# Factors Influencing Construction Labor Productivity in Egypt

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**Abstract:** Construction is a labor-intensive industry. Therefore, construction labor productivity is of critical importance to the profitability of most construction projects. Many construction industry sectors have been experiencing chronic problems such as poor management, inferior working conditions, and insufficient quality. Many researchers have identified these problems as factors that affect construction productivity and will affect a company's performance and the overall economy of the country. This paper aims to identify, investigate, and rank factors perceived to affect construction labor productivity in the Egyptian construction context with respect to their relative importance. To achieve this objective, practitioners and experts comprising a statistically representative sample were invited to participate in a structured questionnaire survey. The questionnaire comprised 30 productivity factors that were classified under the following three primary categories: (1) human/labor, (2) industrial, and (3) management. The management category was ranked first, followed by the labor category and the industrial category. This study revealed that the following five factors, ranked in descending order, are the most significant in their effects on construction labor productivity in Egypt: (1) labor experience and skills; (2) incentive programs; (3) availability of the material and ease of handling; (4) leadership and competency of construction management; and (5) competency of labor supervision. Industry practitioners and researchers can use the primary outcomes of this study in developing systems to enhance and improve construction labor productivity in Egypt. Also, this paper can serve as a guide for contractors and construction managers for the effective management of construction labor forces and help to achieve a competitive level of quality and a cost-effective project. **DOI: 10.1061/(ASCE)ME.1943-5479.0000168.** *© 2014 American Society of Civil Engineers.*

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## Introduction

In most countries, experience and literature have revealed that construction labor costs account for 30–60% of the total cost of a project (Gomar et al. 2002; Hanna et al. 2002). Therefore, construction labor productivity is of critical importance to the profitability of most construction projects. Many construction industry sectors have been experiencing chronic problems such as poor management, inferior working conditions, and insufficient quality. Many researchers have identified these problems as factors that affect the productivity of construction and will subsequently affect the performance of a company and the overall economy of the country.

The performance of labor is affected by many factors and is usually linked to the performances of time, cost, and quality. The identification and evaluation of factors affecting construction labor productivity have been conducted in the last decade; however, a deeper understanding is still needed to improve labor productivity.

To achieve the income expected from any construction project, it is important to have control of the productivity factors that contribute to the integrated composition of production, such as labor, equipment, and cash flow. In Egypt, the literature has revealed that the second performance criterion out of 12 by which construction managers would like their performance to be evaluated is "the efficient utilization of resources" (Abdel-Razek 1997). Also, the literature has shown that young site engineers working in contracting organizations ranked the utilization of resources as the second out of 12 factors that affect the performance of construction organizations in Egypt (Abdel-Razek 2004).

The proper management of resources in construction projects can yield substantial savings in time and cost. Therefore, the objective of this research is to identify and rank the relative importance of factors perceived by contractors, engineering firms, and clients to affect construction labor productivity in Egypt. The outcomes can be used by not only local but international industry practitioners, who may be further interested in venturing into potential megascale projects, but possess no prior practical knowledge of the construction industry in Egypt. The outcomes can help all practitioners to develop a wider and deeper perspective of the factors influencing the productivity of operatives and to provide guidance to project and construction managers for the efficient utilization of the labor force.

The predominant traditional construction project delivery method practiced in Egypt is design/bid/build. The nature of this method allows the contractors to face predetermined decisions regarding the criteria for design and specifications on the one hand, and contractual conditions on the other. The contractor must implement this during the contract duration of the project; hence, as end user, the contractor is in a better position to provide an objective assessment of the effects of such products on the productivity of operatives. This method gives the chance to the clients and engineering firm consultants to address the productivity and factors affecting it in more precise detail, especially in cases of delay

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and loss of productivity claims. This provides the importance and the logic behind focusing on the perspectives of contractors, engineering firms, and clients in this study.

Labor forces, whether directly employed or subcontracted, are under the management and supervision of the contractor. In this research, based on this fact, more concentration was focused on collecting data from contractors. The direct supervisor, who is under daily interaction with laborers, can afford to render a reasonably accurate judgment on the primary and relevant factors influencing their efficiency.

The literature has identified several factors that were explored in this study. A lack of stable metrics makes it difficult to compare the results of studies that investigate factors affecting productivity. This paper investigates factors perceived to affect construction labor productivity in Egyptian construction sites with respect to identifying and ranking their relative importance. Building from the literature and with input from industry experts, this research develops a schematic model of factors affecting construction labor productivity in Egypt and explores them by using statistical methods. The following sections present literature review, research methodology, results and discussion, and conclusions and recommendations.

## Background and Literature Review

Productivity can be defined and measured in many ways. In construction, productivity usually means labor productivity; that is, units of work placed or produced per staff-hour. The inverse of labor productivity, staff-hours per unit (unit rate), is also commonly used (Halligan et al. 1994). This is an activity-oriented model of productivity often referred to as partial or single factor productivity.

The way in which productivity should be measured is profoundly influenced by the purpose for which the results will be used. A popular concept in the U.S., and increasingly in the U.K., is the concept of earned hours. This relies on the establishment of a set of standard outputs, or "norms," for each unit operation. Thus, a number of earned hours is associated with each unit of work completed. Productivity may be defined as the ratio of earned to actual hours. The problem with this concept is in establishing reliable norms for setting standards. It also depends on the method used to measure productivity and on the extent to which all of the factors are accounted for that may affect productivity.

Therefore, a statement like "construction productivity in the U.K. is 30% greater than that in Egypt" is meaningless. Its truth depends on the definition of productivity and how it is measured. If, for example, the construction of office blocks in Cairo and London is compared, an indicator may be used such as square meters of floor area completed per week. However, this may not account for differences in specification (quality), design (build ability), building regulations, construction technology, available resources, and climate (Horner and Talhouni 1998).

