FACTORS AFFECTING LABOR PRODUCTIVITY IN BUILDING PROJECTS IN GREAT CAIRO

Hashem,Y.M.[1] ; Ali, Samia M.[2] and Dokhan Sh.A.[3]
[1] Professor of Reinforced Concrete, Faculty of Engineering (Shoubra), Benha University
[2] Assistant Professor of Construction Management, Faculty of Engineering (Shoubra), Benha University
[3] Demonstrator, Faculty of Engineering (Shoubra), Benha University

ملخص البحث
يستعرض هذا البحث العوامل المؤثرة في انتاحية العمالة في مشاريع التشييد للمباني في القاهرة الكبرى في القطاعين العام و الخاص عن طريق نموذج لتحديد معدل الخطورة لهذه العوامل. و شملت الدراسة ثلاثون عامل من العوامل المؤثرة في انتاجية العمالة تم جمعها في ثمان مجموعات تبعا لمصدرها. تم القيام بمسح ميداني من خلال استبيان منظم شمل احدى و أربعون مشروعا من مشاريع تشييد المباني في القاهرة الكبرى و ذلك من وجهة نظر و خبرة مديري المشاريع. هذا و قد رتبت هذه العوامل التي تؤثر في انتاجية العمالة حسب مؤشري الأهمية و التكرار و على حسب معدل الخطورة لكل من العومل المذكورة في البحث. قد خلص البحث الى أن أهم العوامل المؤثرة في انتاجية العمالة في مشاريع التشييد للمباني هي : طول يوم العمل, أعطال المعدات, نقص المواد, نقص المعدات المناسبة, نقص الأدوات المناسبة, قلة مهارة العما لة, نوع المواد, حجم العمل الكبير, الجودة (رسومات غير كاملة, مواصفات غير واضحة, ...الخ).

1. Abstract

This paper reports an investigation of the productivity problems through a structured questionnaire survey of 41 project managers working on construction building projects in Greater Cairo. The projects are divided into two main categories residential building projects and nonresidential building projects. Respondents were required to rate how thirty factors affecting labor productivity with respect to importance and frequency of occurrence. The overall severity of productivity problems was then established using the product of these importance and frequency responses. The ten most significant problems affecting labor productivity were identified as length of work day, equipment breakdown, lack of materials, lack of proper equipments, lack of proper tools, inadequate supervision skill, material type, large volume of work, quality required, and work complexity. The reliability of those thirty factors was tested using Cronbach's Alpha measurement and the results indicated that the thirty factors studied are reliable (α = 0.837) for future use in assessing the severity of the productivity problems.

2. Introduction

Labor productivity is one of the most important risks in construction projects [1], and labor represents even the most significant risk to contractors [2]. The Egyptian construction industry suffers from delays and cost overruns, which are indicators of productivity problems. In developing countries, buildings construction consumes 70% of the construction investment [3,4] , the situation in Egypt is no different with about 80% of the construction investment directed to buildings construction [5]. Egypt is one of the most densely populated countries in the world with almost 75 million inhabitants. The country therefore adopted a labor incentive strategy to support its economic development. Labor becomes more important input in the construction industry in developing countries since labor costs comprise between 25-40% of the total project cost [6,7].

3. Aims of this study

The fundamental aims of the research reported in this paper may be summarized as follows:1)To confirm Egyptian construction labor productivity problems in building projects .2)To establish a model of evaluating the severity of these problems in Greater Cairo Governorate – Egypt. 3)To evaluate the resulting model using reliability analysis.

4. Factors affecting construction productivity

Over the years, the factors influencing construction productivity have been the subject of inquiry by many researchers[9-13]. The frequencies and importance of these factors varies from one country to another, and from one project to another. Several approaches have been adopted in relation to the classification of factors affecting construction productivity. Various factors have been identified by different researchers from years ago in different countries Nigeria [14], Singapore[15], United states[16], Tanzania [17], Indonesia [18], Thailand [8], Hong Kong [19], Palestine [20], and Uganda [21]. From the existing literature on construction productivity of other countries, it is possible to identify the main productivity problems. In all, 30 factors were investigated on building projects in Greater Cairo governorates. These factors were divided into 8 groups: Site related factors, Work type related factors, Tools and equipments related factors, Material related factors, Consultant related factors, Labor related factors, Contractor related factors, and External factors.

