Chapter (5)
Data Analysis and Results

5.1. Introduction

The methodology of analyzing the questionnaire having been given in chapter 4, the appropriate techniques that will be used to reach the needed results from the survey are set out in this chapter. The results of the data collected through a questionnaire survey which was responded by project managers working in the 41 construction building projects in Greater Cairo are presented and discussed. This chapter focuses on the main objectives of this survey and ranks the problems that affect the labor productivity in the 41 construction building projects based on the opinions of the project managers. Each rank table is ordered according to the severity of the productivity problems. The severities of these causes are based on the integration of their importance and frequencies.

5. 2. Analysis of factors according to importance and frequency

The following section presents and discusses the data collected regarding the importance and frequency of the factors based on the data collected. Different sorts of ranking analysis will be presented and discussed, and severity-based ranks will include a group ranking. Moreover, two ways of ranking are used; all factors rank, and main groups rank .The analysis and discussion of ranking focuses directly on the severity of causes rather than ranking them based on importance and frequency separately. However, because of the significance value of presenting the rank of factors based on the importance and frequency separately, tables showing the factors rank based on importance and frequency separately are provided. The factors affecting labor productivity were grouped into eight main categories. These were analyzed based on the Average Severity Index which was determined as the average of importance index and frequency index of all factors that came under the category. The project managers of the building projects were interviewed and asked to asses the importance and frequency of each problem from the 30 problems included in the questionnaire affecting labor productivity in their sites. Based on the respondents' answers, the importance index I and frequency index F were

calculated for each factor. After calculating these indices the problems were ranked according to their relative importance and frequency. Tables 5-1, shows the ranking of the factors affecting labor productivity in building projects according to importance index.

Table 5-1. Ranking of the problems according to their elative importance for building projects.

Category	Problem	Importance index	Rank
Site	Poor site management & access	3.100	12
	Lack of facility areas	2.900	20
Work type	Work complexity	2.933	19
	Height	3.100	12
	Extra work	2.733	25
	Large volume of work	3.133	11
	Length of work day	3.833	1
Tools& Equipments	Lack of proper equipment	3.400	5
	Lack of proper tools	3.233	7
	Equipment break down	3.033	16
Material	Lack of materials	3.467	4
	Material type	3.200	8
Consultant	Quality required (drawing &specs.)	3.200	8
	Inspection & safety requirements	2.633	27
	Change orders	2.733	25
	Rework	3.400	5
Labors	Inadequate labor skill	2.767	22
	Working overtime	3.033	16
	Absenteeism	3.533	3
	Changing crew members	2.633	27
	Overcrowding	2.133	30
	Crew interfacing	2.967	18
Contractor	Poor organization & management	3.100	12
	Inadequate construction methods	3.067	15
	Improper crew design	3.200	8
	Supervision delay	2.767	22
	Inadequate supervisors skill	3.567	2
External factors	Weather conditions	2.767	22
	Regulatory requirements	2.633	27
	Disruptions	2.800	21

The results indicate that the top ten important problems affecting labor productivity in construction projects as shown in table 5-1 were: Length of work day, inadequate supervision skills, absenteeism, lack of materials, rework, lack of proper equipments, Lack of proper tools, Quality required, Material type, improper crew design. Length of work day was ranked as the first important problem leading to productivity loss with importance index 3.833 from a scale 0 to 4, followed by inadequate supervision skill which was ranked second important problem with importance index 3.567. Absenteeism was ranked third with importance index 3.533, followed by the lack of materials with importance index 3.467. Rework and lack of proper equipments also ranked from the top ten problems, as both were ranked fifth with importance index 3.400, followed by lack of proper tools which was ranked seventh with importance index 3.233. Three problems with equal importance index 3.200 were ranked eighth, these problems are improper crew design, material type, and quality required.

