Computer Integrated Model to Estimate the Construction Cost and Duration of Building Projects at Their Feasibility Stage

By

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I dedicate This Work to My Family Especially My Father and My Mother

ACKNOLEGMENT

First, I would like to thank God for helping me to finish this work.

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Abstract

Presently, owners are interested in evaluating the feasibility of investing in the construction of new building projects based on cost and time constraints. They need to therefore have an idea about the project construction costs, the time required to finish construction of a project in its conceptual phase, and about the implementation of feasibility study. Because due to associated risks, construction cost estimates and schedules are vital to any project. The research's objective is to develop a methodology that can be used to create an integrated computer model that helps owners and designers generate construction cost estimates, and derive the baseline schedule for any proposed building project at its feasibility stage. All the relevant data used within the model is collected from the literature and is stored in comprehensive databases designed for this purpose. The data is based on 2011 RSMeans publications and consist of around 4,000 previously constructed projects. The model is developed in a Microsoft environment using Microsoft Excel 2007 and Microsoft Project 2007.

This model uses deterministic and stochastic approaches to execute all necessary calculations for the conceptual cost estimate and baseline schedule. A deterministic approach relies on realistic data while a stochastic one relies on incorporating the uncertainty and risk available in calculating the cost and duration of any construction building project. The model is user friendly, flexible and executes all the necessary calculations quickly. The successful development of the model would help owners and investors identify the cost and baseline schedule of proposed projects at the early stages of the project life, so that they have an idea of the budget required for construction and the time needed to recover their investment.

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Glossary

A	Activity percentage.
C	Published cost per square foot of activity.
D	Duration of each activity of the project.
F	Location factor.
Q	Quantity of each activity of the project.
X	Size factor.
Y(1)	Cost multiplier (1).
Y(2)	Cost multiplier (2).
AF	Architectural fee.
AP	The activity percentage.
C_A	Cost in city A.
C_d	Cost per square foot of division.
C_L	Adjusted cost per square foot for location difference.
C_N	National average cost.
CP	Cost per square foot (Published).
C_S	Adjusted cost per square foot for size difference.
C_V	Cost value.

DC Total daily cost per crew.

DL Daily output per labor.

DP Division percentage.

D_V Duration value.

HC Total hourly labor cost per crew.

I_A Index for city A.

I_N Index based on 30 major cities in North America.

MC Most likely cost value.

MD Most likely duration value.

OC Optimistic cost value.

OD Optimistic duration value.

OV Overhead cost.

PC Pessimistic cost value.

PD Percentage of daily output per labor.

PI Probabilistic percentage of the influence of each factor on every project activity.

PS Project size (Square foot area).

SD Summation of the daily cost rate per labor of each crew.

SH Summation of hourly labor cost per crew.

SO Summation of daily output of (Labor, Material, Equipment).

TC Total project cost.

UC Unit cost per activity.

VP Variation percentage.

ACA Adjusted cost per square foot per activity (Published).

ACD Adjusted cost per square foot per division.

ATC Adjusted total cost per square foot of project.

CPA Cost per activity.

CPD Cost per division.

PDU Pessimistic duration value.

PTC Published total cost per square foot of project.

SPR Size of the proposed project.

SPU Size of the published project.

TCD Total cost per square foot per division.

WVC Percentage weighted variation of the effective factors on the cost of each activity.

WVD Percentage weighted variation of the effective factors on the duration of each activity.

Chapter One

Introduction

1.1- Background:

Generally, any construction project relies on estimating two important elements. They are the cost and duration of construction. These elements are important to owners, investors and decision makers because they provide an indication of the size of the budget and time needed to complete the construction. Knowing the value of these elements is vital at the conceptual stage when feasibility studies are implemented. This is because major decisions on continuation or dismissal of the project are taken based on them.

Estimating the construction cost and duration of a project at the feasibility stage depends on three main factors. 1- The availability of historical data from similar projects that are constructed in the past. 2- The estimator's experience, which plays an important role during the estimation process. 3- The accuracy of the estimate because it has a big impact on the failure or success of the project.

Estimating at the feasibility stage can be processed by using a deterministic or stochastic approach or by combining them. With a deterministic approach, the cost and duration of the construction are calculated by using one certain value for every single variable incorporated in the proposed project. Whereas, in the stochastic approach, calculating the cost and duration of construction is done by using the probability theory which deals with the uncertainty that resides in variable values. This research will use the two approaches to provide owners and investors with more information about the budget and the time required to finish the construction project; and the probability to achieve these values.

1.2- Research Objectives:

During the feasibility study of any proposed project the objective is to be able to estimate the construction cost and duration with an acceptable degree of accuracy. By identifying the desired budget and the required completion time, the project implementation cycle will be known.

This research's objectives are specified based on the actual problems that face estimators and investors during the estimation process when conducting feasibility study for proposed building projects. Thus, the main objective of this research is to develop an integrated methodology for modeling the construction cost and duration estimates for building projects at the feasibility stage of their life cycle. The sub- objectives of the research are to:

1. Study and evaluate the different methods used to estimate the construction cost and duration of building projects.
2. Identify the relationships between the cost and duration of construction projects and their importance.
3. Determine the factors that influence the accuracy of estimating the cost and duration of construction projects.
4. Automate the process of generating conceptual cost estimates and baseline schedules by using both the deterministic and stochastic approaches.

1.3- Methodology:

To accomplish all the above listed objectives the following steps need to be taken:

1.3.1- Literature Review:

A comprehensive literature review in the area of conceptual cost estimating, baseline scheduling, probability theory and Mont Carlo Simulation must be conducted.

1.3.2- Data Collection:

Preparing cost estimates and baseline schedules heavily depend on data; therefore data collection has to be carried out to develop the proposed model. Since the collected data of actual projects previously constructed is not sufficient to cover all project types, published data is the only remaining alternative. Therefore, all the data used in this research is collected from 2011 RSMeans publications. The RSMeans standard provides all the information related to construction cost and duration estimates in North America. The collected data resources from RSMeans include: RSMeans-Square Foot Costs (2011) and RSMeans-Building Construction Cost Data (2011).