5. Data collection

A questionnaire was designed to identify relative importance and frequency of occurrence of factors affecting labor productivity in construction building projects. The questionnaire was designed giving each respondent opportunity to rate problems on a scale from 4(very important) to 1(not important), or zero for variable that they consider not applicable to their projects .They were then asked to rate the frequency of occurrence of each problem on there present construction sites on a scale from 3(high), through 2(medium), to 1(low). Although a simple random sample is the usual choice in most of research projects, but in order to guarantee that a specific sub sample of the population is adequately represented, a stratified sample was selected to ensure a representative sample of all projects [22]. The characteristics of the strata or segment was carried on three stages: first, the research target the building construction projects as it represent the majority of the construction investment in Egypt and that includes residential and nonresidential buildings. Second, construction projects carried out in year 2006 / 2007 to help in keeping the results of the productivity problems close to the recent situation. Third, construction projects carried out in Greater Cairo were selected, as Greater Cairo has the largest share of the construction investment in Egypt. Sample size of unlimited population "n_o" calculated from equation (1) was equal to 43 projects, and sample size of limited population "n" calculated from equation (2) is equal to 42 construction building projects.

$$n_o = Z^2 * P (1 – P) / d^2 \qquad \text{Eq.(1)}$$

$$n = n_o / (1 + (n_o - 1) / N) \qquad \text{Eq.(2)}$$

Where:
n_o = sample size for unlimited population
Z = statistic for a level of confidence (Z= 1.64 for 90% confidence level)
P = expected prevalence or proportion, or degree of variance between element population (20% P =0.2)
d = precision (90% confidence; 10% error d=0.1)
n = sample size of limited population
N = population (N=1600)
A total of 45 construction building project within Greater Cairo Governorate were surveyed; 15 residential, 26 nonresidential. The overall response to the survey comprised a total of 41 completed questionnaires, representing approximately 91 % response rate. The characteristics of the projects surveyed in this study budget cost, and planned schedule are shown in figure 1.