Some agencies use the economic model in terms of dollars, because dollars are the only measure common to both inputs and outputs. Eq. (1) shows the total factor productivity (TFP), which represents this type of model:

$$\text{TPF} = \frac{\text{Total output}}{\text{Labor} + \text{Materials} + \text{Equipment} + \text{Energy} + \text{Capital}} \quad (1)$$

where TPF = ratio of dollars of output to dollars of input.

A project-specific model is a more accurate definition that can be used for specific program planning and for conceptual estimates on individual projects. Eq. (2) shows this model:

$$\text{Productivity} = \frac{\text{Output}}{\text{Labor} + \text{Equipment} + \text{Materials}} \quad (2)$$

This measure is a ratio of, for example, square meters of output to dollars of input (Thomas et al. 1990).

The complex nature of the construction process and the interaction of its activities make the single factor productivity measure a popular option because effective control systems separately monitor each input. It focuses on a selected factor, e.g., labor input, which makes the measurement process easy and controllable. Moreover, reliable and accurate data can be obtained. On the other hand, the TFP measure is difficult to accurately measure and to determine all of the input resources utilized to achieve the output. Therefore, the TFP measure is often impractical.

Fig. 1 shows the open conversion system by Drewin (Thomas et al., 1990) that can be applied to most of construction operations. This open conversion system, which is closer to Eq. (1), models the construction process and the primary factors affecting its productivity. It provides examples of categorized factors that affect the overall construction productivity, including labor, and reflects the complex nature of the construction process as an open conversion system. Also, it shows the flow of feedback information that allows a continual improvement in construction productivity. This can help the practitioner to understand the role of factors affecting the construction process, and thus to control and improve its productivity.

Table 1 shows a summary of previous studies in different countries on factors affecting construction labor productivity. It shows the total number of factors in the study and the most effective factors, ranked in descending order based on their importance.

There is no consensus in the literature on the identification of factors that affect the construction times of buildings, i.e., the length of time between a building being started and being completed. One reason for this is that researchers have largely viewed the subject from diverse perspectives. The poor productivity of construction labor is agreed to be one of the factors that cause construction delay. Therefore, studying factors affecting construction labor productivity is crucial to improve productivity, and thus, to help manage construction to achieve a competitive level of quality and cost-effective projects in a timely manner.

The classification of the factors that affect construction labor productivity into primary global groups or categories is helpful to better identify and manage such factors, and thus, to improve construction labor productivity and construction times of buildings. Alwi (2003) classified the key factors influencing construction

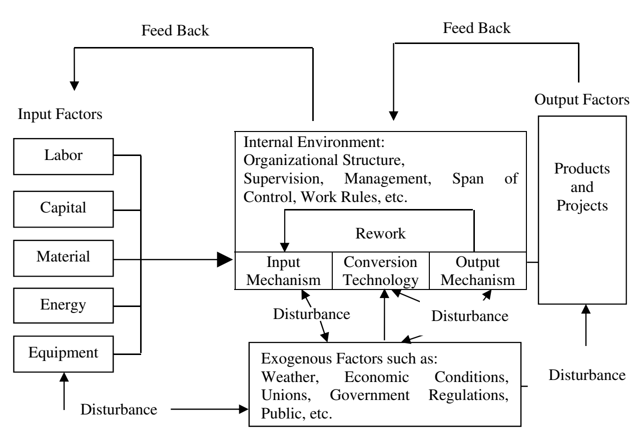


**Fig. 1.** Drewin's open construction conversion system (Thomas et al. 1990, © ASCE)



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**Table 1.** Literature Summary of the Factors Affecting Construction Labor Productivity

| Country | Reference | Total number of studied factors | Major factors ranked in descending order based on their RII |
|---|---|---|---|
| U.K. | Horner et al. (1989) | 13 | Skill of labor; buildability; quality of supervision; method of working; incentive scheme; site layout; complexity of construction information; crew size and composition; length of working day; availability of power tools; absenteeism; total number of operatives on site; proportion of work subcontracted |
| Singapore | Lim and Alum (1995) | 17 | Difficulty in recruitment supervisors; difficulty in recruiting workers; high rate of labor turnover; absenteeism at work site; communication problems with foreign workers; inclement weather that requires work stoppage for one day or more |
| Iran | Zakeri et al. (1996) | 13 | Material shortage; weather and site conditions; equipment breakdown; drawing deficiencies/change orders; lack of proper tools and equipment |
| Indonesia | Kaming et al. (1997) | 11 | Lack of materials; rework; absenteeism of operatives; lack of suitable tools and equipment; crew interference |
| Thailand | Makulsawatudom et al. (2004) | 23 | Lack of material; incomplete drawings; incompetent supervisors; lack of tools and equipment; absenteeism; poor communication; instruction time; poor site layout; inspection delay; rework. |
| Malaysia | Abdul Kadir et al. (2005) | 50 | Material shortage at site; nonpayment to suppliers, causing the stoppage of material delivery to site; change orders by consultants; late issuance of construction drawings by consultants; incapability of the contractors' site management to organize site activities |
| Uganda | Alinaitwe et al. (2007) | 36 | Incompetent supervisors; lack of skills among the workers; rework; lack of tools/equipment; poor construction methods; poor communication; stoppages because of work being rejected by consultants; political insecurity; tools/equipment breakdown; harsh weather conditions |
| Gaza Strip | Enshassi et al. (2007) | 45 | Material shortage; lack of labor experience; lack of labor surveillance; misunderstanding between labor and superintendents; alteration of drawings and specifications during execution |
| New Zealand | Durdyev and Mbachu (2011) | 56 | Reworks; level of skill and experience of the workforce; adequacy of method of construction; buildability issues; inadequate supervision and coordination; statutory compliance; unforeseen events; wider external dynamics |
| Kuwait | Jarkas and Bitar (2012) | 45 | Clarity of technical specifications; extent of variation/change orders during execution; coordination level among various design disciplines; lack of labor supervision; proportion of work subcontracted |

