SIMULATION AS A TOOL IN TIME SCHEDULING OF CONSTRUCTION PROJECTS (CASE STUDY)

عنوان البحث: استعمال المحاكاة كاداة لجدولة المشاريع الانشائية (دراسة حالة)

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Abstract

This study deals with using simulation as a tool in time scheduling of construction projects taking a real project as a case study. This study shows that there is no unique situation to execute a construction project regarding its duration or cost. Instead there are probabilities of risk in these features that must be taken in planning phase .Simulation is an effective tool to expect so many situations regarding project duration or cost in that it enables the manager to take a wide range view or the construction in planning phase. In this study an Excel simulation model was made and there was ability to expect a more likely duration for the project under this study (with an increase of 5%) and a more likely cost (with an increase of 0.7%) . Taken three standard deviations from these values it was very reasonable to put in hand a tool that can be used by the project manager as a performance measure.

Key Words

Scheduling, Simulation, Critical Path Method (CPM) , Direct Cost (D.C.) , Indirect Cost (I.C.) , Risk , Iraqi Dinar (I.D.)

المستخلص

تبين الدراسة وجود طرائق متعددة لتنفيذ المشاريع الانشائية فيما يخص وقت الانجاز والكلفة. كما ان هناك احتمالية التعرض للمخاطر يجب اخذها بنظر الاعتبار في عملية التخطيط للمشاريع.

يعد اسلوب المحاكاة اداة فعالة لمواجهة مواقف تعالج اهم محددين في المشروع (مدة الانجاز و كلفته). تم استخدام برنامج (Excel) لوضع نموذج المحاكاة ومن خلاله حددنا الوقت الاكثر احتمالاً لانجاز المشروع قيد الدراسة ب (5%) زيادة, بالاضافة الى التكلفة الاكثر احتمالاً وبزيادة تبلغ (0.7%) وعند حساب الانحراف المعياري بمستوى جودة (3σ), فتكون هذه الدراسة قد وضعت تحت ايدينا اداتين فعالتين تمكن مدير المشروع من تبنيهما كونها معقولة من وجهة نظر الادارة في قياس الاداء.

Introduction

Scheduling is the most important step in planning of any construction project even in the execution phase of projects. This includes both time and cost requirements. Deterministic methods of scheduling is the most widely used in local and even global practices. However, these traditional methods like Critical Path Method (CPM) are not enough to give the real picture for the project. For instance, they could not take into account the possible risks of elongation of project duration or increasing of costs [1]. This study try to put under viewing this problem and to give a method taking in account the mentioned risks. A real project has been studied in detail.

The Research Aims

The main aim of this research is to construct a time schedule for a real construction project taking into account risks of delay and over cost budget. Another aim is to introduce an EXCELL sheet that makes iterations to get obvious picture for the future during executing the project.

Project under Study

The project of this study is a house building of one story and with an area about 200 square meters. Figure (1) shows the plan of the building. The final durations and direct costs for activities involved in the project of this study are calculated and summarized in Table (1) from which the total direct cost of the project is 330,196,600 I.D. These values are computed as a sum of all breakdown components of each activity. This involves labor, materials and equipment required to finish work as specified by drawings and bill of quantities of the project. Figure (2) shows the CPM network made using method of rectangles with a resulted total duration of 141 days . Figure (3) shows the same network using method of circles and arrows. The Bar Chart of the project is shown in Figure (4). The indirect cost is estimated as 300,000 I.D. Per day. Thus, the total estimated indirect cost of the project is 42,300,000 I.D and the total cost of the project is 372,496,600 I.D. In the practical situation these figures are not the same and hence there are always risks in time and cost in terms of increased duration and increased cost [2]. To take into account the variability in durations and costs of various activities an Excel sheet is prepared such that each duration of each activity is given a range of variability extracted from a data base that represents the performance of previous implemented activities. Similar range of variability is given for each activity's direct cost. The ranges of variations are represented by standard deviations (σ) and shown in detail in Table (2). Figure (5) shows a part from the Excel sheet with which the simulation for durations and direct costs is made by generating random numbers as follows [3]:

RORM.INV (RAND ( );mean value ; standard deviation)

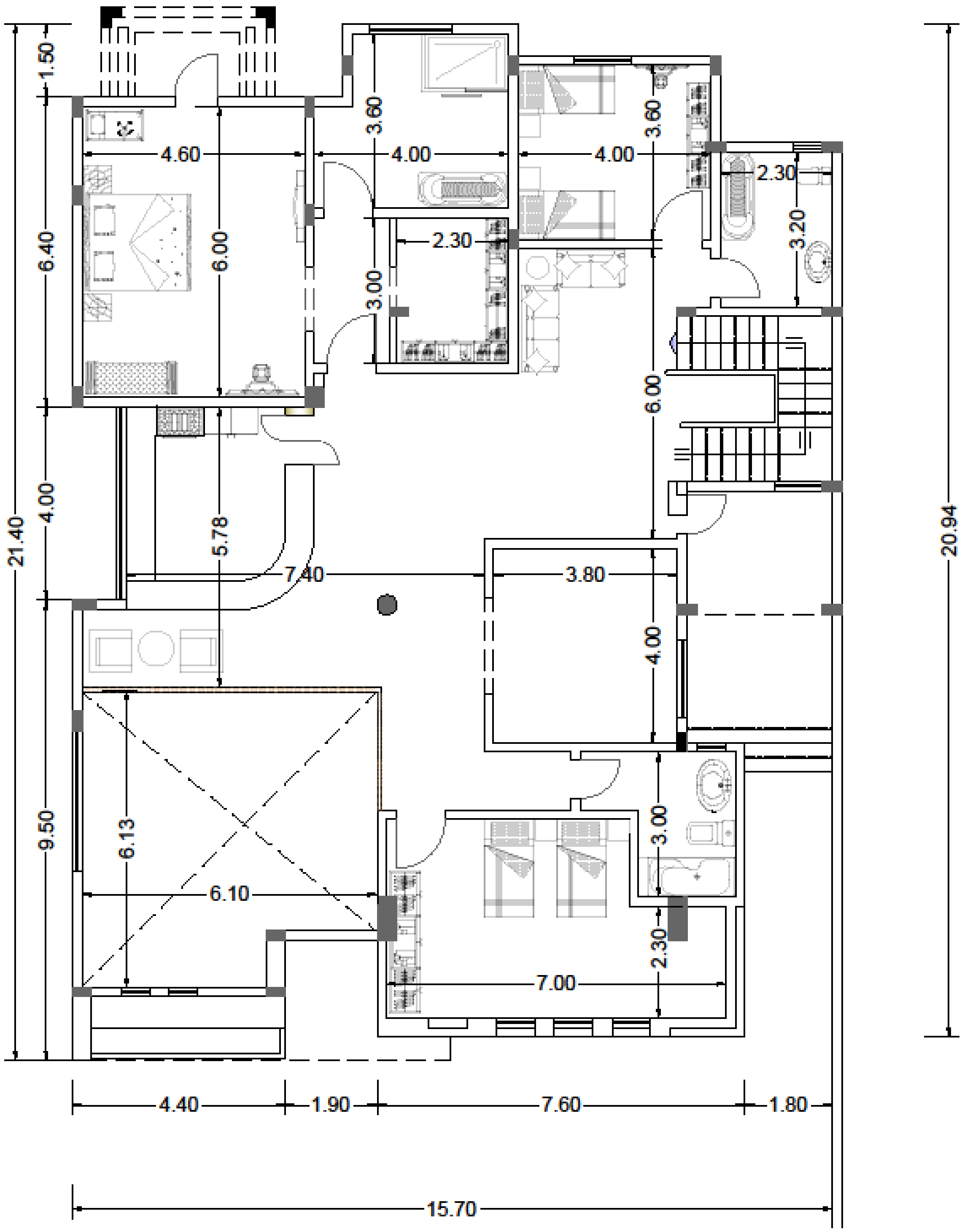


Figure (1) Plan of the project under study

Table (1) Direct and indirect costs of the project

Activity	Abbreviation	Duration (days)	Direct Cost (I.D.)
Foundation	FND	24	33,841,100
Structure	STR	44	69,600,000
Masonry	MAS	16	24,500,000
Tiling	TIL	10	11,340,000
Plastering	PLS	28	31,200,000
Electrical Works	ELC	50	6,125,000
Plumbing Works	PLM	47	10,846,000
Roofing	ROF	10	9,450,000
Elevation Works	ELV	15	24,700,000
Windows and Doors	WAD	20	3,795,000
Outer Works	OUT	10	5,500,000
Fencing	FNC	30	82,699,500
Painting	PNT	15	15,600,000
Finishing	FSH	7	1,000,000
		Direct Cost	330,196,600
		Indirect Cost	42,300,000
		Total	372,496,600

