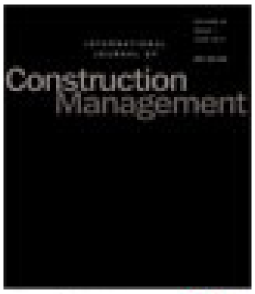

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Impact of poor labor productivity on construction project cost

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ABSTRACT
Construction industry faces challenges with relevancy problems related to labor productivity. Numerous ways are implemented to quantify the damages which are resulted from poor labors productivity in construction. The aim of this paper is to spot the impact of poor labor productivity on the construction project cost. Using the measured baseline productivity and determining the difference between the actual cumulated times and the baseline estimation at the ending of the work period, the increase of the project cost is going to be determined. The data was collected, measured and investigated from a mega construction project in Egypt. The project consists of 18 apartment buildings with an area 1600 square meter for each building. The study is based on data which was taken through 69 daily works of labor celling steel fixer's productivity over a 6-month period. It was concluded that the final labor cost of the project was greater than the estimated cost as a result of the poor labor productivity. Finally, the time used by a construction laborer to complete the total quantities of the work in normal operating condition averages about 81% of the overall time used.

KEYWORDS
Baseline productivity; poor labor productivity; construction project cost

Introduction

Poor labor productivity of construction projects is one in all the problems in developing countries, wherever most of the building construction work remains on manual basis. Poor labor productivity of construction is always one of the causes of cost and time overruns in construction projects. One of the largest issues for any company is to enhance their labor productivity, represent the exchange of resources into wanted products and determine the business profit. Many studies, which evaluated and measured labor productivity, are presented for construction sector in the past. The current paper indicates that it is hard to estimate such an influence of poor labor productivity on the cost of the project, and at present-day there are no generally accepted criteria to determine poor labor productivity in the construction sector. This shortage of strategies for measurement construction labor productivity highlights the requirement to reinforce measurable assessments for the building construction labor productivity, and this is often purported to be the subject of this study. The first goal of this paper is to produce an applied approach for calculating the labor productivity baseline that reflects a contractor's normal operational performance and develop the impact of poor labor productivity on the cost of the projects. There are many productivity measurement methods applied for estimating productivity of labor for crew in construction sectors. These techniques are the Activity Sampling (AS), the Study of Time (SOT), Forman Delay Survey (FDS), and Craftsman Questionnaire (CQ) (Zeyad and Adnan 2003). In this study, AS technique is used to determine the time of the worker which is spent in any activity. AS is described as a method in which considerable quantity of observations are created for labors, equipment, or activities throughout a period. Every observation logs what is occurring at that moment and the measurement logged for a specific activity is an amount of the time in which that activity happens. AS investigations offer the essential data to establish how time is being used by the labor, discover the trouble region that produce the poor labor productivity, and establish a base line value for labor productivity development (Thomas et al. 1984).

For every project, quality, cost, time and productivity are the most concern. Higher productivity is often attained if the management of project includes the abilities of coaching and education, personal fitness, the work technique, motivational aspects, the kind of machines, tools, needed materials and equipment, the work to be performed, expected quality of work, and the kind of work to be performed (Rowlinson and Procter 1999). Therefore, great attempt has been focused to grasp the productivity thought with totally different methodologies taken by researchers, leading to a good sort of productivity meanings (Pilcher 1992; Lema and Samson 2002). Productivity is usually described as the mean labor times needed to install a unit of material (Rowlinson and Procter 1999). The U.S. Commerce Department outlined productivity as 'the moneys of output per human-hour of labor input' (Adrian 1987). The term 'productivity' states the link between outputs and inputs (Borcherding and Liou 1986). In 1950, the European Economic Cooperation Organization presented the meaning of productivity as an amount attained by dividing the output by one in all the production aspects (Sumanth 1984). In 1883, Littre stated the productivity as the 'ability to produce' (Jarkas 2005). Labor is one of the fundamental needs within the construction sector. Productivity of labor sometimes relates workforce in terms of labor cost to the amount of outputs created (Borcherding and Liou 1986). In different words, the meaning of labor productivity is the quantity of services and products which are created by a helpful factor (labor) within the unit of time (Drewin 1982).

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Table 1. Daily data collection sheet.

Project address: Sheikh Zayed City				
Day No: 16			Floor No: ground floor	
Work start: 8 am			Work End: 5 pm Break: 1 h	
No. of labor: 17		Forman: 1	Craftsman: 12	Unskilled Workers: 4
Item	Crew size	Work hour (h)	Daily quantities (kg)	Labor daily productivity (kg/h)
Col.	17	136	10000	73.529

Daily quantities (kg) = 10000 kg.
Work hours (h) = 17 (labors) X 8 (h) = 136 h.
Labor daily productivity (kg/h) = 10000/136 = 73.529 kg/h.