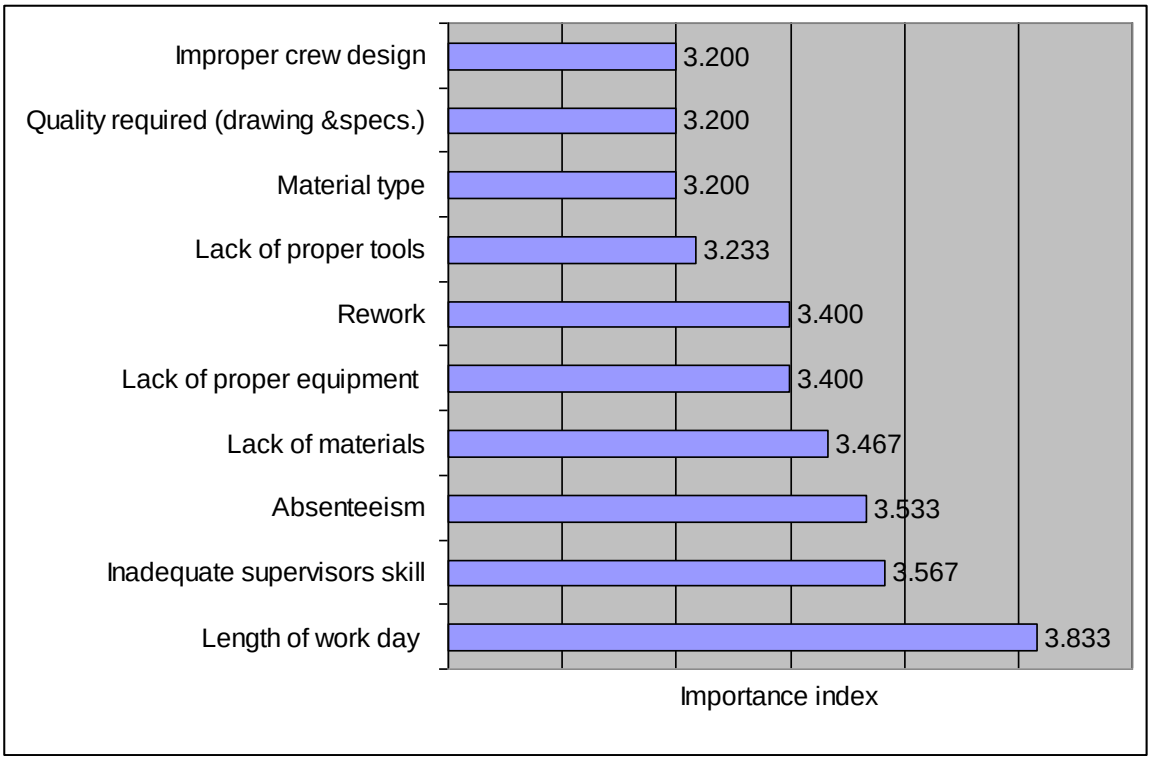

Figure 5-1. Top ten important factors affecting labor productivity in construction building projects

It is obvious that the top ranked problems according to relative importance have small difference in their importance index as shown in figure 5-1, which submit the need to calculate the frequency index to assess the severity of the problems correctly. The factors with high importance ranking belong to all the groups except the external factor group. All the factors included in the material group was ranked high ,which means that problems related to material have a great influence in labor productivity in building projects. The lowest ranked group is the external factor group as none of the problems included in this group was ranked high.

Tables 5-2, shows the ranking of the factors affecting labor productivity in building projects according to frequency index. For a scale from 1 to 3 for frequency index, the top ten problems according to frequency of occurrence as shown in table 5-2 were: Equipment breakdown, length of workday, lack of materials, lack of proper tools, lack of proper equipments, work complexity, large volume of work, quality required, inadequate supervision skill, and material type. Equipment breakdown have the highest frequency index 2.533, followed by length of work day with importance index 2.433. Lack of materials was ranked third with frequency index 2.100. Lack of proper tools and equipments came fourth and fifth with frequency indices 2.067, and 2.033 respectively. Work complexity was ranked sixth with frequency index 1.967. Large volume of work and quality required also were ranked seventh according to frequency of occurrence with frequency index equal to 1.933. Inadequate supervision skill was ranked ninth with frequency index 1.900, followed by material type in the tenth position with frequency index 1.867. The problem with lowest frequency of occurrence was supervision delay with frequency index 1.267.

It is also obvious that the small variations between frequency indices of the problems especially the top ranked problems which range from 2.533 to 1.867 as shown in figure 5-2. The top ten factors according to frequency of occurrence were distributed between the eight groups except the site group, consultant group and labor group. All of the problems related to material, tools and equipment were ranked with high frequency.

Table 5-2. Ranking of the problems according to frequency of occurrence for building projects

Category	Problem	Frequency index	Rank
Site	Poor site management & access	1.633	18
	Lack of facility areas	1.400	23
Work type	Work complexity	1.967	6
	Height	1.567	20
	Extra work	1.833	11
	Large volume of work	1.933	7
	Length of work day	2.433	2
Tools& Equipments	Lack of proper equipment	2.033	5
	Lack of proper tools	2.067	4
	Equipment break down	2.533	1
Material	Lack of materials	2.100	3
	Material type	1.867	10
Consultant	Quality required (drawing &specs.)	1.933	7
	Inspection & safety requirements	1.367	25
	Change orders	1.300	28
	Rework	1.333	26
Labors	Inadequate labor skill	1.333	26
	Working overtime	1.800	14
	Absenteeism	1.433	22
	Changing crew members	1.467	21
	Overcrowding	1.667	17
	Crew interfacing	1.800	14
Contractor	Poor organization & management	1.400	23
	Inadequate construction methods	1.300	28
	Improper crew design	1.600	19
	Supervision delay	1.267	30
	Inadequate supervisors skill	1.900	9
External factors	Weather conditions	1.833	11
	Regulatory requirements	1.767	16
	Disruptions	1.833	11