1.4- Thesis Organization:

This thesis has six chapters. A brief description of each is provided as follows:

- Chapter Two: presents the comprehensive literature review of this research. This is divided into construction cost and duration estimates at the feasibility stage. The first part focuses on project cost estimates, their definitions, their purposes and types. It describes the process of modeling the cost and the factors that affect building project cost estimates. The second part reviews the methods used to predict the construction time for building projects. This is achieved by identifying the construction activities, the methods of computing their duration and the tools used in planning and scheduling these activities. Moreover, it introduces the factors that influence the activity duration and the overall duration of the project.

- Chapter Three: describes the methodology that has been used in developing the proposed model, clarifying its components and data flow.

- Chapter Four: illustrates the proposed model development process and methods used to merge both the deterministic and stochastic approaches needed to prepare conceptual cost estimates and to generate preliminary baseline schedules.

- Chapter Five: examines the capability and feasibility of the developed model by estimating the cost and duration of an actual building project.

- Chapter Six: presents the thesis conclusions and recommendations for future expansions, as well as limitations of the current research.

Chapter Two

Literature Review

2.1-Introduction

Cost, time, quality and good will are common objectives of any construction project. However, cost and time are considered the most important parameters to take into account at the feasibility stage of a building project. These parameters are of high importance to owners and decision makers because they provide insight into the budget and time needed to finish the construction project. Therefore, the cost and time values rely on many factors such as, the estimators' experience and historical data from previous construction projects and the accuracy of the estimate that specifies the success or failure of the project. For this reason, this chapter incorporates a comprehensive literature review in the areas of construction cost estimating and construction scheduling, taking into consideration deterministic and stochastic techniques used at the conception phase of a construction project.

The first part focuses on reviewing the literature related to construction cost estimating at the feasibility stage. It clarifies the definition of cost estimates, purposes of cost estimates and cost estimate types with their different levels of accuracy. In addition, it highlights how to do cost modeling and lists several factors that have high impact on the project cost.

The second part highlights how to forecast the duration of any building project at the feasibility stage. This is accomplished by identifying and defining construction activities, looking at different methods used in calculating the duration of these activities, and the tools used in planning and scheduling project activities. Moreover, it presents factors that influence the duration of the project and the scheduling process of construction projects.

2.2- Cost Estimate

Estimating the cost of any construction project at the feasibility stage is of great importance because based on these estimates owners and decision makers may decide on dismissing or continuing the process. The following paragraphs illustrate the information required for the cost estimating process.

2.2.1- Definitions

Experts and researchers provide various definitions of cost estimation. The following paragraphs address some of these definitions.

Cost estimation is one of the significant tasks in the early stages of a project life cycle (An et al, 2011). In addition, Bradley et al (1990) think that the best cost estimate can be obtained from the examination of provided conditions which depend on existing rates and prices in similar situations. On the other hand, cost estimation at the conceptual stage is a critical factor in any construction project (Arafa and Alqedra, 2011). Moreover, a conceptual cost estimate is a tool used to specify the necessary funding and to measure the needs of a project (Butcher and Demmers, 2003). Cheng et al (2009) define the cost estimate as an essential task for all projects because it affects planning, bidding, design, budget and construction management. This estimate allows owners and planners to assess project feasibility and monitor costs. Carr (1989) considers that an estimate is a report of the approximate quantity of material, time and cost needed to complete construction. (Jrade and Alkass, 2007) define an accurate cost estimate as a crucial aspect for any organization liable for budget submission, contract negotiation and financial decision making. On the other hand, Kim and Liu (2007) consider a cost estimate a method by which to gauge the performance of a project. Estimating is the prediction of building costs at a stage where the design is not yet ready (Ogunlana et al, 2001). Rad (2001) defines the meaning of estimation as the art and science of using historical data and experience to forecast the total cost and duration of a project.

2.2.2-Purposes of Cost Estimates

The main purpose of cost estimates is to provide detailed information to the owners or any construction company about the project. Its purpose is to help them make their decision about the project based on whether or not it looks profitable according to the budget and the period needed for completion. According to Ji et al (2011) the purpose of estimating (the cost, schedule and risk) is to convince key decision makers to start or continue a project. On the other hand, the benefit of estimation is that it allows managers to select sufficient alternatives and to avoid misjudged solutions (Arafa and Alqedra, 2011). Lowe et al (2006) explain that the purpose of estimating is to help the customer check the construction budget, the prediction of the tender price and manage the design in accordance with the required budget. Jrade (2000) summarizes the purposes of cost estimation as follows:

- Gives an evaluation of capital costs for a particular piece of work.
- Forms the basis for planning and monitoring by defining the scope of work.
- Gives main information such as hours, resources, tasks and durations.
- Gives the financial input necessary to prepare a cash flow curve.
- Provides help to evaluate productivity and risk.

2.2.3-Types of Cost Estimate

Cost estimates are divided into two categories. The first is an approximated conceptual or parametric estimate, which is a cost estimation process utilized before the project design is prepared. The second is a detailed estimate which is a process of forecasting the cost of a construction project (Butcher and Demmers, 2003). According to Ritz (1994) there are four cost estimate types as follows: 1- Feasibility estimate is used to specify the practicality of a project. 2- Appropriation estimate is used to acquire funding for a project. 3- Capital cost estimate is a budget control within a project. 4- Definitive estimate is a process by which to obtain the final cost. Halpin (1985) provides several common estimate types regularly used in a construction project. These types include: the conceptual estimate, preliminary estimate, engineer's estimate and bid estimate. These four types represent the estimate circle that starts with the conceptual and ends with the bid estimate. Throughout this process the estimate level of accuracy is increased. Barrie and Paulson (1978) think cost estimate is divided into three types: 1- Conceptual and preliminary estimates that are used for estimating the budget of the project. 2- Fair cost estimation which is usually used for bidding purposes. 3- The definitive estimate which is prepared to forecast the final cost of a project with a small margin of error. Moreover, Oberlender et al (2001) classified the cost estimate into three types. They are: 1- A back of the envelope estimate. 2- Preliminary or conceptual estimates. 3- The full funding estimate. On the other hand, AACE International (2005) clarified the level of accuracy during the estimation at the feasibility stage, as shown in Figure 2.1.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Figure 2.1 Cost Estimate Classification Matrix for the Process Industries (AACE International, 2005)