Ahmad et al. (2020) investigate macro-economic labour productivity and identify the methodological problems inhibiting the effective measurement of construction labour productivity in Norwegian. The results suggest that construction labour productivity is not declining and is actually a productive industry in terms of value added per working hour. Panas and Pantouvakis (2018) use the learning curves for the estimation of construction productivity. Another study was development in Jordan to explain and examine the factors that influence construction labor productivity. It was ended that the top three categorized were 'productivity increases by financial incentives', 'high labor experience increases productivity', and 'productivity increases by trust and communications between management and workers' (Hiyassat et al. 2016). In the construction sector, several internal and external factors are irregular and are tough to predict. These factors lead to a continuous deviation in labor productivity. The results of those variations might result in serious money losses. Jarkas (2015) identifies, explores, and ranks the relative weight of the important aspects affecting labor productivity in Bahrain's construction industry. Using the index of relative importance method, the next factors were identified as greatest important in their impact on labor productivity: (1) labor skills; (2) working overtime; (3) shortage of labor supervision; (4) tough review by the consultant; (5) interruption in responding to needs for information; (6) rework; (7) faults in project drawings; (8) shortage of motivation system; (9) coordination between design disciplines; and (10) bad weather. Sherif et al. (2014) identify the most important factors affecting on labor productivity in Egyptian's construction industry, these factors were (1) delay of payment; (2) weather conditions; (3) overtime of working; (4) technical specification clearness; (5) labor motivation; (6) experienced labor lack; (7) shortage of leadership; (8) increase in humidity; (9) shortage of labor supervision; and (10) labor skill.

Also, Alaghbari et al. (2019) recognize and rank factors influencing construction labor productivity in Yemen. They concluded that labor's skills and experience, materials availability in site, leadership and good organization in site management, and safety and political situation were the highest important factors in their influence on construction labor productivity. Furthermore, significant cost will be often saved if the productivity is improved as a result of an equivalent work which is often done with less manpower, so decreasing total labor cost (Thomas 1991). Productivity is the outcome of many interrelated factors. Past study shows that the productivity decreases with the overtime. Overtime firstly result in amplified output; however ongoing overtime could result in reduced productivity and increased costs (Hinze 1999). The main causes are fatigue, amplified absenteeism, reduced morale, decreased supervision efficiency and increased accidents (Horner and Talhouni 1995). To achieve considerable productivity, each one of a crew needs sufficient area to perform duty without being influenced with the opposite crew members. Once a lot of labors are assigned to execute explicit task, in a located quantity of area, it's possible that interference might happen, therefore reducing productivity. In addition, once many jobs are allocated to work within the same space, the chance of interference increases and construction labor productivity is also decreased. Interference between the varied laborers and crews is due to management on construction project sites. As an example, a crew of steel-fixture will require to wait before setting the reinforcement bars if the carpenter's frame is unfinished. The construction ways and kinds of activities also affect construction labor productivity (Sanders and Thomas 1991). Time utilized by a labor in construction industry equal to 30% of the full time available. Solely, a worker within field works efficiently for 2.5 h of his 8-h shift (Alinaitwe et al. 2005).

Objectives

In the construction sector, poor labor productivity is one of the most issues. Labor costs in the construction sector are approximated to be about 40% of the total construction project cost (Hanna et al. 2005). As a result of labor productivity is more variable and changeable than different project-cost parts, it becomes essential to measure the labor productivity and understand the impact of labor productivity on the cost of project. An increase in construction labor productivity can decrease the labor cost in an inversely proportion. The objective of this study provides an approach for establishing the labor productivity baseline and develops the impact of poor productivity on the cost of the construction projects. Thus the contractor will use this data as a lesson learned in future projects.

Research method

The data were collected from a construction project in the 6th October city in Egypt which consists of 18 apartment buildings, and each building has 5 stories, with an area 1600 square meter for each building. The study is based on data which was taken through 69 daily works (2896 work hours) of labor celling steel fixer's productivity over a 6-month period based on number of observations as follow:

Number of observations

Observations number needed to find the construction labor productivity were estimated from the next formula (Harris and McCaffer 1995; Lema 1995; Olomolaiye et al. 1998).

$$N = \frac{Z^2 * P * (1 - P)}{L^2} \quad (1)$$

where N is the size of sample, Z is the value taken from the statistical tables and depend on the level of confidence, P is activity observed percentage and L is the accuracy limit which will be ± 5%. This study used (Z = 2) for 95% confidence level. To

Table 2. Data of daily labors productivity of steel fixing activity.