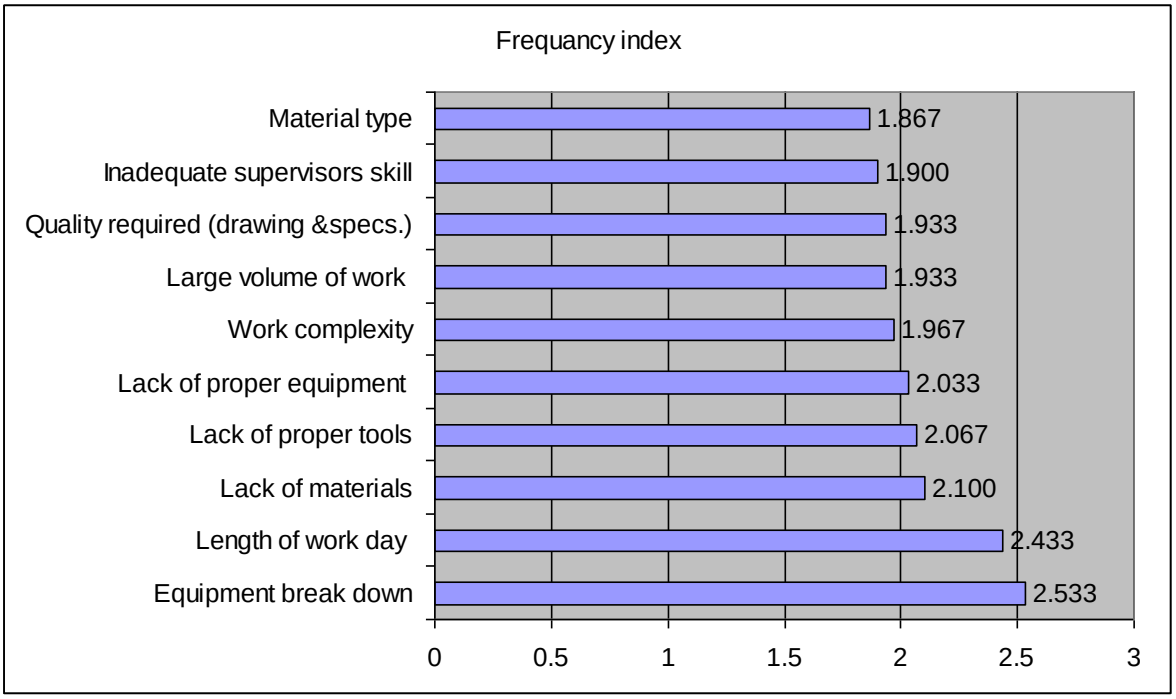

Figure 5-2. Top ten factors affecting labor productivity in construction building projects according to frequency of occurrence

After calculating the Importance index I and frequency index F of each problem, the severity index SI was calculated and problems were ranked according to their severity index. Table 5-3 shows the severity index and ranking for each problem affecting labor productivity in construction projects. The group severity index was also calculated as an average of factors included in each group, and then groups were ranked according to their severity. Table 5-4 shows the group severity index and the ranking of the groups. Also, figure 5-3 shows the most sever factors affecting labor productivity in construction building projects.

Table 5-3. 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 5-4. Ranking of groups according to group severity index

Category	Problem	SI	Group index	Group rank
Site	Poor site management & access	5.533	4.63	6
	Lack of facility areas	3.733		
Work type	Work complexity	5.867	6.27	3
	Height	4.800		
	Extra work	5.167		
	Large volume of work	6.167		
	Length of work day	9.367		
Tools& Equipments	Lack of proper equipment	7.433	7.40	1
	Lack of proper tools	6.933		
	Equipment break down	7.833		
Material	Lack of materials	7.767	7.03	2
	Material type	6.300		
Consultant	Quality required (drawing &specs.)	6.100	4.43	8
	Inspection & safety requirements	3.600		
	Change orders	3.333		
	Rework	4.700		
Labors	Inadequate labor skill	3.767	4.57	7
	Working overtime	5.600		
	Absenteeism	4.867		
	Changing crew members	3.933		
	Overcrowding	3.733		
	Crew interfacing	5.500		
Contractor	Poor organization & management	4.567	4.75	5
	Inadequate construction methods	3.833		
	Improper crew design	5.100		
	Supervision delay	3.500		
	Inadequate supervisors skill	6.733		
External factors	Weather conditions	5.267	5.31	4
	Regulatory requirements	5.033		
	Disruptions	5.633		

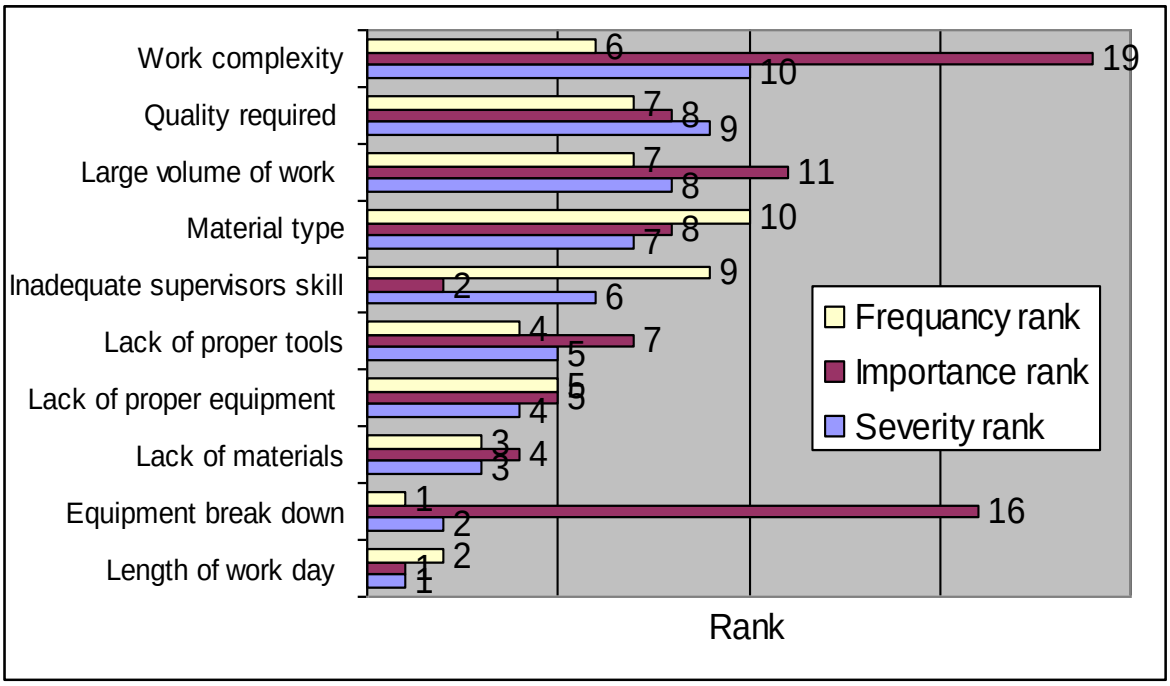

Figure 5-3. Top ten factors affecting labor productivity in construction building projects according to severity rank

5.3. Analysis of factors according to severity

This section contains the results from the ratings as given in Tables 5-3, 5-4 and a discussion about the factors.