2.2.4- Cost Modeling

A cost model is defined as a nominal expression of a system which describes the factors that have high impact on the cost. It can help consultants and contractors give more trustworthy cost advice to their clients (Ji et al, 2010). On the other hand, Koo et al (2011) describe the purpose of a cost model as that which predicts the construction costs in order to arrive at a suitable decision. Sonmez (2011) considers that construction cost models reflect expertise unique to a construction association for specific types of projects. The parametric cost model was developed to forecast the cost of a construction project from previous construction projects (Sonmez, 2008). Ashworth (1988) indicates the following eight stages of cost modeling: 1- Formulating the problem. 2- Data collection. 3- Data analysis. 4- Project model. 5- Optimum model. 6- Assessment. 7- Testing. 8- Application.

There are two types of cost models: the deterministic model and the probabilistic model. In the deterministic model, it is supposed that the values can be appropriated with different kinds of variables and that all of these values are known or can be calculated accurately. On the other hand, in the probabilistic model, all the variable values are not totally certain but an estimate can be made (Yaman and TAS, 2007). Whereas, Ashworth (1988) divides cost models into two types: the deterministic model and the probabilistic model. The deterministic model can be predicted by known variables or values. The probabilistic model can be estimated by using a probability theory to recognize the uncertainty of several variables.

2.2.5- Factors that Influence Project Cost Estimates

The factors that affect a construction project are divided into two types: monitor factors and characteristic factors. Monitor factors are factors that can be dominated by estimators to improve the performance estimation such as material and equipment. Characteristic factors are those that affect cost estimation but without the domination of estimators such as market condition, project complexity, weather, size of contract, site constraints, resources availability, type of procurement, contract and work type (Liu and Zhu, 2007). There are two groups of factors that highly influence the estimated cost of project. These groups represent: 1- estimator-specific factors, and 2- design and project-specific factors. The first group representing estimator-specific factors are controllable and can be achieved by reviewing the computation and preparation of all the related information for the estimator. The second group consists of design and project specific factors that affect the cost estimate of a project indirectly, including: ambiguity in scope, design complexity and the size of the construction project (Akinci and Fischer, 1998). In addition, An et al (2011) indicate numerous factors that influence the conceptual cost estimate. All these factors are clarified in Figure 2.2.

Category	Factor
Information (Data)	Availability of data on underground factors
	Level of site survey
	Experience with similar projects
	Level of available data
Definition of project	Level of planning definition
	Level of quality definition
	Level of quality of drawings
	Level of construction start date definition
	Capacity of architectural team
Cost estimator (Team)	Estimator's career experience
	Estimator's field work experience
	Estimator's experience with similar projects
	Estimator's experience with field work in similar projects
	Level of estimator's commitment
Procedure	Time to estimate
	Standard procedure for estimating
Uncertainty	Capacity of client
	Level of construction difficulty
	Level of competition
	Contingency

Figure 2.2 Factors that Influence the conceptual cost estimate (An et al, 2011)

2.3- Duration Estimate

Estimating the construction duration of a building project is very important at the conceptual stage because it gives owners and investors an idea about the required time to complete the proposed project. The following paragraphs provide information related to estimating the duration of a project.

2.3.1- Definitions

The construction duration of a project is defined in different ways, some of which are provided in the following paragraphs:

Project duration is related to work organized to finish the project on time or before the scheduled date (Hanna et al, 2005). On the other hand, it is considered a standard for gauging project performance (Hoffman et al, 2007). Kwakye (1994) defines the construction duration as a specified time to implement and finish all the activities of the project by using available information and resources. Duration means time desired to finish a particular task or activity (Bhokha and Ogunlana, 1999). Moreover, Hinze (2012) defines the duration of a project is an estimated time and it is desired to complete the construction project. Ritz (1994) clarified two types of definitions: 1- Planning which is the forecasted identifications of the factors, impacts and essential relationships required to accomplish the goals and 2- Project schedule which is a plan of work per time unit.

2.3.2- Estimating Duration

Estimating the total duration of a construction project requires taking into account several factors and calculating related time frames. These factors are: 1- Quantity of material and degree of accuracy required especially for big projects like dams; 2- The availability of equipment. 3- The schedulers experience, which is often considered the most crucial factor affecting successful estimation. 4- The availability of historical data from previous construction projects a very valuable resource for schedulers (Hinze, 2012).

2.3.3- Methods of Estimating the Duration

The methods used in estimating project duration are divided into two categories, the deterministic (i.e. CPM) and the stochastic (i.e. PERT). The following paragraphs provide detailed information about each of these categories.

2.3.3.1- Critical Path Method (CPM)

Critical Path Method (CPM) is a traditional method. It is one of the most common scheduling methods used for construction projects. CPM is a fundamental method for any construction project so the project can be executed on time and within budget. The application of the Critical Path Method is considered relating simple. Although, CPM is not appropriate to support decision makers while making major decisions about the project, it is very helpful for reporting and organizational purposes (Hegazy and Menesi, 2010). One of CPM's features is that it saves time and effort during the data gathering process and when specifying the probability distribution (Lee et al, 2009). In addition, the purpose of the Critical Path Method is to calculate the project duration in a deterministic manner by analyzing the gradation of all activities (Lee and Arditi, 2006). CPM relies on deterministic fixed values (Lee, 2005). Yi and Langford (2006) think that CPM technique allows project managers to specify proper safety performance standards. However, CPM has several disadvantages listed as follows: 1- Trouble with numerous complex relationships (i.e., finish to finish and start to start relationships) which can create a complicated process and cause part of an activity to become crucial. 2- The calculations of the schedule can be inaccurate. 3- Schedule analysis is complex during and after implementation (Hegazy and Menesi, 2010).