productivity in Indonesia into the following three categories: (1) characteristics of contractors; (2) inadequate management strategy; and (3) the focus of the organization. The characteristics of contractors include ownership type, qualifications, accumulated experience, classifications, and the caliber of staff employed. Management strategy refers to the tools and managerial approaches adopted to minimize waste and unproductive activities, thus promoting lean, efficient, and cost-effective operations. The focus of the organization relates to the client objectives and motivation, project goal, and the active involvement of all construction personnel. Singh (2010) classified factors affecting the productivity of construction operations of infrastructures and buildings in the United Arab Emirates into four categories: industry level factors, labor factors, site management factors, and external factors. Singh studied the following overall 10 factors with respect to their categories to help improve the productivity: (1) priority of production in the industry; (2) production system design; (3) financial issues; (4) predictability of demand; (5) skill and experience issues; (6) work schedule and crew mix; (7) training policy; (8) coordination and supervision; (9) material and equipment quality; and (10) weather and statute. Therefore, the authors in this research proposed the following three primary categories for classifying the corresponding factors explored in this study: (1) human/labor related factors; (2) industry related factors; and (3) management related factors.

## Research Methodology

This research is based on a survey designed to gather all necessary information in an effective way. The survey presents 30 productivity factors generated on the basis of related research works on construction productivity (Sanders and Thomas 1991; Lim and Alum 1995; Makulsawatudom et al. 2004; Abdul Kadir et al. 2005; Enshassi et al. 2007; Jarkas and Bitar 2012), with input, revision, and modifications by local experts. These factors were classified into the following three categories based on previous literature and advice by local experts: human/labor related factors, industry related factors, and management related factors. To consider the effect of the different levels of experiences of the participants, the results are grouped into three groups: Group 1 for respondents with up to 15 years of experience; Group 2 for respondents with experience from 16 to 25 years; Group 3 for respondents with more than 25 years of experience. Fig. 2 depicts these groups.

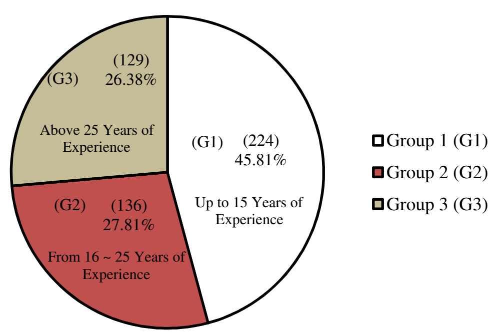


**Fig. 2.** Sizes and types of participating groups based on their experiences



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The studied target population includes clients, consultants, and contractors. On the national level, one recognized way of categorizing construction companies is with the grade of the Egyptian Federation for Construction and Building Contractors (EFCBC). Therefore, contractors were selected from those who hold valid membership in the EFCBC. The primary criteria for grading are related to the company's capital, the total highest value of the executed contracts within twelve months during the last five years, the value of the largest successfully executed project during the last five years, the value of the income related to the work done in the official budget, the duration of previous experience, and staffing (technical, financial, administrative, and lawful). The total number of contracting companies in Egypt who have valid membership under the available seven grades for the category of integrated building works is 19,779, as of March 1, 2012. For the purpose of this research, the targeted contractors are those who represent the top four grades. The first grade comprises 232 firms, the second grade comprises 157 firms, the third grade comprises 213 firms, and the fourth grade comprises 681 firms, with a total of 1,283 firms. A systematic random sample was selected to ensure a representative sample of all targeted contractors by using Eq. (3) (Hogg and Tanis 2009):

$$n = \frac{m}{1 + (\frac{m-1}{N})} \tag{3}$$

where $n$, $m$, and $N$ = sample sizes of the limited, unlimited, and available population, respectively. On the other hand, $m$ is estimated by Eq. (4):

$$m = \frac{z^2 \times p \times (1 - p)}{\varepsilon^2} \tag{4}$$

where $Z$ = statistical value for the confidence level used, i.e., 2.575, 1.96, and 1.645, for 99, 95, and 90% confidence levels, respectively; $P$ = value of the proportion of the population being estimated; and $\varepsilon$ = sampling error of the point estimate.

Because the value of $P$ is unknown, Sincich et al. (2002) suggested a conservative value of 0.50 to be used so that a sample size is obtained that is at least as large as required. Using a 95% confidence level, i.e., 5% significance level, the unlimited sample size of the population, $m$, is approximated as follows:

$$m = \frac{(1.96)^2 \times 0.50 \times (1 - 0.50)}{(0.05)^2} \cong 385$$

Accordingly, the total number, $N$, of considered classified contractors under the first, second, third, and fourth grades equals 1,283.

The sample size was statistically determined, as will be shown later. The results were achieved by continuous follow-up and close contact with all participants. The sample was selected randomly from a combination of the contractors under the top four contractors' grades to cover the sample, representing the total population of 1,283 contracting companies. Because there are no accurate data regarding the number of consultants or clients, 18 consulting and client firms were selected randomly and added to the statistically determined sample size of contractors, as will be shown later.