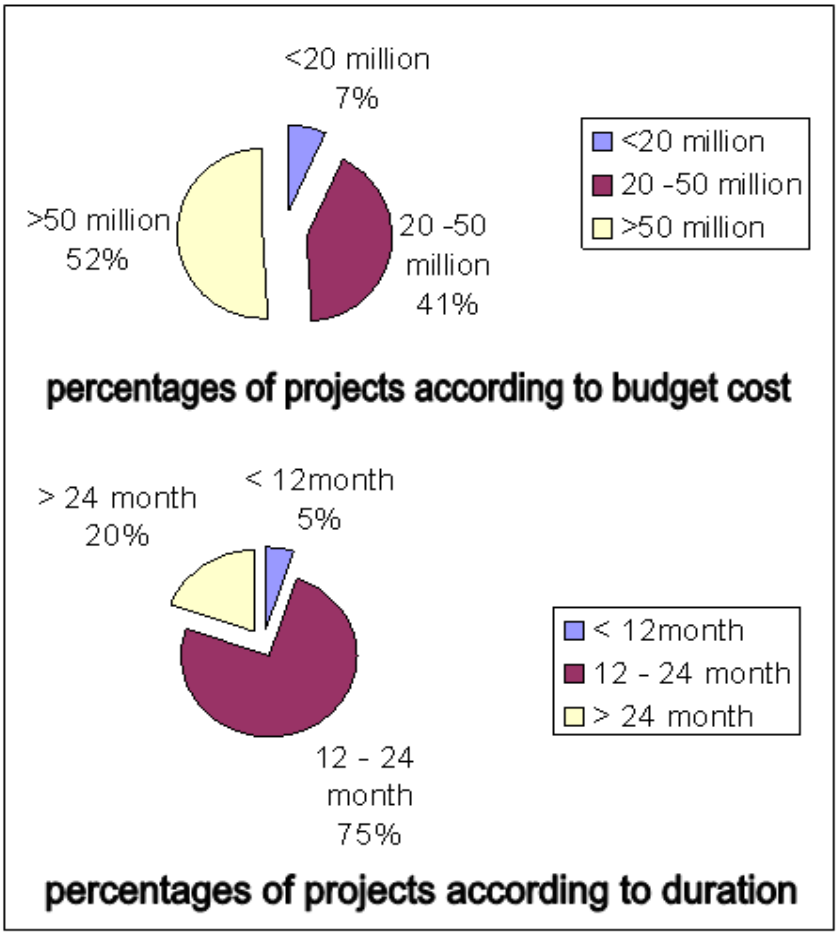

Figure 1. characteristics of the projects surveyed

6. Method of analysis

For data analysis, an advanced and accurate analysis method was needed to arrange the large body of data in a systematic, fast and reliable way. For this purpose the computer software Statistical Package for Social Science (SPSS) and Excel were chosen as the best options available. Data collected from sites will be analyzed using the severity model (figure 2) on three stages.

