.1144	0.7593	0.4048
50	Project 50	0.3933	0.162	20	38.7000	0.8243	0.6484	0.2005
51	Project 51	0.2257	0.171	22	43.5909	0.8738	0.7276	0.1667
52	Project 52	0.2999	0.173	16	48.8750	0.8670	0.7307	0.1554
53	Project 53	0.3441	0.388	14	40.5000	1.0970	0.8200	0.3158
54	Project 54	0.3951	0.108	11	40.9700	1.1183	1.0115	0.1218
55	Project 55	0.2782	0.171	10	41.1540	0.9963	0.8740	0.1394
56	Project 56	0.4260	0.211	10	40.8240	0.9651	0.8498	0.1315
57	Project 57	0.5234	0.479	10	69.4830	0.9196	0.7110	0.2379
58	Project 58	0.2508	0.163	10	43.7670	0.9825	0.8598	0.1399
59	Project 59	0.3887	0.198	10	39.1120	1.0406	0.9294	0.1267
60	Project 60	0.3719	0.230	8	37.2875	1.0727	0.9459	0.1446
61	Project 61	0.4073	0.224	15	57.6220	0.9765	0.8389	0.1568

Source: Researcher's field work