A. Site related factors

This group of related factors has a little effect on labor productivity in construction building projects. This group was ranked sixth with group severity index 4.63 as shown in table 5-4.

A.1. Poor site management and access

Table 5-3 illustrates that poor site management has moderate effect on labor productivity as it was ranked in position 13 with severity index 1.633. This problem was also ranked 12 and 18 according to importance and frequency as shown in tables 22 and 23 respectively. This result agree with studies by Motwani *et al.* (1995) in US construction projects, Makuksawatudom and Emsely, (2001) in Thailand, and Sanders and Thomas, (1991) who found that factors as restricted access has negative impact on masonry productivity..

A.2. Lack of facility area

The results from table 5-3 shows that lack of facility areas has small negative effect on labor productivity; this problem came in position 26 with severity index 3.733. This may be attributed to the relative little importance and frequency of occurrence as shown in tables 5-1 and 5-2. This result agree with results by Sanders and Thomas, (1991), who stated that size and organization of materials storage location have a significant impact on masonry productivity, this result is justified as labor needs more time to fetch required materials from unsuitable storage locations, which negatively affects productivity.

B. Work related factors

This group of factors has an obvious negative effect on labor productivity; it was ranked third with group index 6.27. This group includes two of the top ranked severe problems Length of work day and large volume of work.

B.1. 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. This result agree with previous studies on masonry projects submitted by Sanders and Thomas, (1991) who found that design requirements has dramatic impact on masonry productivity.

B.2. Height

Height was ranked in position 20 of all factors negatively affecting labor productivity with severity index 4.800. This may be a result of the last ranking position for this problem in heavy projects. Working at high places is not considered to be as instrumental as other factors. This result is justified, as most construction building projects in Greater Cairo have a few numbers of stories; therefore labor seldom faces this problem.

B.3. Extra work

Extra work is one of the problems that have moderate effect because it was ranked in position 16 with severity index 5.167 as shown in table 5-3. This could be attributed to the fact that most of the supervisors often direct the non skilled labor to do the extra work, so the labor productivity will not be affected directly.

B.4. Large volume of work

This problem was among the top ten severe problems that negatively affects labor productivity in construction; it was ranked eighth with severity index 6.167 as shown in table 5-3. This result is justified, as most of the construction projects suffer delays and always in need of schedule acceleration and as a result large volume of work may cause fatigue which lead to productivity loss, but labors don't care about achieving this as long they are being paid.

B.5. Length of work day

The most severe problem negatively affects productivity between all the 30 factors included in the research; it was ranked first with the highest severity index 9.367 as shown from table 5-3. This ranking is a clear reason of the high ranking of this group. 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. This result agrees with results found by Kaming *et al.* (1998b) in high rise buildings in Indonesia. 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 toward work, of worker will result in lowered output. Fatigue causes deterioration in morale and positive attitude.

C. Tools and equipments related factors

All of the factors included in this group were ranked with high severity index which gives a clear indication of advanced ranking of this group; Table 5-4 shows that this group ranked first between the eight groups with severity index 7.400.

C.1. Lack of proper equipments

Table 5-3 illustrates that 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 lack of equipment, productivity will decrease.

C.2. Lack of proper tools

This factor was ranked fifth with severity index 6.933 as shown in table 5-3. 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). Tool and equipment shortages also have a high effect in the US, UK, Indonesia, Thailand, Uganda and Nigeria. (Kaming *et al.*, 1998b, Makuksawatudom and Emsely, 2001, Ng *et al.*, 2004, and Alinaitwe *et al.*, 2007)

C.3. Equipment breakdown

The second most severe problem between all factors was equipment break down with severity index 7.833 as shown in table 5-3. Although this problem was ranked 16 according to importance as shown in table 5-1 but it was ranked first according to frequency of occurrence as shown in table 5-2, this explains the advanced ranking of this problem on the severity scale. These breakdowns are due to poor maintenance and lack of regular service. Many of them are also not in the best condition as they lack spares. There is a need for good garages and workshops to take care of the repairs and maintenance and for contractors to understand that there is optimal age for replacing such tools and equipment. This resulted agrees with results by Kaming *et al.*, (1998b) who found equipment breakdown to be the third severe factor affects labor productivity in Indonesia. This result was also supported by Aliaitwe *et al.*, (2007) in Uganda.

D. Material related factors

This group also includes two of the most severe problems negatively affect labor productivity. This group was ranked second with group index 7.03 as shown in table 5-4.

D.1. Lack of materials

The factor of materials shortages and delays is ranked third with severity index 7.767 with small difference from the second problem equipment breakdown as shown in table 5-3. However, basing on the importance index and frequency index, it was ranked fourth and third respectively. This is similar to what was found out in earlier research (Kaming *et al.,* 1998b, Makuksawatudom and Emsely, 2001, Ng *et al.,* 2004, Kadir *et al.,* 2005, and Enshassi *et al.,* 2007). In a lot of countries this problem was ranked as the first problem affects labor productivity in construction projects. This is clearly reasonable, because materials are necessary for the construction process. In addition, since project activities are usually interrelated, if materials are short for a particular activity, this could affect other project activities.

D.2. Material type

Table 5-3 demonstrates that material type was ranked 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.

E. Consultant related factors

This group came as the last severe group negatively affects labor productivity; the group severity index calculated for this group was 4.43 as shown in table 5-4.