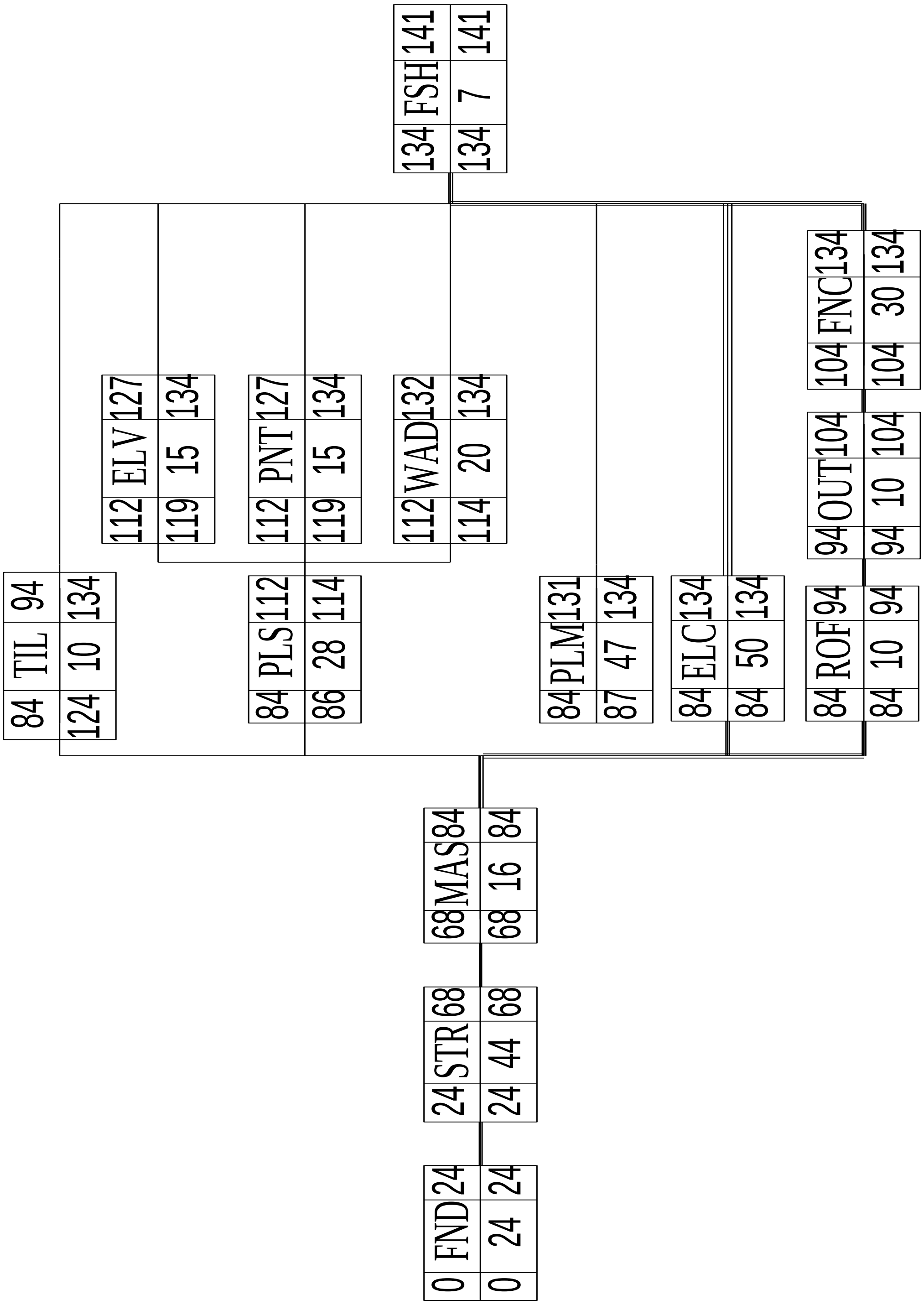


Figure (2) CPM network for the project (method of rectangles)