For analyzing data, the relative importance index (RII) technique was used. This index was computed for every factor for each specific year of the participants' experience by using Eq. (5) (Lim and Alum 1995; Enshassi et al. 2007; Jarkas and Bitar 2012):

$$\mathrm{RII}_k(\%) = \frac{6(n6) + 5(n5) + 4(n4) + 3(n3) + 2(n2) + n1}{6(n1 + n2 + n3 + n4 + n5 + n6)} \times 100 \tag{5}$$

where $\mathrm{RII}(\%)_k$ = yearly experience percentage of the RII of each factor, which is calculated separately for each corresponding year ($k$) of experience of categorized respondents; $k$ = number that represents the years of experience of categorized respondents (from first year of experience, $k = 1$, to last year of experience, $k = K$); and $n1$, $n2$, $n3$, $n4$, $n5$, and $n6$ = numbers of respondents of the survey who selected "0" for no effect, "1" for very little effect, "2" for little effect, "3" for average effect, "4" for high effect, or "5" for very high effect. Therefore, Eq. (6) is used for computing the overall RII for each factor of all respondents, considering all years of experiences of the respondents, which is calculated as a weighted average of $\mathrm{RII}_k$ obtained from Eq. (5):

$$\text{Overall RII}(\%) = \frac{\sum_{k=1}^{k=K} (k \times \mathrm{RII}_k)}{\sum_{k=1}^{k=K} k} \tag{6}$$

where Overall RII (%) = total weighted average percentage of the RII of each factor, which is calculated based upon all of the years of experience of the respondents; $k$ = years of experience of categorized respondents (from one year of experience, $k = 1$, to last year of experience, $k = K$); and $\mathrm{RII}_k$ = yearly experience percentage of the RII of each factor, which is calculated separately for the corresponding year ($k$) of experience of categorized respondents and calculated by Eq. (5).

The category index was calculated by using the average of the RII of the factors in each category.

### Questionnaire Design

The design philosophy of the questionnaire was that the questions had to be simple, clear, and understandable for the respondents, and able to be accurately interpreted by the researcher. The questionnaire has the definite advantages of requiring a smaller time to be responded and more accuracy in the final outcome. Factors affecting the productivity of construction labor were identified through the literature based on previous research, with input, revision, and modifications by local experts; a total of 30 factors were identified. The participants were required to rate the factors for the way they affect construction labor productivity, considering time, cost, and quality using their own experiences on building sites. The questionnaire required the respondents to rank the factors affecting labor productivity on a scale with the rating of "0," representing no effect; "1," very little effect; "2," little effect; "3," average effect; "4," high effect; and "5," very high effect, according to the degree of importance on construction labor productivity. The numbers assigned to the agreement scale (0, 1, 2, 3, 4, 5) do not indicate that the intervals between the scales are equal, nor do they indicate absolute quantities.

### Pilot Study

A pilot study was conducted to ensure the clarity and relevance of the questionnaire to participants. The questionnaire was shown to two researchers in the same field. Based on their feedback, amendments were made. The second phase of the pilot study was conducted on five building project managers among those who were not participating in the final survey. Based on the feedback, minor amendments were made to remove any ambiguities and discrepancies. This pilot study was conducted to validate and improve the questionnaire in terms of the wording of statements, the overall



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content, and the format and layout. The draft questionnaire was revised to include the suggestions of these participants. The questionnaire was validated through this process, which provided the authors with improvement opportunities before launching the primary survey.

### Determination and Selection of Samples

The survey gathered data from practitioners of building contractors, consultants, and owners from as broad a geographic area within Egypt as possible. The target population of contractors was 1,283 companies, which were current members of EFCBC within first, second, third, and fourth grades during this study. The required representative sample size, $n$, of the target population of contracting companies was determined by using Eq. (3) as follows:

$$n = \frac{385}{1 + \left(\frac{385-1}{1{,}283}\right)} \cong 297$$

On the basis of this equation, a total of 300 contracting companies in Egypt were surveyed as a sample representing the total population of 1,283 contracting companies. The surveyed companies were only within the top four grades of EFCBC. The sample was selected randomly from a combination of contractors under the top four contractors' grades. Sometimes, more than one completed questionnaire was received from each surveyed company, representing different levels of experience, but including at least the input of one project manager. The total number of completed questionnaires obtained from the surveyed contracting companies was 430. The total number of completed questionnaires obtained from the surveyed consulting and client firms was 59, representing 18 consulting and client firms. The overall number of the completed questionnaires included in this study was 489, which comprises the statistical data sample size that represents contractors, consultants, and clients.

## Results and Discussion

The perceived effect of each of the 30 factors on construction labor productivity in Egypt is determined. The overall factors are classified under three major categories as follows: nine under the labor category; 11 under the industry category; and 10 under the management category. The RIIs, ranks within the corresponding category, and the overall ranks of the factors under investigation are presented, discussed, and compared to previous related research findings. Furthermore, the category importance indices are quantified, and a comparison is conducted to determine their relevant importance. The results are grouped into three groups: Group 1 for respondents with up to 15 years of experience, Group 2 for respondents with experience from 15 to 25 years, and Group 3 for respondents with more than 25 years of experience.

The RIIs for the factors of each category in the three groups are calculated by using Eq. (6). The average is calculated for each category in the three groups. Fig. 3 shows the results.

It is clear that the results of the three groups are almost consistent. The ranks of the three categories are the same in the three groups in which the categories are ranked from top to bottom as management, labor/human, and industry. Also, the ranks of the factors of each category are the same in the three groups, with slight differences in the value of the RII. This gives more confidence in the overall results obtained because there is consistency in the results, regardless the level of the experience of the participants. Nevertheless, the overall RII for all factors is calculated by using Eq. (6), which considers the level of experience.