2.3.3.2- Program Evaluation and Review Technique (PERT)

Program Evaluation and Review Technique (PERT) is a network tool used for planning and scheduling complicated projects such as buildings. The PERT method can be used during the design and construction phases of the project. It operates in such a way as to maintain precedence or equivalent relationships between the activities within a project (Chinneck, 2009). PERT is a probabilistic method for estimating the project duration, by using three different times known as pessimistic, optimistic and most likely (Lee et al, 2009). PERT is considered an extended approach to CPM because it takes into account the possibility of uncertainties during the estimation process. PERT uses the expected mean time (Te) and the standard deviation for every activity on the critical path, then calculates the probability of finishing the project within a specific period (Lee, 2005). On the other hand, with the PERT method the expected mean time is calculated by using the following equation: (T_e= (A+4M+B)/6) with 50% chance of achieving that duration (Khamooshi and Cioffi, 2012).

2.3.4- Factors that Affect Project Duration

Factors that influence project duration are classified into four groups as follows: 1- Owner, contractor, consultant and designer factors. 2- Material, workforce and equipment factors. 3- Environmental factors which entail natural or external factors such as windy weather, changes in governmental laws and traffic control. 4- Project factors, which are factors dependant on project characteristics and project delivery systems (Luu et al, 2009). Hoffman et al (2007) clarify the factors that affect project duration as shown in Figure 2.3. Yi and Langford (2006) specify factors that have influence on the duration of the project activities. These factors are: procedure, human resources, technology and physical environment.

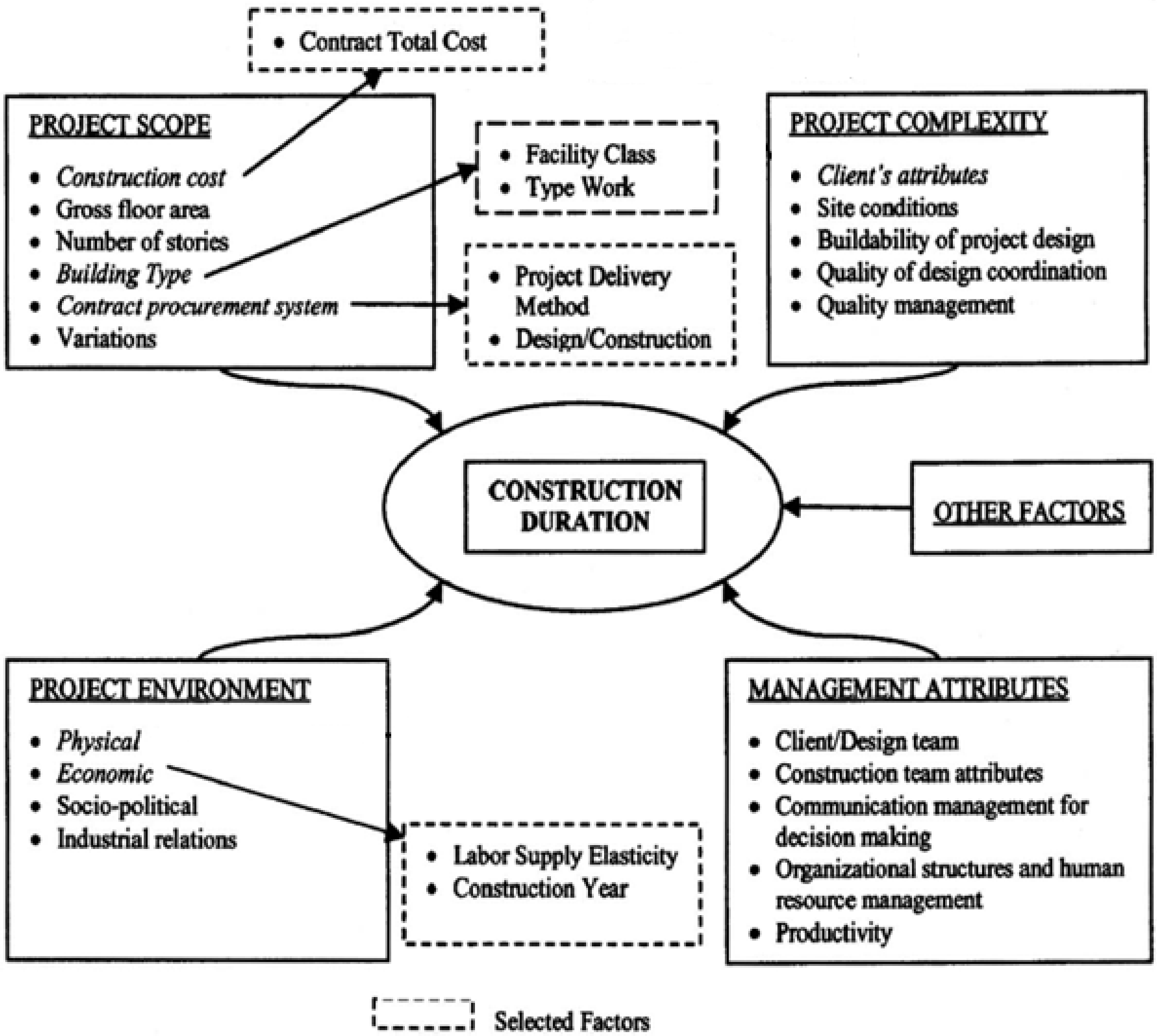


Figure 2.3 Factors that have high impact on the construction duration (Hoffman et al, 2007)

2.3.5- Types of Planning

Ritz, (1994) identifies three types of planning:

1. Strategic planning which includes high level selection of project goals;
2. Operational planning, which includes the detailed planning desired to achieve the strategic goals set, and;

3. Scheduling that puts the operational plan on a time scale adjusted by the strategic objectives outlined.

2.3.6- Scheduling Process within a Construction Project

According to Karshenas and Sharma (2010) the process of scheduling implementation includes the following steps:

1. A breakdown of the project into the actual number of activities and an estimation of the duration of each activity.
2. A transfer of the information for each activity into one of the compatible scheduling software programs.
3. The development of a project sequence that each activity will be involved in during the construction and scheduling processes.