E.1. Quality required

The most important factor in this group is quality required. Table 5-3 illustrates that 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 contracts are traditional. The frequency of meetings between contractors, clients, and designers may not be as often as it should and this brings gaps in communication. Also, quality management system may not be taken into consideration or may not be applied well. 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. From all the previous, there is no doubt that why this factor has a high effect on productivity. This factor occurs due to clients' limited time and budget for the designer to do the design in order to expedite the bidding process, and/or error from the engineering department of an organization working carelessly or scheduling inappropriately. This was similar to what was found in earlier studies (Makuksawatudom and Emsely, 2001, and Alinaitwe *et al.*, 2007).

E.2. Inspection and safety requirements

This factor has little negative effect on labor productivity as it came in late position 28 with severity index 3.600; this could be attributed to low ranking of this problem according to importance and frequency of occurrence. This is linked to the overall quality management process. A number of contractors do not follow the quality management procedures and many are not Total Quality

Management certified. Specifications are at times kept in the offices and only used when there is a need for reference. This similar to what was found by Borcherding *et al.*, (1980) who found that inspection delays affect productivity in five nuclear power plants, and similar to other earlier studies(Makuksawatudom and Emsely, 2001, and Ng *et al.*, 2004).

E.3. Change orders

The results from table 5-3 shows that this problem has a little or no effect on labor productivity as it came in the last place between all 30 factors with severity index 3.333. This result is justified, as most of the construction projects in Egypt don't experience a lot of change orders. The project managers interviewed believed that change orders have a little importance and don't add any complexity to the specified tasks. This result disagrees to what was found by Abdul Kadir *et al.*, (2005) who found that change order is one of the five most important factors affects labor productivity in Malaysian residential projects.

E.4. Rework

Although rework was ranked fifth according to importance as shown in table 5-1, it was ranked 21 with severity index 4.7 as shown in table 5-3, which illustrates the moderate effect on labor productivity. This could be attributed to its ranking according to frequency of occurrence as it was ranked in position 26 as shown in table 5-2. It is mainly caused by failure to follow specifications. Specifications should be made clear and explained to the executing team to avoid rework. Repetition of instructions everyday with visual management aids could possibly make it easier for the workers to access them. At the moment, the specifications are usually kept in office and relayed only when they are needed. Also, not preparing a management system for quality is possibly from the main reasons for this problem. This rank is disagreed slightly with earlier studies (Kaming *et al.*, 1998b, Makuksawatudom and Emsely, 2001, and Alinaitwe *et al.*, 2007); most of these studies ranked rework as one of the most severe problems affecting labor productivity in construction.

F. Labor related factors

Table 5-4 demonstrates that this group was ranked seventh with group index equal to 4.57. This gives an indication of the little effect of this group on labor productivity, as none of the factors under this group was ranked high according to severity.

F.1. Inadequate labor skill

The results in table 5-3 shows that this problem was ranked in position 25 with severity index 3.767; this could attributed to the low ranking of this problem according to both importance and frequency. From questionnaire sample results, inadequate labor skill has little effect on labor productivity in construction projects. But this result is not logic because both the experience of labors and improving their skills through continuous training will affect extremely their productivity. This questionnaire result also, disagree with results by Heizer and Render (1990), who confirmed that experience of workforce affects job site productivity, and also disagree with results from construction projects from Gaza strip by Enshassi *et al.*, (2007b),and lema (1996).

F.2. Working overtime

Working overtime is the most important factor in this group, as it was ranked 12 with severity index 5.600 as shown in table 5-3. These results show that this problem has moderate effect on labor productivity in construction. This could be attributed to problems that are caused by working overtime, which lead directly to productivity loss.

F.3. Absenteeism

Although absenteeism was ranked in advanced position according to importance as shown in table 5-1, it was ranked in position 19 according to severity index 4.867 as shown in table 5-3; this could be attributed to the low ranking of this problem according to frequency of occurrence as shown in table 5-2. Labor absenteeism in particular had a moderate effect on labor productivity; this result might be justified, given the transient nature of the local workforce and the ease with which construction contractors could hire

additional labor to cover absenteeism. This was found similar to results from earlier studies (Lim and Alum, 1995, Kaming *et al.*, 1997, and Makuksawatudom and Emsely, 2001)

F.4. Changing crew members

The results in table 5-3 showed that changing crew members has little effect on labor productivity as it was ranked in position 23 with severity index 3.933. This could be attributed to the frequency of occurrence of this problem is low beside the fact that not always the skilled force that is changed or replaced in most of the construction projects. This questionnaire result disagrees with what was found by Olomolaiye *et al.*, (1987) in Nigeria and Kaming *et al.*, (1998b) in Indonesia.

F.5. Overcrowding

Overcrowding is one of the factors that have little negative effect on labor productivity, it was ranked in position 26 with severity index 3.733; this could be attributed to the results in table 5-2 which ranked the overcrowding problem in position 30 according to importance .Increasing the workforce on the construction site is the main source of overcrowding. This result disagreed with most of the previous studies in different countries (Kaming *et al.*, 1998b, and Ng *et al.*, 2004) which mentioned that increasing the workforce on a construction site has an adverse impact on labor productivity.

F.6. Crew interfacing

Interference has an average impact on labor productivity, and was ranked in position 14 of all factors with severity index 5.500 as shown in table 5-3. Interference also has a significant impact on labor productivity in the US, UK, Nigeria, and Indonesia (Yates and Guhathakurta, 1993; Kaming *et al.*, 1998b). Interference between gangs and workers is caused by mismanagement on construction sites, with steel fixers suffering more of this, possibly because they are more dependent on other trades. For example, if the carpenters have not completed the formworks, steel fixers will have to wait before fixing the reinforcement rods.

G. Contractor related factors

Table 5-4 demonstrates that this group was ranked fifth with group index 4.75, which illustrate the moderate effect of this group of factors on labor productivity.