Work day	Crew size per day	Number of craftsman	unskilled workers	Labor hours (h)	Daily quantities (kg)	Labor daily productivity (kg/h)	Cumulative hours (h)	Cumulative quantities (kg)	Cumulative quantities percentage
1	7	5	2	56	3160	56.429	56	3160	1.200
2	4	3	1	32	2200	68.750	88	5360	2.036
3	7	5	2	56	2300	41.071	144	7660	2.909
4	4	3	1	32	1600	50.000	176	9260	3.517
5	3	3	0	24	1600	66.667	200	10860	4.124
6	7	5	2	56	3400	60.714	256	14260	5.416
7	4	3	1	32	1700	53.125	288	15960	6.061
8	6	5	1	48	2200	45.833	336	18160	6.897
9	3	3	0	24	1600	66.667	360	19760	7.504
10	5	4	1	40	1700	42.500	400	21460	8.150
11	7	5	2	56	2900	51.786	456	24360	9.251
12	4	3	1	32	1800	56.250	488	26160	9.935
13	9	7	2	72	3700	51.389	560	29860	11.340
14	8	6	2	64	3200	50.000	624	33060	12.555
15	19	14	5	152	9060	59.605	776	42120	15.996
16	17	13	4	136	10000	73.529	912	52120	19.794
17	19	14	5	152	10000	65.789	1064	62120	23.592
18	17	13	4	136	6000	44.118	1200	68120	25.870
19	14	11	3	112	5250	46.875	1312	73370	27.864
20	14	11	3	112	7500	66.964	1424	80870	30.713
21	10	7	3	80	6000	75.000	1504	86870	32.991
22	10	7	3	80	5500	68.750	1584	92370	35.080
23	8	6	2	64	4000	62.500	1648	96370	36.599
24	10	7	3	80	6300	78.750	1728	102670	38.992
25	10	7	3	80	6000	75.000	1808	108670	41.270
26	14	11	3	112	6000	53.571	1920	114670	43.549
27	8	6	2	64	3575	55.859	1984	118245	44.907
28	6	5	1	48	2575	53.646	2032	120820	45.885
29	16	12	4	128	5149	40.227	2160	125969	47.840
30	12	9	3	96	1030	10.729	2256	126999	48.231
31	18	13	5	144	1350	9.375	2400	128349	48.744
32	18	13	5	144	1783	12.382	2544	130132	49.421
33	18	13	5	144	1436	9.972	2688	131568	49.967
34	7	5	2	56	1130	20.179	2744	132698	50.396
35	19	13	6	152	1270	8.355	2896	133968	50.878
36	8	6	2	64	1470	22.969	2960	135438	51.436
37	20	14	6	160	1730	10.813	3120	137168	52.093
38	20	14	6	160	2575	16.094	3280	139743	53.071
39	16	12	4	128	1915	14.961	3408	141658	53.799
40	16	12	4	128	7400	57.813	3536	149058	56.609
41	18	13	5	144	2583	17.938	3680	151641	57.590
42	16	12	4	128	6600	51.563	3808	158241	60.096
43	23	16	7	184	1151	6.255	3992	159392	60.534
44	12	9	3	96	1335	13.906	4088	160727	61.041
45	24	17	7	192	1311	6.828	4280	162038	61.538
46	7	5	2	56	2934	52.393	4336	164972	62.653
47	20	14	6	160	2000	12.500	4496	166972	63.412
48	8	6	2	64	2990	46.719	4560	169962	64.548
49	6	5	1	48	3000	62.500	4608	172962	65.687
50	5	4	1	40	3000	75.000	4648	175962	66.826
51	6	5	1	48	3000	62.500	4696	178962	67.966
52	6	5	1	48	3000	62.500	4744	181962	69.105
53	6	5	1	48	3800	79.167	4792	185762	70.548
54	5	4	1	40	2700	67.500	4832	188462	71.574
55	6	5	1	48	3300	68.750	4880	191762	72.827
56	7	5	2	56	3900	69.643	4936	195662	74.308
57	7	5	2	56	3850	68.750	4992	199512	75.770
58	8	6	2	64	4600	71.875	5056	204112	77.517
59	6	5	1	48	3600	75.000	5104	207712	78.884
60	11	8	3	88	6800	77.273	5192	214512	81.467
61	12	9	3	96	6000	62.500	5288	220512	83.746
62	8	6	2	64	5000	78.125	5352	225512	85.644
63	12	9	3	96	5000	52.083	5448	230512	87.543
64	11	8	3	88	5800	65.909	5536	236312	89.746
65	10	7	3	80	4000	50.000	5616	240312	91.265
66	11	8	3	88	6300	71.591	5704	246612	93.658
67	10	7	3	80	5000	62.500	5784	251612	95.557
68	11	8	3	88	6500	73.864	5872	258112	98.025
69	10	7	3	80	5200	65.000	5952	263312	100.000