2.4- Monte Carlo Simulation (MCS)

Monte Carlo Simulation (MCS) is a method designed to assist in the decision making process. MCS relies on a random sampling of variable probability distribution using historical data. It does this by using random numbers, converting them to real numbers, using existing mathematical equations and assumed probability distribution (Chou, 2011). Ersahin et al, (2004) defines Monte Carlo Simulation as a next step in addressing the risk analysis complication. It is an iterative pattern wherein a sample is taken from each duration distribution. Simulation is an analysis method and an automated model used to compute the stochastic and random nature of system parts to demonstrate the event to the real world (Lee, 2005). MCS is a probabilistic technique for conceptual cost estimate and decision making. The fundamental of simulation processes go through the following: data collection, random number generation, model formulation, analysis and visual presentation (Chou, 2011).

There are several advantages to using Monte Carlo Simulation, such as:

1. Monte Carlo Simulation deals with risk analysis and uncertainty. Moreover, MCS is used to predict the total cost of projects (Barraza and Bueno, 2007).
2. MCS does not need independent assumptions among the activities, and the relationship between cost and duration can be formulated (Ersahin et al, 2004).
3. MCS can be used to calculate the required duration of a project (Barraza, 2011).
4. Monte Carlo Simulation helps users generate probabilistic results; specify perfect strategy in choosing projects; create virtual test, scenario analysis, sensitivity analysis in few cases, and forecast quality of business processes (Raychaudhuri, 2008).

2.5- Previous Researches:

According to literature review, many researchers were focused only on the cost estimate, such as: 1- Yaman and Tas, (2007) who pointed to the use of functional elements to provide a model for building cost estimate at the design phase. 2- An et al (2011) focused on reliability and accuracy of conceptual cost estimates for the building of construction projects. 3- Arafa and Alqedra, (2011) estimated the cost of building projects by using Artificial Neural Networks at the early stage. On the other hand, other researchers concentrated on estimating the duration of the construction projects such as: 1- Bhokha and Ogunlana, (1999) who used the application of Artificial Neural Networks to predict the construction duration of buildings at the conceptual stage. 2- Lee et al, (2009) utilized the probabilistic model to estimate the duration of high rise buildings. 3- Hegazy and Menesi, (2010) utilized critical path segment techniques to acquire the construction project schedule. In addition, Khamooshi and Cioffi (2012) focused on analysing cost and time estimate errors and concentrated on the reliability of the estimates.

Literature review indicates that there are limited researches have been conducted to develop a model that estimates both construction costs and duration of proposed projects at their feasibility stage. However, some have focused on cost, others on the duration of the construction project separately. Therefore, there is a need for a model that can be used by owners, decision makers and management to identify the construction costs and duration of their proposed projects so that necessary budget and payback period can be identified at the early stage. The proposed model will be used to estimate cost and duration using both deterministic and probabilistic approaches.

2.6- Summary

This chapter reviewed the most important aspects of a construction project at its feasibility stage. First, it addressed the cost estimate by looking at definitions, purposes, types and cost models. It also addressed all factors that influence cost estimation. Secondly, estimating duration was highlighted and included: duration definitions, how to estimate a project's duration and the methods used to predict that duration. Factors that have a high impact on the construction duration and the scheduling process were also considered. This chapter covered the advantages of using Monte Carlo Simulation, which is one of probabilistic tools used to deal with risk analysis and uncertainty.

Chapter Three

Methodology

3.1-Introduction

This chapter explains the methodology used to develop and implement a cost and time estimating model for proposed building projects at the feasibility stage. The proposed model applies both the deterministic and the probabilistic or stochastic approaches. These approaches vary from one to the other. They are dependent on the availability of information from similar projects built in the past and the experience of the estimators and schedulers who are dealing with these methods. The steps involved in designing a cost and time model are determined by 1- categorizing owners and investors main goals during the feasibility stage of construction projects, 2- collecting all necessary data, 3- identifying the components needed for the cost and schedule models, and all necessary equations related to the cost and time estimating with the use of deterministic and probabilistic methods.

3.2- The Main Goals of Owners and Investors

This research considers that the accuracy of estimating project cost and duration is a major aim of owners and investors during the feasibility stage of a project, also particularly to have an idea about the budget required to implement and finish the project. This accuracy differs from one estimator to another based on experience levels, a factor which plays an important role in construction management. On the other hand, the levels of accuracy and quality are not always stable because these indices fluctuate depending on different factors, such as: project scope, project complexity, project environment and management attributes. This model provides for a substantial level of accuracy when a feasibility study is being undertaken.

3.3- Data Collection

The data to be used in the proposed methodology are collected from RSMeans 2011 publications, which consist of 4000 previous building projects. RSMeans' standards provide all the information related to construction cost and duration estimates in North America. The proposed methodology uses two types of RSMeans standards, which include: RSMeans-Square Foot Costs (2011) and RSMeans-Building Construction cost data (2011). However, the collected data is adjusted so it reflects the direct construction cost using the following equations:

- $$ATC = \frac{PTC}{AF \times OV} \qquad 3.1$$

Where, ATC = the adjusted total cost/ft^2 of project.

PTC = Published total cost per square foot of project.

AF = Architectural fee.

OV = Overhead cost.