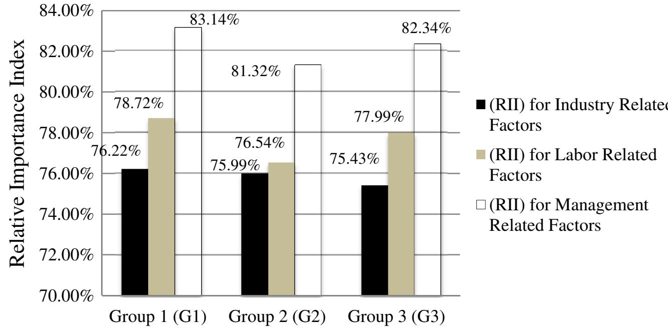


**Fig. 3.** RIIs relevant to the three categories of factors for the three participating groups

### Management Category

The relative importance indices and ranks of the 10 factors classified under the management category are shown in Table 2.

The surveyed contractors, consultants, and clients ranked "incentive programs" as the most important factor affecting labor productivity in this category, with a relative importance index of 91.87%. This top ranked factor is ranked second in its effect among all factors in the study, which indicates the significant impact of this factor on the efficiency of construction labor productivity in Egypt. Horner et al. (1989) ranked it fifth among 13 factors explored in the UK.

This effect is related to the nature of construction labor available in Egypt, which, in its absolute majority, comprises laborers that can be found in rural areas and villages coming to work in cities where the majority of construction is conducted. They basically share a common goal: to make and save as much as possible, then go back home. Also, the majority of these laborers work for low wages on a daily basis without any kind of insurance umbrella. Thus, a monetary incentive scheme further promotes the objective for these operatives and creates a high level of motivation and satisfaction among them; as a result, higher efficiency is achieved on sites. The related influence of this factor agrees with the findings reported by Enshassi et al. (2007), in which the outcome of what the authors termed "lack of financial motivation system" was ranked second after "payment delay," compared with six other factors classified under "motivation group." Jarkas and Bitar (2012) found it to be the third factor in the management group and seventh compared to all 45 surveyed factors.

The "availability of the materials and their ease of handling" factor, with RII of 90.34%, is ranked second within the management group and third among all 30 factors. This is the top ranked

**Table 2.** RII and Ranking of Factors in the Management Category Affecting Construction Labor Productivity in Egypt

| Factors | Overall RII (%) | Rank |
|---|---|---|
| Incentive programs | 91.87 | 1 |
| Availability of materials and their ease of handling | 90.34 | 2 |
| Leadership and competency of construction management | 88.40 | 3 |
| Competency of labor supervision | 87.43 | 4 |
| Planning, work flow, and site congestion | 84.54 | 5 |
| Clarity of instructions and information exchange | 80.73 | 6 |
| Surrounding events (revolutions) | 80.09 | 7 |
| Services offered to laborers (social insurance, medical care) | 77.74 | 8 |
| Construction management type (individuals, firms) | 71.98 | 9 |
| Management of subcontractors | 69.08 | 10 |



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factor affecting construction labor productivity in Gaza Strip, Jordan, Indonesia, Thailand, Malaysia, and Singapore (Enshassi et al. 2007; Kaming et al. 1997; Makulsawatudom et al. 2004; Abdul Kadir et al. 2005; Lim and Alum 1995). The effect of this factor on the productivity of the construction industry in Egypt can probably be related to the following two reasons: (1) the financial problems of local contractors, and thus, liquidity problems or shortage of credit facilities, which is a common obstacle for material procurement; and (2) the delay in ordering the materials as a result of design/schedule changes or client delay of payment.

The "leadership and competency of construction management" factor, with RII of 88.40%, is ranked third within the management category and fourth among all 30 explored factors. Leadership is defined as the capability of setting the direction of a project or activity and encouraging and guiding people towards that direction. Therefore, leadership is using one's own power to win the hearts and minds of people to achieve a common purpose.

This effect substantiates the results obtained by Abdul Kadir et al. (2005), whose research placed the "incapability of site management" factor in the fifth rank among 50 productivity factors recognized to affect labor productivity in Malaysia. Also, it substantiates the results obtained by Jarkas and Bitar (2012), in which this factor ranks fourth in the management group and eighth overall of the 45 surveyed factors.

The "competency of labor supervision" factor, with RII of 87.43%, ranked fourth in the management category and fifth among all 30 explored factors, which confirms the significant impact of this factor on the productivity of construction labor. Supervision is about telling people what to do and how to do it, leaving precious little space for them to use their own initiative.

Horner et al. (1989) ranked it third among 13 factors explored in the U.K. Jarkas and Bitar (2012) ranked it first in the management category and fourth among all 45 surveyed factors. This indicates that the continuous supervision of labor is necessary to maximize productivity. A lack of supervision may encourage operatives to engage in unproductive activities, take frequent unscheduled breaks, wait idly, or even leave job sites during working hours to attend to personal matters. Direct supervision of labor is required to avoid faulty work that does not conform to contractual specifications, and to minimize the expensive incidents of rework and the associated delays to construction activities.

The "planning, work flow, and site congestion" factor, with RII of 84.54%, ranked fifth in the management category and eighth among all 30 factors. Abdul Kadir et al. (2005) ranked it 24th among all 50 surveyed factors. Alinaitwe et al. (2007) ranked it 30th among all 36 surveyed factors. Enshassi et al. (2007) ranked it second in the project category and 24th among all 45 surveyed factors. Jarkas and Bitar (2012) ranked it ninth in the management category and 25th among all 45 surveyed factors.

Site congestion is usually attributed to inappropriate construction site arrangement and overcrowding of the workers in some workplaces, which can cause obstructions to the desired productivity and quality. The overcrowding of workers usually results from inappropriate general planning of construction site activities.