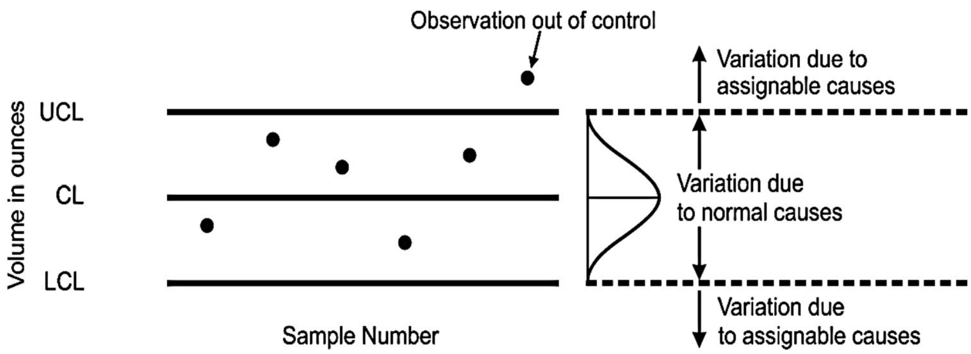

Figure 1. Control chart.

maximize N, the differentiation of N will be equal to zero,

$$\frac{dN}{dP} = \frac{Z^2}{L^2}(1 - 2P) = 0 \quad (2)$$

Then, P equals 0.5 (Lema 1995). Substituting $Z = 2$, $P = 0.5$ and $L = 0.05$ into the Equation (1) provides: N equals 400.

Thus if N equals 400 is applied, all possible values of P would meet the accuracy criteria. No of observation in this research was taken 2896 work hours through 69 daily.

Table 1 shows daily data collection sheet in which the location of the project, crew size number, daily work hours, and daily quantities are collected. The number of work hours per day is 8 h and there is no night shift in this steel fixing activity for the study project because the crew of steel fixing waits the framework crew to finish their working. Interdependent activities are the efforts that are performed by more than one craft. Consequently, the work is combined. In this study, the framework crew constructs the frame tracked by steel fixing crew. The framework crew can operate at its own rate while the time of the steel fixing crew is influenced by the framework crew. Table 2 shows data of crew size, composition, working hours, daily quantities, labor daily productivity, cumulative hours, cumulative quantities and cumulative quantities percentage of steel fixing activity for the studied project.

The main objective of this study is to deliver an approach for creating a productivity baseline which shows a contractor's regular working performance. The following steps presented methodology of the research:

1. Use individual labor productivity values related with a specific work effort in dispute.
2. Consecutively use a process control chart to the labor productivity quantities in order to remove abnormal quantities.
3. Compute the baseline labor productivity as the average construction labor productivity, built on the quantities, to make a contractor's regular working performance.
4. Find the difference in time between cumulative times due to the baseline productivity and cumulative times to complete the work.
5. Identify the time loss to complete the work. Hence, calculate the increase of the project cost due to the poor labor productivity.

In practice, it's been troublesome to correctly calculate the incremental cost as a result of labor inefficiencies on construction projects.

Control charts

A control chart is a tool used to monitor, and manage the manufacturing process quality (Shewhart 1931). It was later known as valid to other kinds of processes, like those concerned in the transfer of services and the performance of varied kinds of activities (Deming 1986). The control chart has a specified shape that is represented in Figure 1. The process metric values, which are used to control any process, are drawn on the vertical axis, and the continuous values in time are drawn on the horizontal axis. The metric sometimes could be a related summary statistic, as a sample average, calculated for repetitive samples chosen at every of the time periods denoted.