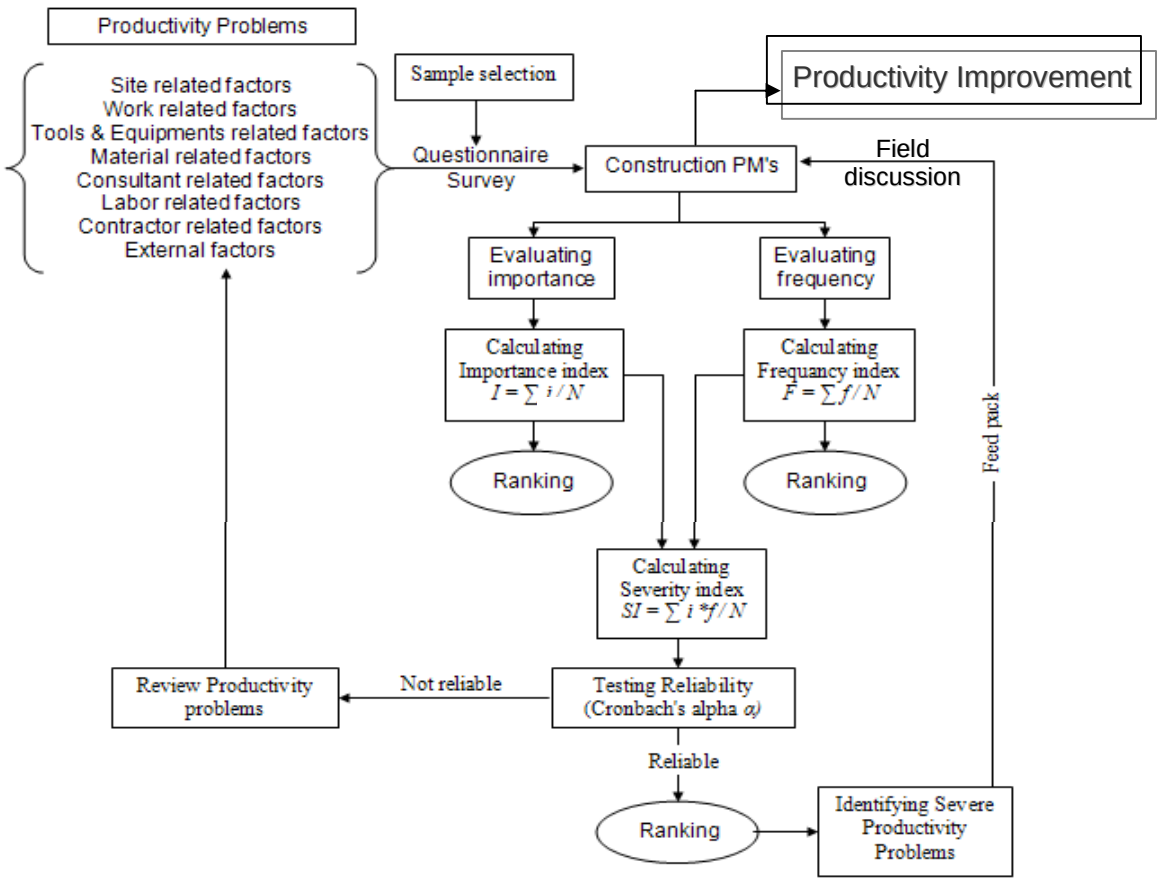

Figure 2. Severity model

The mean value of responses for importance was named the importance index "I" . and The mean value of responses for frequency was named the frequency index "F" using the following equations.

$$I = \sum i / N \qquad \text{Eq. (3)}$$

$$F = \sum f / N \qquad \text{Eq. (4)}$$

Where:

i = Response importance weight (4,3,2,1,0) .

f = Response frequency weight (3,2,1) .

N = Number of projects.

Finally the product of respective importance and frequency responses was named the severity index "SI" and calculated using the following equation.

$$SI = \sum i * f / N \qquad \text{Eq. (5)}$$

Severity indices were used to rank the overall severity of the problems on the building construction projects which affect labor productivity .The greater the index, the more the severity of the productivity problem. Severity index ranges from zero (lowest) when the problem is not applicable to the project, to 12 (highest).

7. Results and discussion

In this study, 30 factors negatively affecting labor productivity in building construction projects have been identified and ranked according to their severity. Table 1 shows the both severity index and the ranking for each problem affecting labor productivity in construction projects. The group severity index was also calculated as an average of the factors included in each group, and then groups were ranked according to their severity. Table 2 shows the group severity index and the ranking of the groups. The results indicated that the main 10 factors negatively affecting labor productivity are: Length of work day; Equipment breakdown; Lack of materials; Lack of proper equipments; Lack of proper tools; Inadequate supervision skill; Material type; Large volume of work; Quality required; and Work complexity.

- Length of work day

  It is the most severe problem negatively affecting productivity between all the 30 factors included in the research. It was ranked the first with the highest severity index 9.367. This could be attributed to the fact that increasing length of work day leads to a lot of problems as fatigue, absenteeism, accidents, and super vision problems which directly lead to productivity loss. Increasing length of work day was mainly due to schedule acceleration and labors most of the time are paid the same wages, which adversely affects morale and positive attitudes of the workers toward the work, that result in loss in productivity. Also, fatigue causes deterioration in morale and positive attitude.

- Equipment breakdown

  The second most severe problem between all factors was equipment break down with severity index 7.833. Although this problem was ranked 16 according to importance but it was ranked first according to frequency of occurrence, this explains the advanced ranking of this problem on the severity scale. These breakdowns are mainly due to poor maintenance and lack of regular service. Many of them are also not in the best condition as they lack spares.

- Lack of materials

  The factor of materials shortages and delays is ranked the third with severity index 7.767 and with small difference from the second problem equipment breakdown. However, basing upon the importance index and frequency index, it was ranked fourth and third respectively.

- Lack of proper equipments

  This factor has a great negative effect on labor productivity; it was ranked fourth with severity index 7.433. Results show that equipment shortages have a high effect on labor productivity, and ranked in advanced positions of all factors negatively affecting labor productivity. This result might be justified, as labor needs a minimum number of equipment to work effectively. If there is a lack of equipment, productivity will decrease.

Table 1. Ranking of problems in building projects according to severity index

Category	Problem	Severity index	Rank
Site	Poor site management & access	5.533	13
	Lack of facility areas	3.733	26
Work type	Work complexity	5.867	10
	Height	4.800	20
	Extra work	5.167	16
	Large volume of work	6.167	8
	Length of work day	9.367	1
Tools& Equipments	Lack of proper equipment	7.433	4
	Lack of proper tools	6.933	5
	Equipment break down	7.833	2
Material	Lack of materials	7.767	3
	Material type	6.300	7
Consultant	Quality required (drawing &specs.)	6.100	9
	Inspection & safety requirements	3.600	28
	Change orders	3.333	30
	Rework	4.700	21
Labors	Inadequate labor skill	3.767	25
	Working overtime	5.600	12
	Absenteeism	4.867	19
	Changing crew members	3.933	23
	Overcrowding	3.733	26
	Crew interfacing	5.500	14
Contractor	Poor organization & management	4.567	22
	Inadequate construction methods	3.833	24
	Improper crew design	5.100	17
	Supervision delay	3.500	29
	Inadequate supervisors skill	6.733	6
External factors	Weather conditions	5.267	15
	Regulatory requirements	5.033	18
	Disruptions	5.633	11