G.1. Poor organization and management

Although this problem was ranked 12 according to importance as shown in table 40 but results in table 5-3 demonstrates that this problem has little effect on labor productivity, as it was ranked in position 22 with severity index 4.567. In the contrary of the results found by Abdul Kadir *et al.*, (2005) who found that incapability of contractors' site management to organize site activities as one of the five most important factors affects labor productivity in construction projects.

G.2. Inadequate construction methods

Results indicate that the construction method in the project are not considered to be as instrumental as other factors, and was ranked in position 24 of all 45 factors negatively affecting labor productivity with severity index 3.833 as shown in table 5-3; this could be attributed to late ranking position of this problem according to frequency of occurrence. Poor construction methods are mainly due to poor planning of the work. Contractors should be encouraged to develop work statements before the work starts. This result is not supported by Sanders and Thomas, (1991), who found that construction method and project features have a high impact on labor productivity. This result might be justified, because construction projects in Egypt are not complex and are small in size. Therefore activities in different projects largely have the same features, and there is no major difference between methods used in construction.

G.3. Improper crew design

Results from table 5-3 illustrates that improper crew design has moderate effect on labor productivity, as it was ranked in position 17 with severity index 5.100. This result is justified; as improper crew design may lead the crews not perform productively by increasing the waiting time for assistance to skilled labors.

G.4. Supervision delay

Supervision delay has no or little effect on labor productivity, as it was ranked in position 29 with little severity index 3.500. Supervision delay was ranked in positions 22 and 30 according to importance and frequency of occurrence respectively. This could be partly because the simplicity and repetition of the construction tasks; effect of supervision delays increased when there are unfamiliar or complex details needing careful explanation and checking.

G.5. Inadequate supervisors' skills

The most severe factor in this group is inadequate supervisors' skills, as it was ranked sixth with severity index 6.733; this could be attributed to the advanced ranking of this factor according to both importance and frequency of occurrence. The factor of Incompetent supervisors is rated highest on the overall severity index. 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. There is therefore a need for continuous training of the supervisors. The other issue is that they may not be well facilitated to do their work. Incompetence of supervisors affects many other factors. This was found similar to earlier studies (Kaming *et al.,* 1998b, Makuksawatudom and Emsely, 2001, Ng *et al.,* 2004, and Enshassi *et al.*, 2007b).

I. External factors

This group of factors was ranked fourth according to severity group index equal to 5.310 as shown in table 5-4. This group has moderate effect on labor productivity in construction projects.

I.1. Weather conditions

Adverse weather conditions have moderate effect on labor productivity. The factor of harsh weather conditions is ranked in position 15 from the overall severity index with severity index 5.267 as shown in table 5-3. Sanders and Thomas, (1991) support this result in their study of factors affecting

productivity in the United States. Egypt; being in the Middle East region, experiences fine weather conditions most time of the year. The temperature in Egypt is within acceptable range and therefore, increase and decrease of temperature have a low effect on labor productivity. However, adverse winter weather such as winds and rains reduce labor productivity; particularly external work such as formwork, steel work, concrete casting, external plastering, external painting, and external tiling. They cause damage to unprotected building components under construction that are mainly carried out in situ. Adverse weather sometimes stopped work totally. This result was found similar to earlier studies (Motwani *et al.*, 1995, and Alinaitwe *et al.*, 2007).

I.2. Regulatory requirements

Although it was ranked in position 27 according to importance, regulatory requirements have moderate effect on labor productivity as it was ranked in position 18 of all factors negatively affecting labor productivity with severity index 5.033 as shown in table 5-3; this could be attributed to moderate ranking of this problem according to frequency of occurrence. Results show that augmentation of government regulations related to the construction sector is not considered to be as instrumental as other factors. This result might be justified within Egypt, where government regulation of construction projects has been subjected to minor changes only during the last years.

I.3. Disruptions

Table 5-3 illustrates that disruptions was ranked in position 11 according to severity index 5.633. Stoppages because of work being rejected by consultants are the main cause of disruptions. This could be attributed to that most of construction projects suffer from disruptions caused by poor planning, organization between subcontractors, and even some external factors such as material market disruptions.

5.4. Comparison with other countries

Several authors have carried out investigations into productivity problems in various countries, all of which have used different factors. In order to compare the results obtained previously with the results of this study, six factors have been selected, which were highlighted by other authors in different countries, and the ranking of these factors is shown in the following table 5-5. Ranking illustrated in the table is the relative ranking of these six factors from previous research. From this, it is reasonable to conclude that lack of material is the most crucial productivity problem internationally, as the factor was ranked first in almost all countries surveyed except Uganda as it was ranked in position 4; in this research lack of material was ranked first between the six problems which support these results. As for lack of tools and equipments, this factor showed high negative effect on labor productivity in all countries. This problem was ranked second in this research which is supported by the results from all developed and developing countries. Meanwhile, all countries experience the impact of rework at about the same level including this research. The most two countries suffers from rework are Indonesia and Uganda as this problem was ranked second, and the less region suffers from this problem is Greater Cairo as it was ranked fifth in this research, but this doesn't deny the moderate effect of rework on productivity as discussed earlier in this chapter. Developed countries suffer less from absenteeism than developing countries, which agrees with results in this research, as absenteeism was ranked in fourth similar to what found in Thailand and Indonesia. The most country suffering from Absenteeism is Iran as it was ranked third, and the less country suffers from that problem is Palestine as it was ranked sixth, which was similar to what found in US and UK. Interference shows moderate effect on labor productivity in this research which was close to results from other countries except for Nigeria and Uganda which suffers fewer interference problems. Supervision delay was ranked sixth between the selected problems in this research, and that result was found similar to that found in Thailand and Indonesia. On the other hand disagree with results from Uganda and Palestine as supervision delay was ranked first and second respectively. Considering developed and developing countries separately, it is fair to say that developed countries have fewer

problems with supervision delays than developing countries as Uganda and Palestine. On the other hand some of the developing countries showed less problems considering supervision delay as Thailand, Indonesia, and results from this research. In more detail, when focusing only on developing countries, the results of these studies, shown in Table 5-5, showed close ranking between factors. However, the results from this research show great matching with Indonesia and Thailand. For example, when comparing results in this research and Indonesia, four of six factors are ranked exactly the same, and the same for Thailand.