Three horizontal marks are represented in the chart, which match to the upper limit of control (UCL), the center line (CL) and the lower limit of control (LCL). The center line corresponds to a mean value of the metric observed. Conventionally, the upper control limit is computed as: mean value + standard deviation, and the lower control limit is computed as: mean value – standard deviation. When plotted, points falling inside the limits of control are supposed to fall within a regular range of variation or to a typical reason behind variation. Points falling outside any control limit are due to external reasons of variation. The limits of control are made such that when a value falls beyond either limit, it is decided that the matching value is unlikely to be produced by a process working at a normal level specified in the value terms at the center line. Therefore, it will not be created under regular working conditions. Linking to the key subject of the study, namely, removing values of productivity which are not similar to the regular labor performance takes place in order to separate those that can be used to estimate a baseline. Thus, a specific control chart is needed (Grant and Leavenworth 1988; Montgomery 1991). The metric used is that the separate productivity value of labor corresponding to a specific unit of time; such as a day. The center line is computed as: Arithmetic Mean (the values of labor productivity/entire values number). The standard deviation is computed on the basis of several observations that are collected at different points in time. In this study case, the standard deviation is estimated based on another variation measure; the range. The range of observations set is the variance between the greatest and least values during a gathering of observations. In this study case, a technique chosen from statistical process control is usually applied. This is achieved by computing the range between ordered values pairs, averaging these values and dividing by a modification factor to regulate for the fact that the standard deviation value is needed. Automatically, Control charts can be produced with the help of standard arithmetical computer software packages.

Determination of baseline

As detailed above, in order to find a baseline value of the construction labor productivity under the regular conditions of

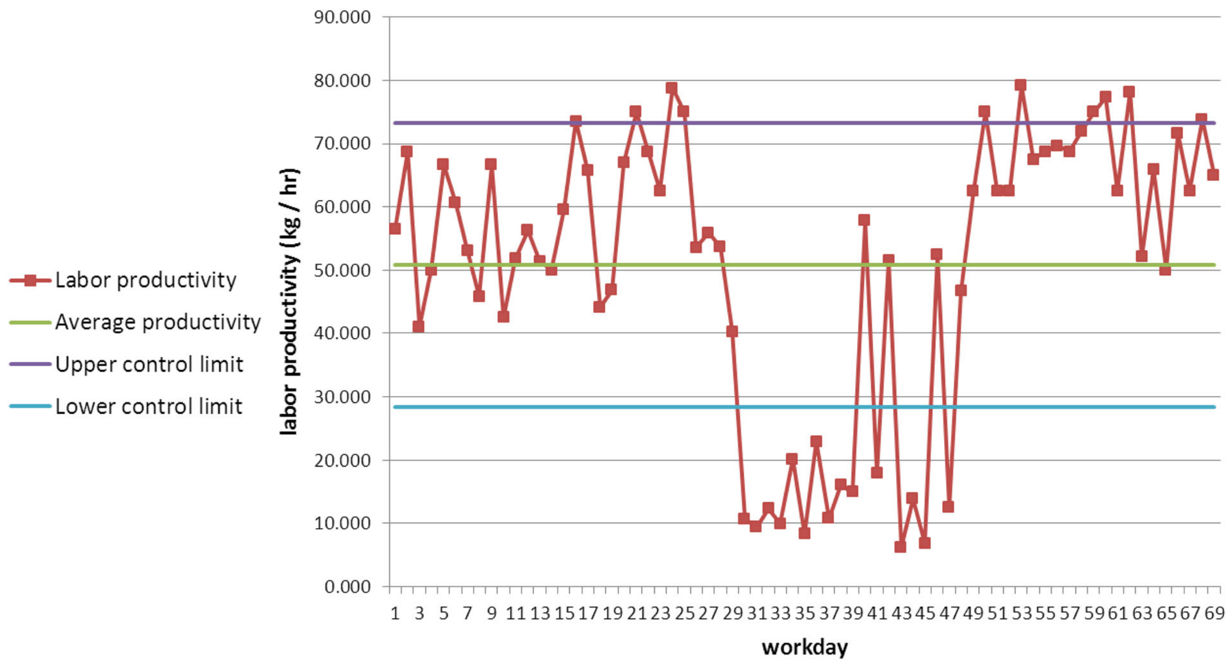

Figure 2. 1st Control chart.