Liu et al. (2011) concluded that labor productivity was positively correlated with percent plan complete (PPC), a measure of work flow variation. The relationship between productivity and the ratio of total task completion to planned tasks, weekly workload, weekly work output, and weekly work hours was also studied, and no significant correlation was found. The results suggest that productivity is not improved by completing as many tasks as possible regardless of the plan, nor from increasing workload, work output, or the number of work hours expended. In contrast, productivity does improve when workflow is made more predictable. The application of modern concepts and systems such as the last planner system (LPS) can help to control and drive the management factors that affect construction labor productivity. These findings can help project/construction managers to focus on actual drivers of productivity. It can also help consulting companies to pinpoint the responsibility for productivity losses in claims.

With RIIs of 80.73, 80.09, 77.74, 71.98, and 69.08%, the factors of "clarity of instructions and information exchange," "surrounding events (revolutions)," "services offered to laborers (social insurance, medical care)," "construction management type (individuals, firms)," and "management of subcontractors" ranked sixth, seventh, eighth, ninth and 10th, respectively, within the management category. Furthermore, among all 30 investigated factors, they ranked 10th, 11th, 15th, 27th, and 29th, respectively.

Although the category of management factors ranked higher than the categories of industry and labor factors, most of the management factors cannot be predicted in advance, specifically at the bidding phase. Therefore, they cannot be used in developing forecasts and can only be controlled during the construction phase, based on the quality and efficiency of the project and construction management during the time of execution.

## Labor/Human Category

The RIIs and ranks of the nine classified factors under the labor/human category are shown in Table 3.

The "laborer experience and skill" factor ranked first in the management category and first among all 30 surveyed factors, with RII of 93.29%. Jarkas and Bitar (2012) ranked it second within the labor/human category and 20th among the 45 explored factors.

The findings substantiate the results obtained by Horner et al. (1989), ranking the factor of skill of labor first in its importance to labor productivity among 13 factors explored in the U.K. This outcome is further supported by Lim and Alum (1995), Alinaitwe et al. (2007), and Enshassi et al. (2007), whose works identified the skill and experience of operatives among the most significant factors impacting the efficiency of construction labor productivity.

Poorly trained and unskilled operatives are commonly characterized by low and faulty outputs coupled with unjustifiably high inputs. In addition, their outputs are almost always rejected by the inspection engineer, either in whole or in part, resulting in extensive and expensive rework, rectifications, or repairs. On the contrary, experienced operatives possess sound intellectual abilities, practical solutions to obstacles, and high technical and motor skills. All of these lead to higher productivity, lower cost of labor, and better quality of finished outputs.

Only one major contracting company in Egypt, Arab Contractors Company, has its own system for training skilled laborers. The other contracting companies rely on the governmental technical

**Table 3.** RII and Ranking of Factors in the Labor/Human Category Affecting Construction Labor Productivity in Egypt

| Factors | Overall RII (%) | Rank |
|---|---|---|
| Laborer experience and skill | 93.29 | 1 |
| Labor operating system (daily wage, lump sum) | 86.16 | 2 |
| Laborer age | 78.12 | 3 |
| Effect of labor availability—work capacity (shortage) | 77.19 | 4 |
| Overtime (up to 4 h after 8 h/day) | 74.85 | 5 |
| Effect of labor availability—work capacity (excess) | 73.63 | 6 |
| Degree of laborer education | 72.52 | 7 |
| Rest time(s) during the workday | 72.23 | 8 |
| Overtime (more than 4 h after 8 h/day) | 71.95 | 9 |



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education, which is poor and inadequate. Thus, the field of construction in Egypt regards "lack of skill and experience of labor" as a major hurdle toward improving construction labor productivity and quality of the work.

The "labor operating system (daily wage, lump sum)" factor ranked second in this group and seventh overall, with RII of 86.16%. The majority of laborers in Egypt work on the complete day system. The quota system (lump sum) and extended day system are applied much less frequently. In general, the quota system can be considered as a cost control system. Also, it can be considered to be a system for improving productivity and minimizing cost when data for productivity are available.

Quota or lump sum operating systems are used in the Egyptian context to determine the maximum labor productivity for any activity in construction projects. The laborers are asked to perform a certain task and leave the site whenever they finish the task. This acts as an incentive for the laborers to finish and leave sites early, thus demonstrating the maximum productivity they could. Therefore, supervisors can determine the maximum productivity of the laborers. This information can help to determine the duration of the next activity.

For nontraditional jobs, a supervisor applies the quota system at the beginning of work to ascertain the rate of productivity. Next, they evaluate the first lump sum to assist in determining the next lump sums. The quota system improves worker ability because workers will attempt to upgrade their skill to reduce the effort needed to achieve the same level of performance. Also, it develops a competitive spirit among crews, which will result in an improvement in productivity.

The "laborer age" factor ranked third within this group and 13 overall, with RII of 78.12%. Enshassi et al. (2007) ranked it sixth in the laborer category and 30 among all 45 surveyed factors. Discussions with the respondents revealed that there is unanimous agreement among respondents that higher age negatively impacts construction labor productivity. They attributed this to the fact that with higher age, the cognitive and mental abilities, agility, and strength decrease. This is supported by Enshassi et al. (2007), who stated, "The increase of laborer age is negatively affect labor productivity as labor speed, agility, and strength decline over time and contribute to a reduced productivity." Nevertheless, the decreased cognitive abilities, agility, and strength of older workers can lead to lower productivity, unless their longer experience and higher levels of job knowledge outweigh these declines. This should be understood within the context of workers. The respondents stated that the relative importance of this factor has a considerable effect on construction labor productivity. This is based on the experience and mental model of the respondents to verify the significance of the productivity difference as a result of the difference in ages of construction laborers in the Egyptian context.

With RIIs of 77.19, 74.85, 73.63, 72.52, 72.23, and 71.95%, the "effect of labor availability—work capacity (shortage)," "overtime (up to 4 h after 8 h/day)," "effect of labor availability—work capacity (excess)," "degree of laborer education," "rest time(s) during the work day," and "overtime (more than 4 h after 8 h/day)" factors ranked fourth, fifth, sixth, seventh, eighth, and ninth, respectively, within the labor/human category. Furthermore, among all 30 investigated factors, they ranked 16th, 18th, 22nd, 24th, 25th, and 28th, respectively.