Table 5-5. Comparison of productivity problems with other countries

Factors affecting productivity	Egypt[4]	Thailand[1]	Indonesia[1]	Iran[1]	Nigeria[1]	Uganda[2]	Palestine[3]	UK[1]	USA[1]
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank
Lack of material	1st	1st	1st	1st	1st	4th	1st	1st	1st
Lack of tools and equipment	2nd	2nd	5th	2nd	3rd	3rd	3rd	5th	2nd
Rework	5th	3rd	2nd	4th	2nd	2nd	4th	3rd	3rd
Absenteeism	4th	4th	4th	3rd	5th	5th	6th	6th	6th
Interference	3rd	5th	3rd	5th	6th	6th	5th	2nd	5th
Supervision delays	6th	6th	6th	N/A	4th	1st	2nd	4th	4th

[1] Makulsawatudom and Emsely, (2001), [2]Alinaitwe *et al.*, (2007)

[3]Adnan Enshassi *et al.*, (2007b), [4] this research

5.5. Model analysis

In this section the data collected from the collected from 41 building sites by project managers was analyzed using descriptive statistical techniques. 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. After that reliability of the scale and individual items will be tested using one of the most common used reliability coefficients Cronbach's alpha (α).

5.5.1. Descriptive statistical analysis

Using the Excel and SPSS software were used to calculate the means, standard deviations, and variances of each item and for the overall scale (factors affecting labor productivity will be referred at as items in this chapter). Table 5-6 shows the overall scale statistics while, table 5-7 shows the descriptive statistics for productivity problems.

Table 5-6. Scale statistics

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

Table 5-7 illustrates that the average scores of the items ranges from 9.37 for item 7 (for length of work day), to 3.33 for item 15 (for change orders) and the sum of item means is 161.70 as shown in table 5-6. Three items from all 30 items experienced large standard deviation values item 8 (lack of proper equipments), item 11(lack of materials), and item 30(Disruptions). their standard deviations are 4.360, 4.108, 4.021 respectively. This means respondents' perceptions showed great variance in respect to the impact of these three items on labor productivity. On the other hand items 2(lack of facility areas), 15(change orders), and 19(absenteeism) had the smallest standard deviations values 1.230, 1.322, and 1.737 respectively; which means that respondents showed little variance on their evaluation of the severity of these items on labor productivity. The rest of factors had reasonable standard deviations as shown from table 5-7. Table 5-6 illustrates that sum of item means is 161.700 and sum of variances is 1,323.528 and the sum of item standard deviations is 36.380.

Table 5-7. Descriptive statistics for productivity problems

Item no.	Problem	Mean	Std. Deviation	Variance
1	Poor site management & access	5.53	3.550	12.602
2	Lack of facility areas	3.73	1.230	1.513
3	Work complexity	5.87	2.636	6.947
4	Height	4.80	2.265	5.131
5	Extra work	5.17	2.743	7.523
6	Large volume of work	6.17	2.408	5.799
7	Length of work day	9.37	3.285	10.792
8	Lack of proper equipment	7.43	4.360	19.013
9	Lack of proper tools	6.93	3.973	15.789
10	Equipment break down	7.83	3.141	9.868
11	Lack of materials	7.77	4.108	16.875
12	Material type	6.30	2.984	8.907
13	Quality required (drawing &specs.)	6.10	2.591	6.714
14	Inspection & safety requirements	3.60	2.581	6.662
15	Change orders	3.33	1.322	1.747
16	Rework	4.70	2.575	6.631
17	Inadequate labor skill	3.77	2.635	6.944
18	Working overtime	5.60	3.092	9.559
19	Absenteeism	4.87	1.737	3.016
20	Changing crew members	3.93	2.803	7.857
21	Overcrowding	3.73	2.993	8.961
22	Crew interfacing	5.50	3.071	9.431
23	Poor organization & management	4.57	2.979	8.875
24	Inadequate construction methods	3.83	2.019	4.075
25	Improper crew design	5.10	2.524	6.369
26	Supervision delay	3.50	2.080	4.328
27	Inadequate supervisors skill	6.73	2.377	5.651
28	Weather conditions	5.27	2.703	7.306
29	Regulatory requirements	5.03	3.429	11.757
30	Disruptions	5.63	4.021	16.171

In order to evaluate the correlation between the items, the correlation matrix of the productivity problems was calculated as shown in table 5-8. Positive values indicate associations between items, in view that a strong correlation (>0.7) shows strong association between items and negative values indicate weak correlations between items. Most of the negative values in the correlation matrix were computed for items 4(height), 5(extra work), 18(working overtime), and 19(absenteeism) which indicates the weak correlation between these items and overall scale. In the contrary, some of the items as item 7 (length of work day) and item 8 (lack of proper equipments) show high values of correlations with other items as shown in table 5-8.

Additional statistics for the scale as a whole are as shown in table 5-9. The average score of any item is 5.39, with range 6.03 and variance 2.2. Similarly, the average of the item variances is 8.43, with a minimum 1.51 for item 2 (lack of facility areas) and maximum 19.01 for item 8 (lack of proper equipments). The correlation between items ranges from -0.86 to 0.88. The average correlation is 0.13, which indicate little association between all items, i.e. the data are not particularly skewed.