operating, we use an individual control chart to the values of labor productivity. Since some of all unfamiliar values may fall outside of control with respect to a particular set of control limits, it is essential to successively reapply the individuals chart to the values of productivity, using a recomputed the limits of control and centre line, till no values fall out the limits of control. The baseline level of productivity equals the average construction labor productivity of the values falling inside the limits of control after the final iteration, which relates to the control chart created after unusual (out-of-control) values are removed. Not only is the resultant baseline not essentially account for the normal productivity level, but it also hides variation around this level. By using the daily labors productivity of the steel fixing activity data showing in Table 2, the impacted and unimpacted period of operation are presented in order to determine the baseline, without mention to an impacted and an unimpacted period. As shown in Figure 2, this is the control chart designated as first Control Chart and applied initially to the points of productivity for the 69 work day record. Labor productivity for Workdays No. 17, 22, 25, 26, 50, 53, 59, 60, 62 and 68 which are shown on the figure, fall outer the upper limit of control and the labor productivity for Workdays No. 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 43, 44, 45 and 47, which are shown on the figure, fall outer the lower limit of control. Therefore, these values are eliminated when recalculating the control bounds for the succeeding chart. More extra iterations are required to get a control chart such that no values fall outer the control limits. Hence, the second control chart is represented in Figure 3. Labor productivity for Workdays No. 2, 20, 34, 35, 36, 37and 42 which are shown in Figure 3, fall outside the upper limit of control and the labor productivity for Workdays No. 3, 8, 10, 17, 18, 25 and 29, fall under the lower limit of control. Therefore, these values are eliminated when recalculating bounds of the control for the succeeding chart. Finally, the third chart developing from this procedure is portrayed in Figure 4, which is described as final Control Chart. This final control chart represents the individual such that no values fall outside of control limits after removing out-of-control values from the immediately preceding chart. The baseline labor productivity, therefore, equals 58.462 kg/h, the center line on the last control chart. This quantity, equivalently, can be estimated as the remaining arithmetic average of the labor productivity after removing the points specified as out-of-control on the last chart. Variation in the remaining 30 values of labor productivity in Figure 4 still exists, but this is significantly less than variation occurring at the outset. Hence, the mean of the corresponding values (i.e. 58.462 kg/h) is used to characterize the average construction labor productivity under the regular conditions of operating. Depending on the particular values of construction labor productivity, the total quantities of work is divided by the average baseline value to find the total hours number to achieve the work required corresponding to the normal condition operation in the absence of a disturbance. This value denotes the baseline total hours as in Figure 5 and equal to (the division of 263312 kg by 58.462 kg/h) 4,504 h.

Results and discussion

The baseline labour productivity in Egyptian's construction industry under normal operating conditions is determined. The total number of hours to complete the work required corresponding to the normal condition operation in the absence of a disruption is carried out.

To identify the loss of time due to poor labor productivity, linearly, use the variance between the estimated unimpacted times, cumulative baseline productivity, and the real cumulated times as the quantity of loss hours. Figure 5 presents the cumulative percent completion in kg related to the cumulative labor productivity of steel fixing operation plotted against the cumulated hours based on everyday data, which gives a simple description of the labor times needed to attain progress through the different project phases. The drawn values are obtained from the construction labor productivity outcomes of the 69 data points of daily labor celling steel fixer's productivity. The necessary data used in the figure are presented in Table 2. A linear projection is shown in the figure, which is built on cumulative of the baseline productivity including the unimpacted values. The

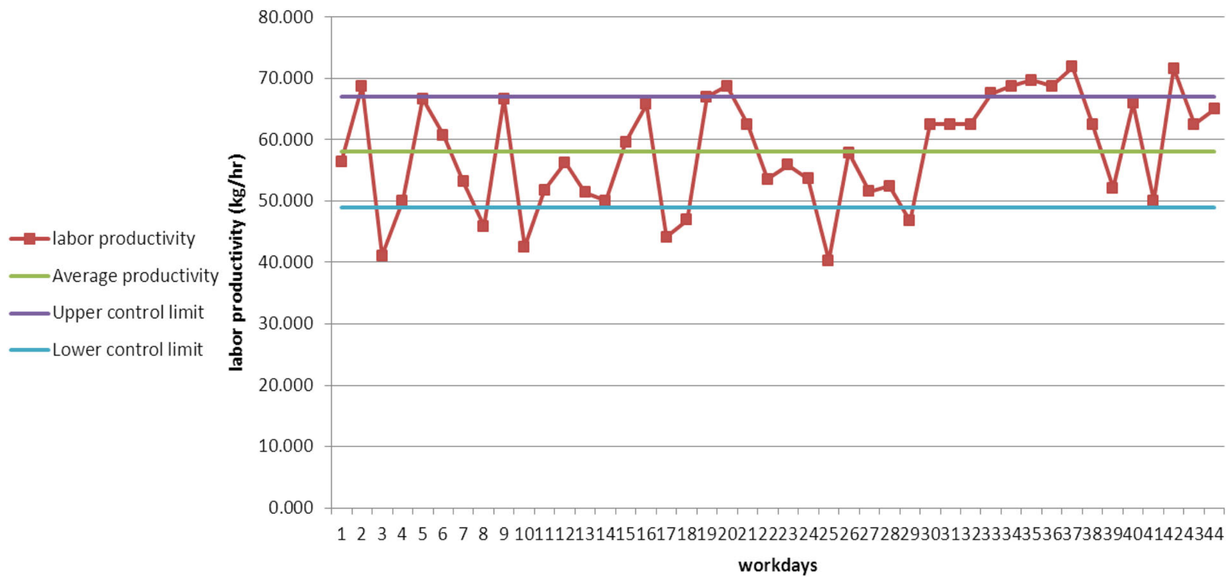

Figure 3. 2nd Control chart.