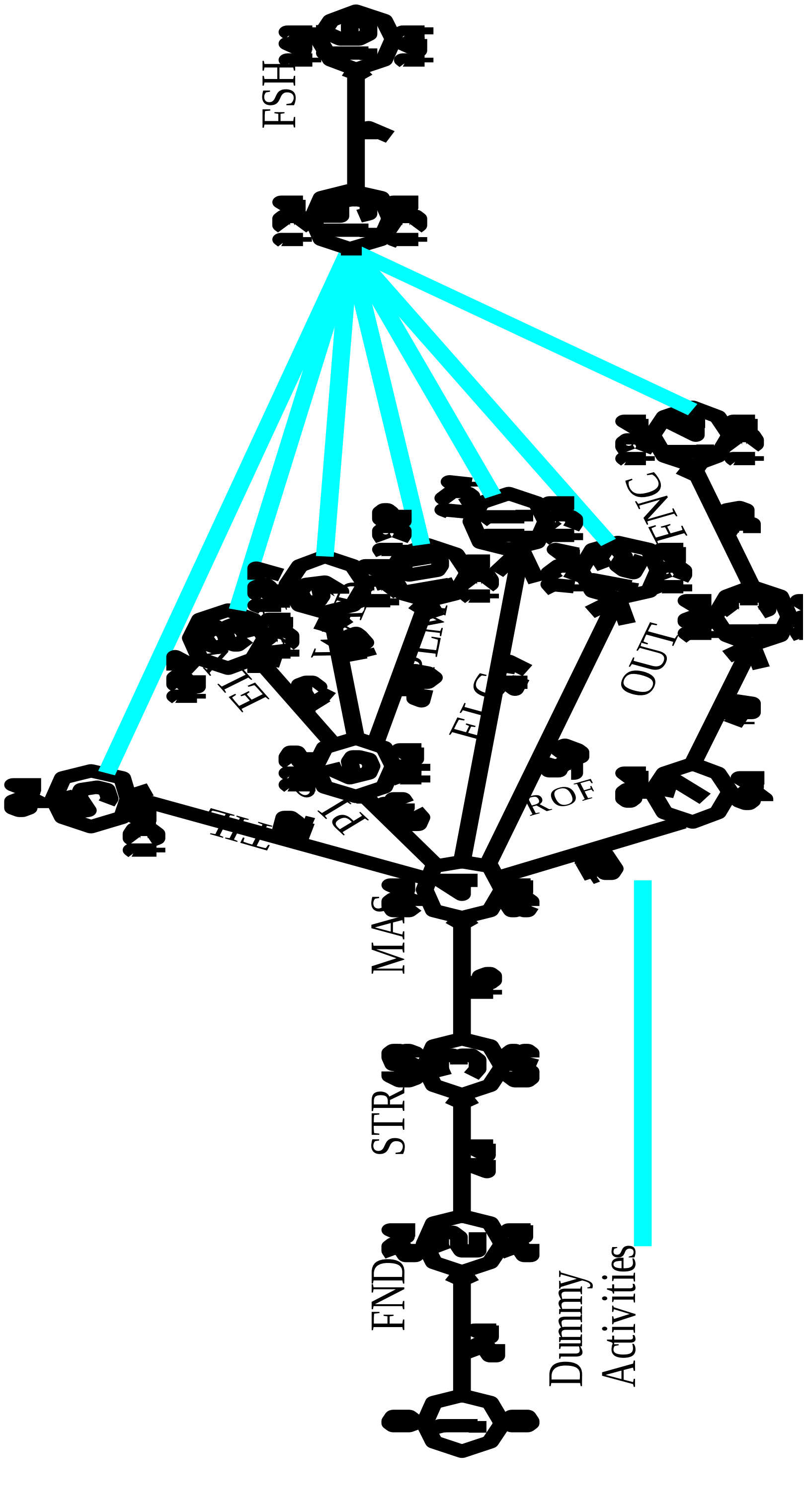


Figure (3) CPM network for the project (method of arrows and circles)

A simulation of 20000 cycles is made for all activities (both durations and direct costs) and the final results are as follows:
Average total duration of the project = 147.8 **days**
Hence the average indirect cost = 147.8 × 300,000 = **44,340,000 I.D**
Average total direct cost of the project = **330,600,000 I.D**
Hence the total cost = 44,340,000 + 330,600,000 = **374,940,000 I.D**
The increase in the duration of the project equals: 147.8 – 141 = **6.8 days**
This represents about **5%** from the expected mean duration of the project.
The increase in the total cost of the project equals: 374,940,000 – 372,496,600 = **2,443,400 I.D**
This represents about **0.7%** from the expected mean total cost of the project [4] [5].
It can be shown from the results of simulation that the standard deviation of the duration (7.5 **days**) approximately equals the squared root of the sum of squared standard deviations of the critical activities (star indicated in table (2)) which is calculated as (**7.1 days**) . However the standard deviation of the total direct cost (13,400,000 **I.D**) is far somewhat from the squared root of the sum of squared standard deviations of all activities which is calculated as (12,800,000 **I.D**). This is so because the total direct cost does not involve only the critical activities but all activities, hence the variation would be more as it is shown. [6].
If the project is to be executed (hypothetically) according to the simulation had been done the expected standard deviation of project duration is 7.5 **days** and that of the total cost is **13,400,000 I.D**. As a measure of managing performance **three standard deviations** may be taken above the expected values of the project duration and cost [7][8] . This means that for the manager of the project to success in performance, the duration of the project should not exceed :
147.8 + 3×7.5 = 170.3 days, say **170 days**
In a similar way, the total cost of the project should not exceed :
374,940,000 + 3× 13,400,000 = 415,140,000 I.D, say **415,000,000 I.D**