The fact remains that if the availability of labor greatly exceeds the demand for labor, an individual worker has the tendency to give maximum effort to retain their job. Also, a lack of labor supply makes the supervisor unable to organize the levels of workers in the crew. This leads to using skilled workers for tasks in which their skills are not effectively utilized. It also may lead to using unskilled laborers in place of skilled ones; both situations lead to lowering craft productivity and increasing the labor unit cost for accomplished units.

The labor productivity during overtime assignments is influenced by the purpose and type of workers who work 4 h overtime after a normal 8-h day. These additional hours may be 100% effective if they are assigned to an operation that is well planned. The experience suggests that a work week of six days, 10 h/day will approach the optimum.

## *Industry Category*

The relative importance indices and ranks of the 11 classified factors under the industry category are shown in Table 4.

The "construction technology (construction method and material)" factor ranked first in the industry category and sixth among all 30 surveyed factors, with RII of 86.64%. Enshassi et al. (2007) ranked it first within the quality category (defined as efficiency of equipment) and 16th among all 45 explored factors. Durdyev and Mbachu (2011) found that the most significant factor related to construction technology affecting the productivity of construction labor is the adequacy of the method of construction.

This paper studied construction technology from the point of view of construction method and material. Continual changes and improvements are occurring in traditional materials and construction techniques. Bricklaying provides a good example of such changes. Although the literal placing of brick on brick has not changed, masonry technology has changed a great deal. Motorized wheelbarrows and mortar mixers, sophisticated scaffolding systems, and forklift trucks now assist the bricklayer. New epoxy mortars provide stronger adhesion between bricks. Mortar additives and cold-weather protection eliminate winter shutdowns.

The "constructability (integrated design and construction)" factor ranked second in the industry category and ninth among all 30 surveyed factors, with RII of 82.01%. Horner et al. (1989) ranked it second in importance to labor productivity among 13 factors explored in the U.K.

Constructability is commonly referred to as "buildability" in Europe. It is defined by the Construction Industry Institute (CII) as "the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives" (CII 1986). Also, it is defined by the Construction Industry Research and Information Association (CIRIA) as "the extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building" (CIRIA 1986).

**Table 4.** RII and Ranking of Factors in the Industry Category Affecting Construction Labor Productivity in Egypt

| Factors | Overall RII (%) | Rank |
|---|---|---|
| Construction technology (construction method and material) | 86.64 | 1 |
| Constructability (integrated design and construction) | 82.01 | 2 |
| Weather effect (temperature, humidity) | 79.73 | 3 |
| Distance between site and cities | 77.89 | 4 |
| Project specifications | 76.63 | 5 |
| Project scale | 74.67 | 6 |
| Available quantity of daily work (workload) | 74.54 | 7 |
| Work interruptions (design changes) | 74.29 | 8 |
| Work at heights | 73.60 | 9 |
| Total project duration (total work hours) | 72.14 | 10 |
| Type of project (industrial, residential) | 60.01 | 11 |

**Table 5.** Overall Average of RII and Ranks of Construction Labor Productivity Categories in Egypt

| Categories | Average RII (%) | Rank |
|---|---|---|
| Management | 82.22 | 1 |
| Human/labor | 77.77 | 2 |
| Industry | 75.65 | 3 |

The significant impact of this factor on labor productivity may be attributed, in whole or in part, to the followings: (1) lack of implementing a value engineering system from the designers to develop and review design alternatives, related details, specifications, and to tender documents; (2) possible negligence of local designers in providing quality work and efficient professional services. The importance of applying the constructability concept to the productivity of the construction process is confirmed by Horner et al. (1989), Zakeri et al. (1996), Kaming et al. (1997), Makulsawatudom et al. (2004), Abdul Kadir et al. (2005), and Alinaitwe et al. (2007).

With RIIs of 79.73, 77.89, 76.63, 74.67, 74.54, 74.29, 73.60, 72.14, and 60.01%, the factors of "weather effects (temperature, humidity)," "distance between the site and cities," "project specifications," "project scale," "available quantity of the daily work (workload)," "work interruptions (design changes)," "work at heights," "total project duration (total work hours)," and "type of the project (industrial, residential)" ranked third, fourth, fifth, sixth, seventh, eighth, ninth, 10th, and 11th, respectively, within the industry category. Furthermore, among all 30 investigated factors, they ranked 12th, 14th, 17th, 19th, 20th, 21st, 23rd, 26th, and 30, respectively.

Table 5 shows the average RIIs and ranks of the three surveyed categories; Table 6 shows the overall RIIs and ranks of the 30 surveyed factors.