Table 5-9. Summary statistics of the items

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	5.39	3.33	9.37	6.03	2.81	2.20
Item Variances	8.43	1.51	19.01	17.50	12.57	18.62
Inter-Item Correlations	0.13	-0.86	0.88	1.74	-1.02	0.10

5.5.2. Reliability analysis

Reliability refers to the extent to which the scale provides consistent results. Ideally, the measurements that we take with a scale would always replicate perfectly. However, in the real world there are a number of external random factors that can affect the way that respondents provide answers to a scale. A particular measurement taken with the scale is therefore composed of two factors: the theoretical "true score" of the scale and the variation caused by random factors. Reliability is a measure of how much of the variability in the observed scores actually represents variability in the underlying true score. Reliability ranges from 0 to 1. In psychology it is preferred to have scales with reliability greater than 0.70. The reliability of a scale is heavily dependent on the number of items composing the scale. Even using items with poor internal consistency, you can get a reliable scale if your scale is long enough. For example, 10 items that have an average inter-item correlation of only 0.20 will produce a scale with a reliability of 0.714. So even the average inter-item correlation calculated for the 30 items represented in this scale is 0.13 as shown in table 30, this scale can be reliable.

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. Cronbach's alpha was calculated for the 30 items discussed in this research using the equation stated in chapter 4. 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 k^{th} variable was calculated by equation stated in chapter 4. It is highly accurate and has the advantage of only requiring a single administration of the scale. The only real disadvantage is that it is difficult to calculate by hand, so the SPSS software was used.

Cronbach's alpha for diagnosing severity of Egyptian productivity problems is 0.837, indicating that our scale is reasonably reliable. The other output in this analysis is labeled the standardized item alpha (0.814). This is the alpha value that would be obtained if all the items were standardized to have a variance of 1. Since the items on our scale have fairly comparable variance, there is little difference

between the two alphas. If items on the scale have widely differing variances, the two alphas may differ substantially. Therefore, the higher the reliability of this scale indicates the easier it is to obtain significant findings. Table 5-10 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 of Table 5-10 shows what the average score for the scale would be if the item were excluded from the scale. For example, we know from Table 5-6 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. The column labeled Corrected item-total correlation is the Pearson correlation coefficient between the score on the individual item and the sum of the scores on the remaining items. For example, the correlation between the score on item 1 and the sum of scores of items 1-30 is only 0.70. This indicates the relationship between each item and other items. From table 5-10 it is clear that some of the items have positive values of corrected item-total correlations which indicate strong relationship with other items. Items 8(lack of proper equipments), 7(length of work day), and 1(poor site management and access), have the highest values of corrected item-total correlation 0.783, 0.749, and 0.700; this reflects the strong relationships between these items and the overall scale. On the other hand, items 5(extra work), 4(height), 19(absenteeism), 18(working overtime), and 6 (large volume of work) have negative values of corrected item-total correlations -0.644, -0.266, -0.264, -0.206, and -0.099 respectively, which indicates negative correlations with the other items.

When we examine individual items, as in Table 5-10, we may want to know how each of the items affects the reliability of the scale. This can be accomplished by calculating Cronbach's alpha when each of the items is removed from the scale. These alphas are shown in the last column of Table 5-10. 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.

Table 5-10. Item-total statistics

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	156.17	1,142.833	0.700	0.818
2	157.97	1,286.171	0.406	0.833
3	155.83	1,301.592	0.079	0.840
4	156.90	1,362.921	-0.266	0.847
5	156.53	1,450.533	-0.644	0.861
6	155.53	1,335.085	-0.099	0.844
7	152.33	1,139.126	0.783	0.816
8	154.27	1,088.892	0.749	0.813
9	154.77	1,161.564	0.540	0.824
10	153.87	1,168.395	0.676	0.820
11	153.93	1,136.754	0.613	0.821
12	155.40	1,174.041	0.687	0.821
13	155.60	1,250.524	0.362	0.832
14	158.10	1,237.541	0.437	0.830
15	158.37	1,289.482	0.340	0.834
16	157.00	1,270.828	0.251	0.835
17	157.93	1,248.685	0.365	0.832
18	156.10	1,361.059	-0.206	0.851
19	156.83	1,354.282	-0.264	0.845
20	157.77	1,185.771	0.673	0.822
21	157.97	1,289.689	0.116	0.840
22	156.20	1,247.200	0.308	0.834
23	157.13	1,205.223	0.529	0.826
24	157.87	1,272.740	0.324	0.833
25	156.60	1,230.455	0.490	0.828
26	158.20	1,251.683	0.459	0.830
27	154.97	1,307.068	0.063	0.840
28	156.43	1,209.013	0.570	0.825
29	156.67	1,180.368	0.558	0.824
30	156.07	1,172.064	0.491	0.827

On the contrary we can see from table 5-10 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. The items that are dropped from the scale are: Height, Extra work, Large volume of work, Working overtime, and Absenteeism. The factors that have positive effect on reliability must be kept within the scale to provide a more reliable scale of factors

affecting labor productivity, these items are: Poor site management and access, length of work day, and lack of proper equipments. The rest of the factors experience little change in the alpha value, because the change of this value is so small, we would not expect any item to be eliminated in order to increase the reliability of the scale. The reliability analysis for assessing the severity of Egyptian labor productivity problems using 30 items has been demonstrated. Results indicate that the 30 items used to measure on-site productivity problems are reliable (alpha = 0.837). Ultimately, the model for assessing severity of the productivity problems using the 25 items could be more reliable after dropping 5 items.