Table 2. Ranking of groups according to group severity index

Category	Group index	Group rank
Site	4.63	6
Work type	6.27	3
Tools& Equipments	7.4	1
Material	7.03	2
Consultant	4.43	8
Labors	4.57	7
Contractor	4.75	5
External factors	5.31	4

- Lack of proper tools

This factor was ranked the fifth with severity index 6.933. The close ranking of this problem and the previous one could have been merged in the same factor from the beginning. Lack of proper tools can be caused by poor maintenance programs leading to frequent breakdown. It has been reported that the main problems regarding tools management, is a careless attitude of workers in handling them and lack of proper maintenance schemes (such as oiling at appropriate intervals and replacing worn parts).

- Inadequate supervisors' skills

The most severe factor in this group is inadequate supervisors' skills, as it was ranked the sixth with severity index 6.733. This could be partly because supervisors do not attend refresher courses. Most of the supervisors are trained but their formal training stops when they leave school. Most of the supervisors in the construction field in Egypt have only attained on-the-job training. Those may not be well versed with many requirements of supervision.

- Material type

Material type was ranked the seventh with severity index 6.300 which illustrate a high effect on labor productivity. This result might be justified, as most of the materials used in construction tasks are not easy to handle and to put in place especially in the lack of needed equipments and the absence of the new technology in most of the construction tasks. Labors spent a lot of the time assigned for the task in handling the materials through the various stages of the project, which result in decreasing the direct work and productivity loss.

- Large volume of work

This problem was among the top ten severe problems that negatively affects labor productivity in construction; it was ranked the eighth with severity index 6.167. This result is justified, as most of the construction projects suffer delays and always in need of schedule acceleration and this result in large volume of work, and labors don’t care about achieving this as long they are being paid.

- Quality required

This problem has high negative effect on labor productivity as it was ranked ninth with severity index 6.100; this could be attributed to high ranking of this problem according to importance and frequency of occurrence. The main cause of this problem is poor communication due to inaccurate instructions and inaccurate drawings. This is largely attributed to the low levels of literacy of the workers and the level of technical training. The most common form of communication is verbal and, moreover, face-to-face. The other reason is that most of the contracting used traditional approach. The frequency of meetings between contractors, clients, and designers may not be as often as it should and this brings gaps in communication. Another common problem was incomplete drawings prevent a project from being progressed smoothly due to, for example, delays for revision or clarification of drawings and specifications, there is no doubt why this factor has a high effect on productivity.

- Work complexity

Although this problem was ranked 19 according to importance but this problem has a noticed negative effect on labor productivity as it was ranked tenth according to severity index 5.867. This could be attributed to the frequency of occurrence of this problem was high as it was ranked sixth according to frequency. The cause of this problem is that of designs that are not easily applicable because designs do not take into account the available resources for construction purposes and inadequate appreciation of construction techniques.

8. Relationship between items and the scale

Data was tested using basic statistics in order to look at the characteristics of the individual items, the characteristics of the overall scale, and the relation between each item and the entire scale. An advanced and accurate analysis method was needed to arrange the large body of data in a systematic, fast and reliable way. For this purpose the computer software Statistical Package for Social Science (SPSS) and Excel were chosen as the best options available. Table 3 shows the overall scale statistics.