This adjustment is implemented because the proposed model does not include the indirect costs that incorporate the architectural fees and company overhead. Once the adjusted total direct square foot cost is calculated, the adjusted cost per ft^2 of every division is calculated using the following equation:

- $$ACD = ATC \times DP. \qquad 3.2$$

Where, ACD = Adjusted cost/ ft^2 of division.

DP = Division percentage.

And where, Division percentage is obtained from R.S.Means publications. In the proposed model a division consists of group of activities. For example, a superstructure division consists of floor construction and roof construction.

After that we can calculate the activity percentage using the following equation:

- $AP = \frac{C}{ACD}$ 3.3

Where, AP = the activity percentage.

C = Published cost per square foot of activity.

Next, we can calculate the adjusted cost/ft^2 per activity using the following equation:

- $ACA = AP \times C_d$. 3.4

Where, ACA = the adjusted cost/ft^2 per activity (published).

C_d = cost/ft^2 of division.

The labor cost is calculated using equation (3.5) through (3.7). First we calculate the total daily cost/ crew using equation (3.5).

- DC = S. 3.5

Where, DC = Total daily cost per crew.

SD = the summation of the daily cost rate per labor of each crew.

Similarity to calculate the total hourly labor cost per crew we use equation (3.6).

- HC = SH 3.6

Where, HC = Total hourly labor cost per crew.

SH = the summation of hourly labor cost per crew.

To find the (%) daily output per labor we use equation (3.7).

- $PD = \frac{DL}{SO}$ 3.7

Where, PD = the percentage of daily output per labor.

DL = the daily output per labor.

SO = summation of daily output of (labor, material and equipment).

All these equations will be used to adjust and smooth the collected data before it is linked to the model.

3.4- The Components of the Cost Model

The proposed cost model consists of four main components: 1- data input; 2- adjusted square foot cost; 3- methods of estimating the total cost; and 4- data output.

3.4.1- Data Inputs: The inputs of the proposed model are considered the main factors that have a high impact on the cost of a construction project, as shown in Figure 3.1.

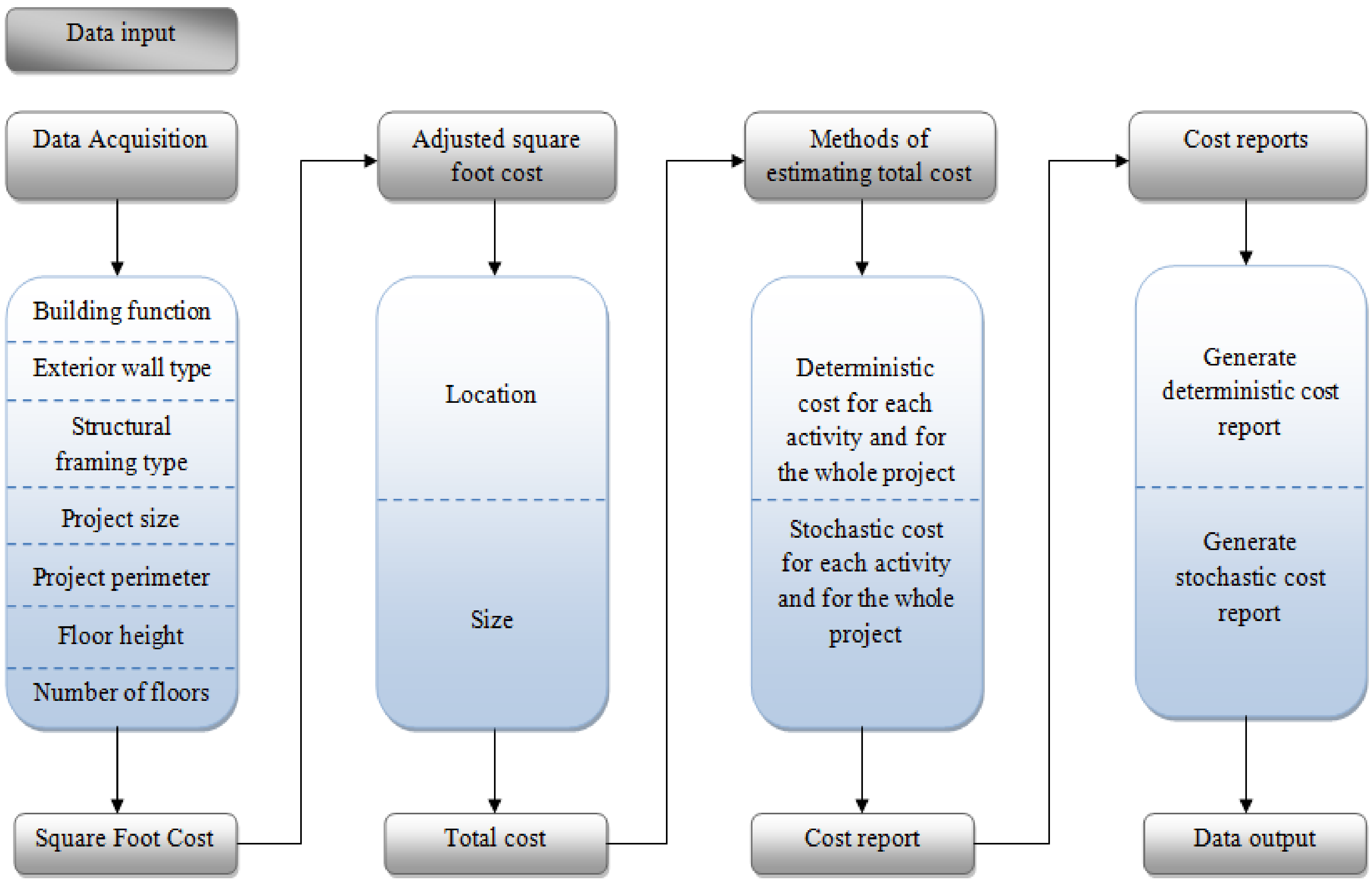


Figure 3.1 Process of Cost Model

I- Data Acquisition:

All the factors that will be used in the proposed model are obtained from RSMeans 2011 publications. These factors are: building function, exterior wall type, structure system, project size, project perimeter, floor to floor height, and numbers of floors. In other word, the final cost of any project will change if there is variation in the values of these factors.