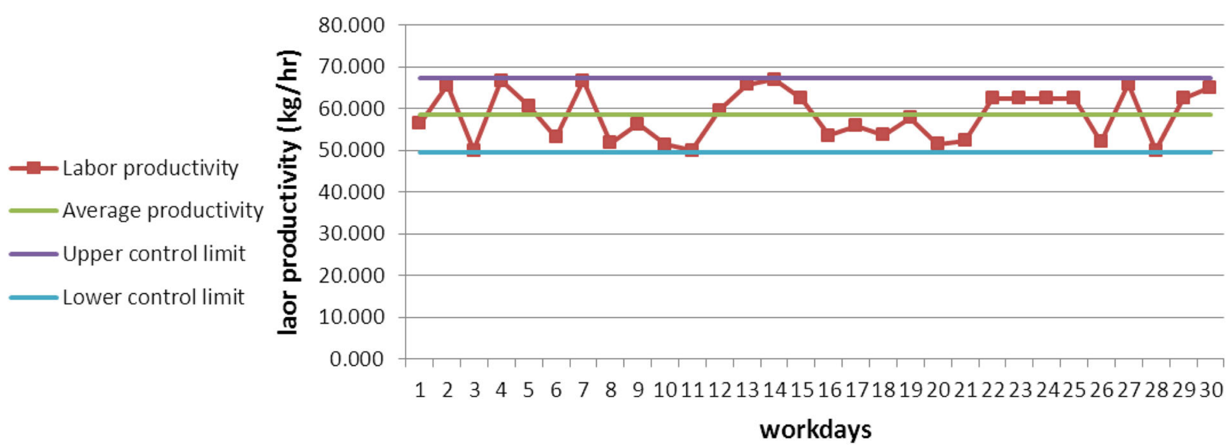

Figure 4. The final control chart.

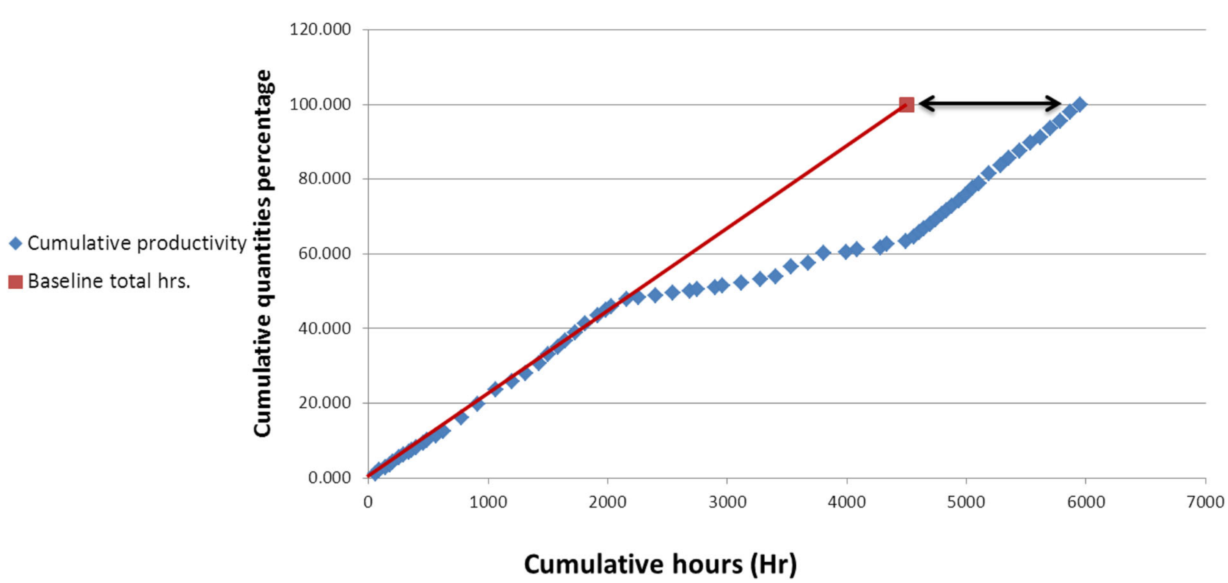

Figure 5. Time loss due to the cumulated hours based on daily records.

rojection of the cumulative baseline productivity leads to a value of 4,504 h at 100% complete of work under the hypothesis that this would characterize the accumulated hours that would have been used. The total hours as the quantity of actual cumulated hours equal 5952 h. The loss of time in hours equals the amount of actual accumulated hours, 5,952 h, minus the cumulative baseline productivity, 4,504 h, which is equal to 1,448 h. This value defines the difference between the final cumulative number of hours to finish the whole project and the cumulative baseline labor productivity which is called time loss as in shown in Figure 5.