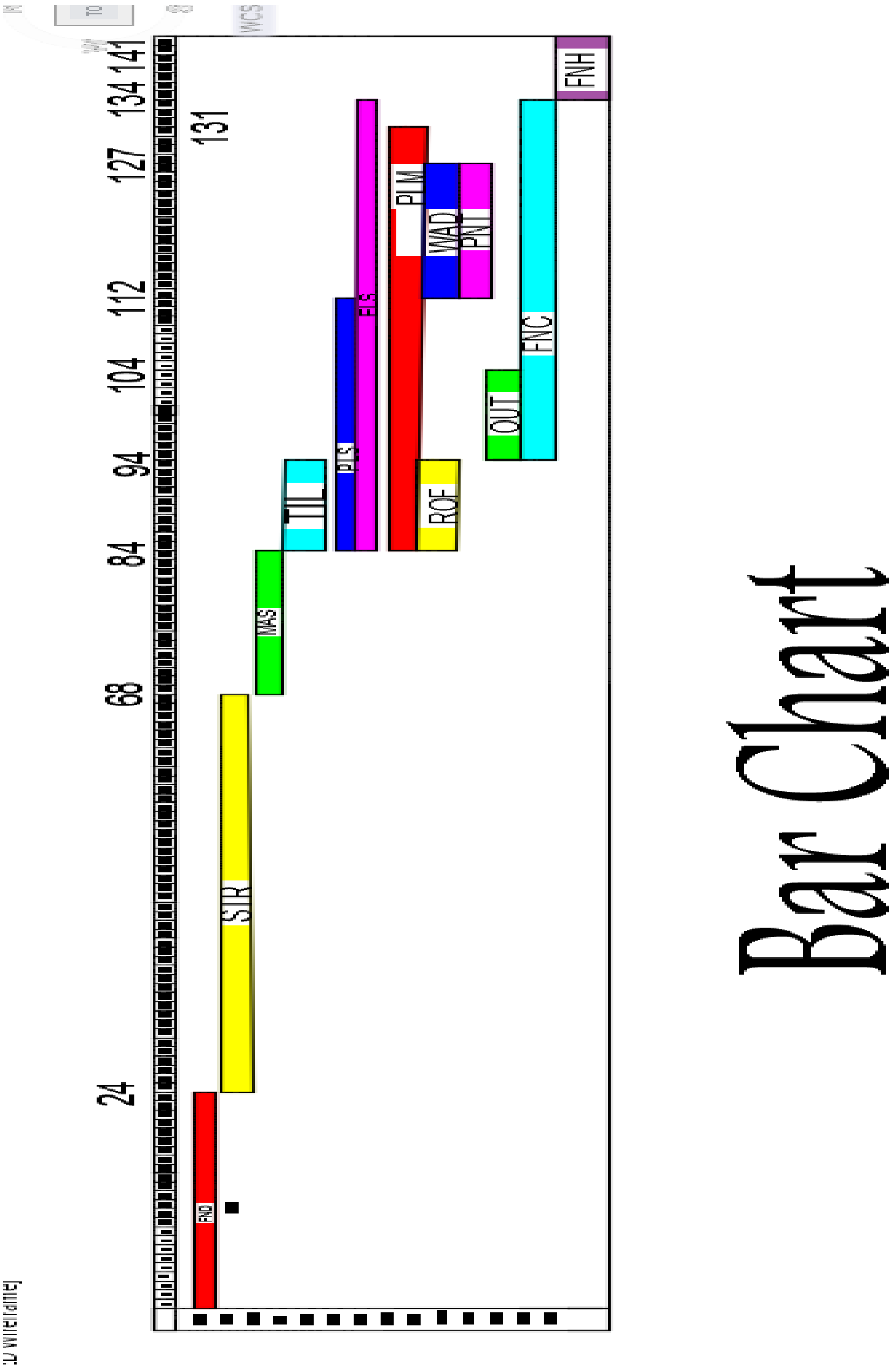