1- Building Function:

According to RSMeans publications, the function of a building project is classified into the following three types: commercial, industrial and institutional. This classification includes around 76 different types of buildings.

2- Exterior Wall Type:

There are different types of exterior walls for building projects according to RSMeans publications. The exterior wall type varies based on the project type and accordingly influence the construction cost.

3- Structural Framing Type:

This function classifies the structural frames of a construction project used to execute any building project. These include: steel frame, wood frame and reinforced concrete frame. Each of these types has different properties that influence the estimated costs.

4- Project Size:

Project size (gross area) relies on the building function and each project has its own size. So, the size of the project is considered one of the major factors that affect the construction cost.

5- Project Perimeter:

Project perimeter is the external part of the construction area and it relies on the project size. Therefore, any changes in the project size leads to a change in the perimeter of the project and accordingly a change in its cost.

6- Floor to Floor Height:

Floor to floor height varies from one project to another and depends on the purpose of the project, because some projects need normal height between their floors while others require higher height. For this reason project height is an important factor to consider when estimating the cost of a construction project.

7- Number of Floors:

This factor depends on the variation of project size. This variation changes by increasing or decreasing the number of floors. Therefore, this factor should be under consideration when estimating costs.

3.4.2- Adjusted Square Foot Cost:

There is a series of adjustments that must be made before obtaining the square foot cost in order to increase the level of accuracy. They are:

1- Adjustment for Size:

This adjustment is a tool used to compensate for the difference in the gross area between the proposed and previous project. It is unlikely one will find a project built in the past that is the same size of the proposed project. This adjustment is based on criteria set by RSMeans publications where a cost multiplier is derived from Figure 3.2 based on the value of the size factor. This type of adjustment is very important due to its influence on cost estimate accuracy. To execute this adjustment, first we have to calculate the size factor using the following equation:

$$X = \frac{SPR}{SPU} \tag{3.8}$$

Where, X = Size factor

SPR = Size of the proposed project.

SPU = Size of the published project.

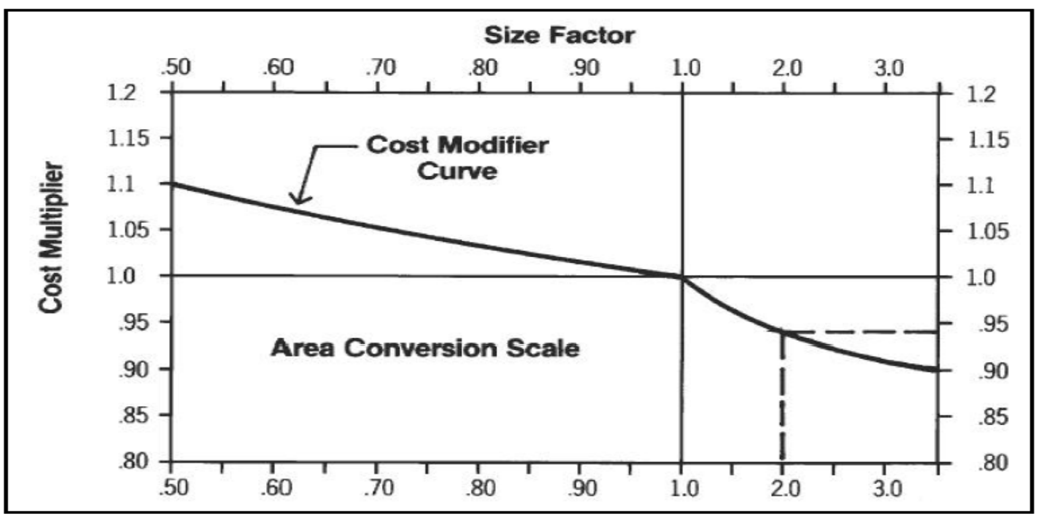
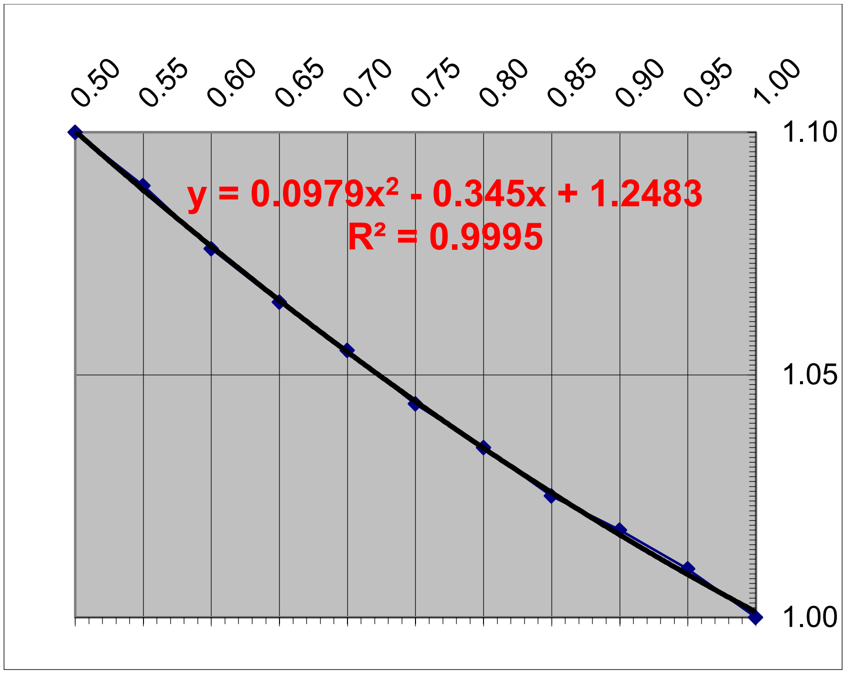


Figure 3.2 Size Factor (RSMeans, 2011)

Once the size factor is calculated from Figure (3.2), we derive the cost multiplier. However, to automate this process, two equations are derived by using Regression analysis. The first equation is derived from Figure 3.3, as illustrated below.