Ordinary labor productivity variation and labor productivity variation due to an external reason are two principal kinds of variation to be classified when allocating sequences of points, such as daily construction labor productivity in this situation. The basic reason of the ordinary labor productivity variation is due to the labor will not achieve the identical productivity from one time to the other time, even in the nonexistence of the external reason influencing the process of the work. This variation cannot be decreased and, so, should be agreed as component of the performance related with any group of recurring jobs.

External reasons of variation are causes that are related to the contractor control or causes that are not. In the case of this study and from the previous information, it is deduced that the reasons for poor labor productivity are the ineffectual supervisors and the absence of labors skills which influence the period to complete activity, thus, there is a necessity for nonstop training of them. On the other hand, weak interaction due to incorrect instructions causes work slowdown, rework, failure to understand the drawings and work being refused by the consultants. As a result, the drawings should be made well-defined and clarified to the labors (Alinaitwe et al. 2007). Moreover, there are additional secondary jobs that require to be made, such as forms clean up, fastening of steel, and cleaning of the site. Therefore, there are additionally hours for these subtasks to be executed. Besides, schedule acceleration arises when the contractor tries to enlarge daily output further than usual size. This is generally made by employing additional labors. Consequently, the control system is insufficient when the number of crew increases so; the labor productivity drops (Thomas et al. 2002). Alongside this, Alinaitwe et al. (2007) stated that abnormally adverse weather influences the labor productivity, so the contractor may build garages and workshops (temporary structures) to prepare the steel inside it, to avoid the bad weather. In other days, it has been noticed on many occurrences that the labor productivity was smaller than usual for obscure cause. Secret questions uncovered that the work that day was badly arranged. The supervisor had been unsuccessful to organize an essential occurrence or resource. Hence, the team was located at the site with small work to achieve. The technique used in the calculation of the base line productivity in this paper removes automatically the unusual values resulting from these causes.

The previously discussed findings further substantiate the results obtained by Panas and Pantouvakis (2018), whose investigation use the learning curves for the estimation of construction productivity and Alaghbari et al. (2019) whose study recognized the significant impact of constructability on labour productivity in the Yemen.

Cost assessment due to poor labor productivity

Using our approach, the control chart could be used to the values of construction labor productivity, firstly, to see that if any are abnormal values and then to calculate baseline productivity. Consequently, losses could be calculated on the basis of these labor productivity values relative to the determined baseline. Then, a total estimate of the losses is determined as the difference between the entire actual hours focus to an impact minus the resultant baseline productivity. The developing value is used in the assessment of the project loss cost due to the poor labor productivity. Hence, if the average daily labor salary in Egypt is about LE150 ($8) in year 2017, which is about $1/h/labor, then the total loss in the project cost in this case will be $1448. This loss in cost is the loss of one activity which is steel fixing in celling; about (1148/5952 = % 19) loss in time and cost. Thus, the time used by a construction laborer to complete the total quantities of the work in normal operating condition averages about 81% of the overall time used.

Conclusion

The primary objective of this paper is to offer a technique for determine the baseline estimate of construction labor productivity that can be applied to find the impact of the poor labor productivity on construction project time in Egypt. The time loss is the difference between the cumulative hours to achieve the total work and the cumulative hours for normal condition as the base line productivity. Then, the another study goal is to determine the cost related to the time lost because of poor labor productivity so as to use this information as a lesson learned for planning the time and cost for future projects. The time loss converted to cost loss; hence we can identify the percentage of cost loss by dividing the time loss on the total time. In this case study, the time used by a construction laborer to complete the total quantities of the work in normal operating condition averages about 81% of the overall time used. This loss in the time and cost is the loss of one activity which is steel fixing in celling; about (% 19) loss in time and cost. By the aid of the specifically designed process control chart, this is done to separate the variation under regular operating conditions from the unusual variation that is not based on regular working conditions of performance. The technique delivered introduces consecutive use of a process control chart to remove the up normal labor productivity values. The ending control chart, from whom the baseline productivity is acquired, is used as a base for determine the baseline labor productivity. In order to produce the methodology, which can be used with all construction projects types and activities, our approach is presented in terms of a case study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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