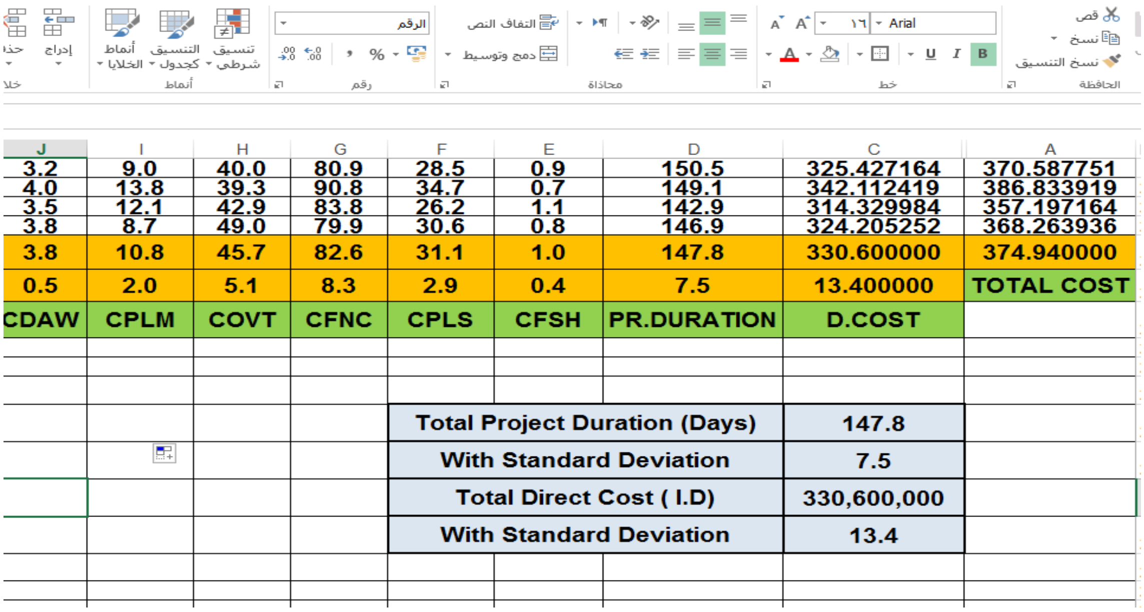