**Table 6.** Overall RII and Ranking of Factors Affecting Construction Labor Productivity in Egypt

| Factors | Overall RII (%) | Rank |
|---|---|---|
| Laborer experience and skill | 93.29 | 1 |
| Incentive programs | 91.87 | 2 |
| Availability of materials and their ease of handling | 90.34 | 3 |
| Leadership and competency of construction management | 88.40 | 4 |
| Competency of labor supervision | 87.43 | 5 |
| Construction technology (construction method and material) | 86.64 | 6 |
| Labor operating system (daily wage, lump sum) | 86.16 | 7 |
| Planning, work flow, and site congestion | 84.54 | 8 |
| Constructability (integrated design and construction) | 82.01 | 9 |
| Clarity of instructions and information exchange | 80.73 | 10 |
| Surrounding events (revolutions) | 80.09 | 11 |
| Weather effect (temperature, humidity) | 79.73 | 12 |
| Laborer age | 78.12 | 13 |
| Distance between site and cities | 77.89 | 14 |
| Services offered to laborers (social insurance, medical care) | 77.74 | 15 |
| Effect of labor availability—work capacity (shortage) | 77.19 | 16 |
| Project specifications | 76.63 | 17 |
| Over time (up to 4 h after 8 h/day) | 74.85 | 18 |
| Project scale | 74.67 | 19 |
| Available quantity of the daily work (workload) | 74.54 | 20 |
| Work interruptions (design changes) | 74.29 | 21 |
| Effect of labor availability—work capacity (excess) | 73.63 | 22 |
| Work at heights | 73.60 | 23 |
| Degree of laborer education | 72.52 | 24 |
| Rest time(s) during the work day | 72.23 | 25 |
| Total project duration (total work hours) | 72.14 | 26 |
| Construction management type (individuals, firms) | 71.98 | 27 |
| Over time (more than 4 h after 8 h/day) | 71.95 | 28 |
| Management of subcontractors | 69.08 | 29 |
| Type of the project (industrial, residential) | 60.01 | 30 |

## Conclusions and Recommendations

To improve construction labor productivity, one must identify and recognize the influence of the primary factors affecting productivity. This research has identified, and, based on the quantified RIIs, determined the influence ranks of 30 factors affecting construction labor productivity in Egypt. These factors were classified under the following three primary classifications: (1) human/labor related factors; (2) industry related factors; and (3) management related factors. To study the effect of the participants' experience on the results, the results were grouped under three additional groups based on the experience of the participants, i.e., up to 15 years, 15 to 25 years, and over 25 years. In this regard, the results were consistent.

This study reveals the importance of management factors on construction labor productivity over the other two categories, labor/human and industry. Despite the importance of management factors, they are almost unpredictable, especially during the bidding phase.

The "incentive programs" factor is the most important factor in the management group. Its importance is because the majority of construction workers come from rural areas to cities and work for low wages on a daily basis without any kind of insurance umbrella. Thus, a monetary incentive scheme further promotes the objective of operatives and creates a high level of motivation and satisfaction among these workers; as a result, higher efficiency is achieved on sites. In the light of these findings, it is recommended that incentive programs should be a part of Egyptian contractors' policies and practices.

Also, the findings revealed the importance of the "availability of the materials and their ease of handling" factor. This requires the designer/engineer to prepare painstaking project documentation and the contractor to prepare a careful delivery plan for the required materials. Also, it reflects the need for proper and efficient selection of the location of material storage. It is recommended that the Egyptian government enhance and encourage the accessibility to construction materials, either through local availability or by direct imports. This would improve competitiveness among material suppliers, thus helping local contractors to overcome their financial and liquidity problems.

The most predictable and significant factor identified by the results is "constructability (integrated design and construction)," which needs much more effort and consideration in the Egyptian construction industry. This confirms the significance of applying this concept to the construction industry and asserting the pivotal role of the relationship between designers/engineers and contractors in the process. The findings, nevertheless, reveal a serious lack of cohesion between the two parties and their inability to see the whole construction process through each other's eyes. The constructability practices among the various designers operating in Egypt reveal a lack of awareness on their part about the importance of this concept to the productivity of the operation. In fact, more opportunities exist to significantly lower total project costs by focusing more attention on the design than on the construction phase. Although the designer's fee typically ranges between 2 and 5% of the project's construction cost, decisions made during the design phase of a project not only have a maximum impact on



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its construction cost, but also dictate its viability, future expenditures, and durations. Furthermore, from the designer's perspective, it would justify the "cutting corners" approach typically used in such circumstances to both quality and design time, to rationalize the cost/benefit ratio of the contract.

Improving the constructability level of designs is certainly the first step in the right direction. This can be accomplished by increasing the designers' awareness of the significant impact of this concept on the productivity of the construction process. Additionally, this may be augmented by encouraging procurement methods that allow the involvement of contractors during the design stage of projects, such as design/build (DB), design/build/operate/transfer (DBOT), or turnkey/engineering, procurement, and construction (EPC), and thus facilitate the incorporation of the construction experience at the early stage of the project development process so that the desired benefits can be achieved during the construction phase. Perhaps, in view of the results, policy makers would consider stipulating a formal value engineering assessment before granting construction permits, in which minimum requirements of constructability must be satisfied before a permit may be obtained.

The result of the "laborer experience and skill" factor agrees with the fact that the Egyptian construction industry suffers from the lack of trained and skilled workers. The investment in people is very valuable, especially in a country like Egypt with a relatively high population and an abundance of labor. The outcome of this research reveals the importance of developing construction labor skills and experience, which can enhance the construction industry and the overall economy. In this regard, the governmental policy should encourage and pay more attention to formal secondary technical education and apprentice programs. Also, contractors should provide strong assistance and support regarding the continual training of their craftsmen.

It is a common interest among contractors, consultants, employers, and policymakers in Egypt to improve the productivity level of the construction sector. The outcomes of this study can assist in achieving this goal by focusing and acting upon the most significant factors perceived to affect the efficiency of construction labor productivity. The results will become worthwhile in determining the major steps to improve labor productivity in the Egyptian construction industry, and thus, to improve the overall performance of project completion time. Researchers and industry practitioners can use the outcome RIIs for the factors in this research as part of further research in modeling the productivity of construction labor by using any valid techniques, i.e., the artificial neural network (ANN) technique. By using such techniques, researchers and industry practitioners may use the outcome importance indices to quantify the weights of affecting factors to obtain and predict relevant labor productivity rates. Also, the results can be used as a part of further research modeling the interaction relationship between the key factors affecting productivity to improve construction labor productivity in the Egyptian construction industry.

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