Table 3. Scale statistics

Statistics of scale	Mean	Variance	Std. Deviation	N of Items
Item means	161.700	1,323.528	36.380	30

Reliability Coefficient

Another additional step was added to test the reliability of the scale. One of the ways to calculate reliability is to use a measure of internal consistency. The most popular of these reliability estimates is Cronbach's alpha. The coefficient alpha has a maximum value of 1.0 . The larger the overall alpha coefficient, the more likely the items contribute to a reliable scale .Nunnally and Bernstein (1994) suggest 0.70 as an acceptable reliability coefficient, smaller reliability coefficient are seen as inadequate.

Cronbach's alpha was calculated for the 30 items discussed in this research using equation (6) is 0.837, indicating that our scale is reasonably reliable.

$$\alpha = (p / p -1) * (1 - (\sum V(Y_j) / V(Y_o)) \qquad \text{Eq. (6)}$$

Where :
P = number of variables which is equal to number of problems 30.
Yj = observed score of each item.
Yo = total observed score which is equal $\sum Yj$.
V(Yj) = variance of observed score.
V(Yo) = variance of total observed score .

Table 4 illustrates the results if each item removed from the scale in order to observe the relationship between the individual items and composite score. For each item, the first column shows what the average score for the scale would be if the item were excluded from the scale. For example, we know from Table 3 that the average score for the scale is 161.7. If item 1 were eliminated from the scale, the average score would be 156.17. This is computed by simply subtracting the average score for the item from the scale mean. In this case, 161.7 -5.53 = 156.17. The next column is the scale variance if the item were eliminated.

Cronbach's alpha coefficient was also calculated to determine how each item reflects the reliability of the scale by calculating the coefficient alpha after deleting each variable independently from the scale .The Cronbach's coefficient alpha from all variables except the kth variable was calculated by equation (7). The Cronbach's coefficient alpha from all variables except the kth variable is given by

$$\alpha_k = (p -1 / p -2) * (1 - (\sum_{i \neq k} V(Y_j) / V_{i \neq k} (Y_o)) \qquad \text{Eq. (7)}$$

These alphas are shown in the last column. We can see that eliminating item 5 (extra work) causes alpha to increase from 0.837 to 0.861. This indicates the negative effect on the reliability of the scale. This is similar to eliminating items 18, 4, 19, and 6 which lead to increase the alpha value. On the contrary we can see from table 4 that eliminating item 8 (lack of proper equipment) the alpha value decrease from 0.837 to 0.813, this indicates the strong affect of this item on the reliability of the scale, and the same results were observed for items 7, and 1. In order to represent a high reliable scale the items that negatively affect the reliability of the model must be dropped from the scale, but since the change in the calculated alphas is relatively small no item will be eliminated in order to increase the reliability of the scale.

9. Conclusions

There are productivity problems in construction building projects is Greater Cairo. 30 factors affecting labor productivity were identified and ranked according to their relative severity from the view point of 41 project managers in building sites. The reliability of these 30 factors for assessing the effect on labor productivity was tested by cronbach's alpha measurement and the results indicated that the 30 factors tested are reliable (α= 0.837). As a result of this research the contracting companies and researchers should focus on the identification of the major factors affecting labor productivity in order to achieve construction productivity improvement. In order to achieve construction improvement, management must know what to improve; therefore the severity model used in this work can help in assessing the severity of any problem in the construction field.

Table 4. Item-total statistics

Item	Scale Mean if Item Deleted	Cronbach's Alpha if Item Deleted
1	156.17	0.818
2	157.97	0.833
3	155.83	0.840
4	156.90	0.847
5	156.53	0.861
6	155.53	0.844
7	152.33	0.816
8	154.27	0.813
9	154.77	0.824
10	153.87	0.820
11	153.93	0.821
12	155.40	0.821
13	155.60	0.832
14	158.10	0.830
15	158.37	0.834
16	157.00	0.835
17	157.93	0.832
18	156.10	0.851
19	156.83	0.845
20	157.77	0.822
21	157.97	0.840
22	156.20	0.834
23	157.13	0.826
24	157.87	0.833
25	156.60	0.828
26	158.20	0.830
27	154.97	0.840
28	156.43	0.825
29	156.67	0.824
30	156.07	0.827

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