Figure (4) Bar Chart of the project

Table (2) Standard deviations of activities' durations and direct costs

Activity	Duration (days)		Direct Cost (1000, 000 I.D)	
	Mean Value	St. Deviation(σ)	Mean Value	St. Deviation(σ)
FND*	24	3	33.8	4
STR*	44	5	69.6	7
MAS*	16	2	24.5	3
TIL	10	1	11.34	1
PLS	28	3	31.2	3
ELC	50	5	6.125	1
PLM	47	5	10.846	2
ROF*	10	1	9.45	1
ELV	15	2	24.7	5
WAD	20	2	3.795	0.5
OUT*	10	1	5.5	5
FNC*	30	3	82.6995	8
PNT	15	2	15.6	5
FSH *	7	1	1.0	0.4

*Critical activities



J	I	H	G	F	E	D	C	A
3.2	9.0	40.0	80.9	28.5	0.9	150.5	325.427164	370.587751
4.0	13.8	39.3	90.8	34.7	0.7	149.1	342.112419	386.833919
3.5	12.1	42.9	83.8	26.2	1.1	142.9	314.329984	357.197164
3.8	8.7	49.0	79.9	30.6	0.8	146.9	324.205252	368.263936
3.8	10.8	45.7	82.6	31.1	1.0	147.8	330.600000	374.940000
0.5	2.0	5.1	8.3	2.9	0.4	7.5	13.400000	TOTAL COST
CDAW	CPLM	COVT	CFNC	CPLS	CFSH	PR.DURATION	D.COST	

Total Project Duration (Days)	147.8
With Standard Deviation	7.5
Total Direct Cost (I.D)	330,600,000
With Standard Deviation	13.4

Figure (5) A part from the Excel sheet for simulating durations and direct costs

Conclusions

There are some conclusions can be extracted from this work as follows:

1- There is no one unique situation to execute a construction project regarding its duration or cost, instead there are probabilities of risks in these features that must be taken in planning phase.
2- Simulation is an effective tool to expect so many situations regarding project duration or cost in that it enables the manager to take a wide range view for the construction in planning phase.
3- In this study there was ability to expect a more likely duration for the project under study (with increasing of **5%**) and a more likely cost (with increasing of **0.7%**). Taken three standard deviations from these values it was very reasonable to put in hand a measure for management performance for the project.

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