X	Y
0.500	1.10
0.550	1.09
0.600	1.08
0.650	1.07
0.700	1.06
0.750	1.04
0.800	1.04
0.850	1.03
0.900	1.02
0.950	1.01
1.000	1.00

Figure 3.3 Regression Analysis (1)

- $Y (1) = 0.0979 (X)^{2} - (0.0345X) + 1.2483.$ 3.9

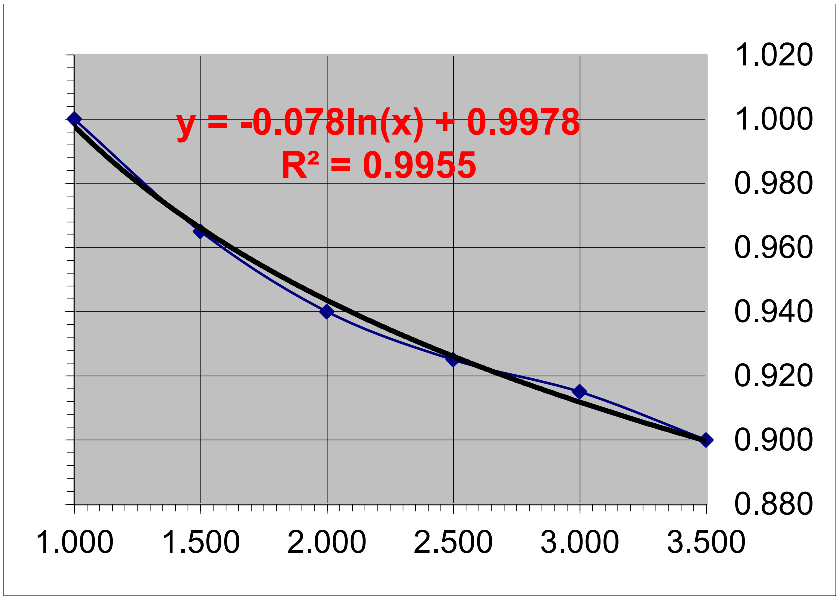
Where, Y(1) = Cost multiplier (1).

This equation is used if the size factor that was obtained from equation (3.8) is less or equal to one.

The second equation is derived from Figure 3.4 as clarified below, if the size factor is bigger than one, the following equation is used:

- $Y (2) = -0.078 \text{ Log} (X) + 0.997.$ 3.10

Where, Y(2) = Cost multiplier (2).



X	Y
1.000	1.000
1.500	0.97
2.000	0.94
2.500	0.93
3.000	0.92
3.500	0.90

Figure 3.4 Regression Analysis (2)

At the end, the adjusted cost per square foot is calculated using equation (3.11).

- $C_s = CP \times Y\ (1, 2)$ 3.11

Where, C_s = the adjusted cost/ft^2 for size difference.

CP = cost/ft^2 (published).

Y (1, 2) = cost multiplier.

2- Adjustment for Location:

Adjustment for location is another important modification that needs to be applied to previous project costs before they can be used to determine the cost of proposed projects. To do this type of adjustment we need to identify the location factor for both the previous and the proposed projects. Afterwards, the previous project's cost is multiplied by the ratio between the two factors in order to calculate the cost of the proposed one. The location factor is classified as either residential or commercial, depending on the project's purpose. This adjustment is implemented using the following equations:

- $C_A = C_N \times (I_A / I_N)$ 3.12

Where, C_A = Cost in city A. C_N = National average cost

I_A = Index for city A. I_N = Index based on the 30 major cities in North America average of 100

- $C_L = C_s \times F$ 3.13

Where, C_L = adjusted cost/ft^2 for location difference.

F = Location factor.

3.4.3- Methods Used to Estimate the Total Cost:

Based on the conducted literature review, there are two methods used to calculate the total cost of a project at the conceptual stage. These methods are: deterministic and stochastic.

1- Deterministic method:

This method relies on known and specified values that can be calculated by the estimator with full confidence. This is done by using Equation (3.14):

- $TC = PS \times C_L$ 3.14

Where, TC = Total project cost.

PS = Project size.

Once the total project is calculated, the cost of every division is derived using equation (3.15).

- $CPD = TC \times DP$ 3.15

Where, CPD = Cost per division.

Furthermore, from the cost per division, we compute the cost per activity using equation (3.16) & (3.17).

- $A = \frac{ACA}{TCD}$ 3.16

Where, A = Activity percentage.

TCD = Total cost/ft^2 per division.

ACA is calculated in equation (3.4)

- $CPA = A \times TCD$ 3.17

Where, CPA = Cost per activity.

2- Stochastic Method:

This method estimates cost by using probability theory to deal with variable values, uncertainty and by applying risk analysis. With this method three cost values are required (optimistic, most likely and pessimistic). To implement this method we need to determine all the factors that affect project activities and give a weight to their values. By doing so, we derive probabilistic percentages that represent the impact of each factor on these activities, as shown in Figure 3.5. To apply this method the following equations are used to calculate the three cost values.

- $WVC = PI \times VP$. 3.18

Where, WVC = the (%) weighted variation of the effective factors on the cost of each activity.

PI = Probabilistic percentage of the influence of each factor on every project activity.

VP = variation percentage.

PI and VP are obtained from the factors that affect each activity of project during the implementation process. All these factors are specified from previous construction projects.

- $OC = C_V - (C_V \times WVC)$. 3.19

Where, OC = the optimistic cost value.

C_V = the cost value.

- MC = assumed to be equal to the deterministic cost value 3.20

Where, MC = the most likely cost value.

- $PC = C_V + (C_V \times WVC)$. 3.21

Where, PC = the pessimistic cost value.

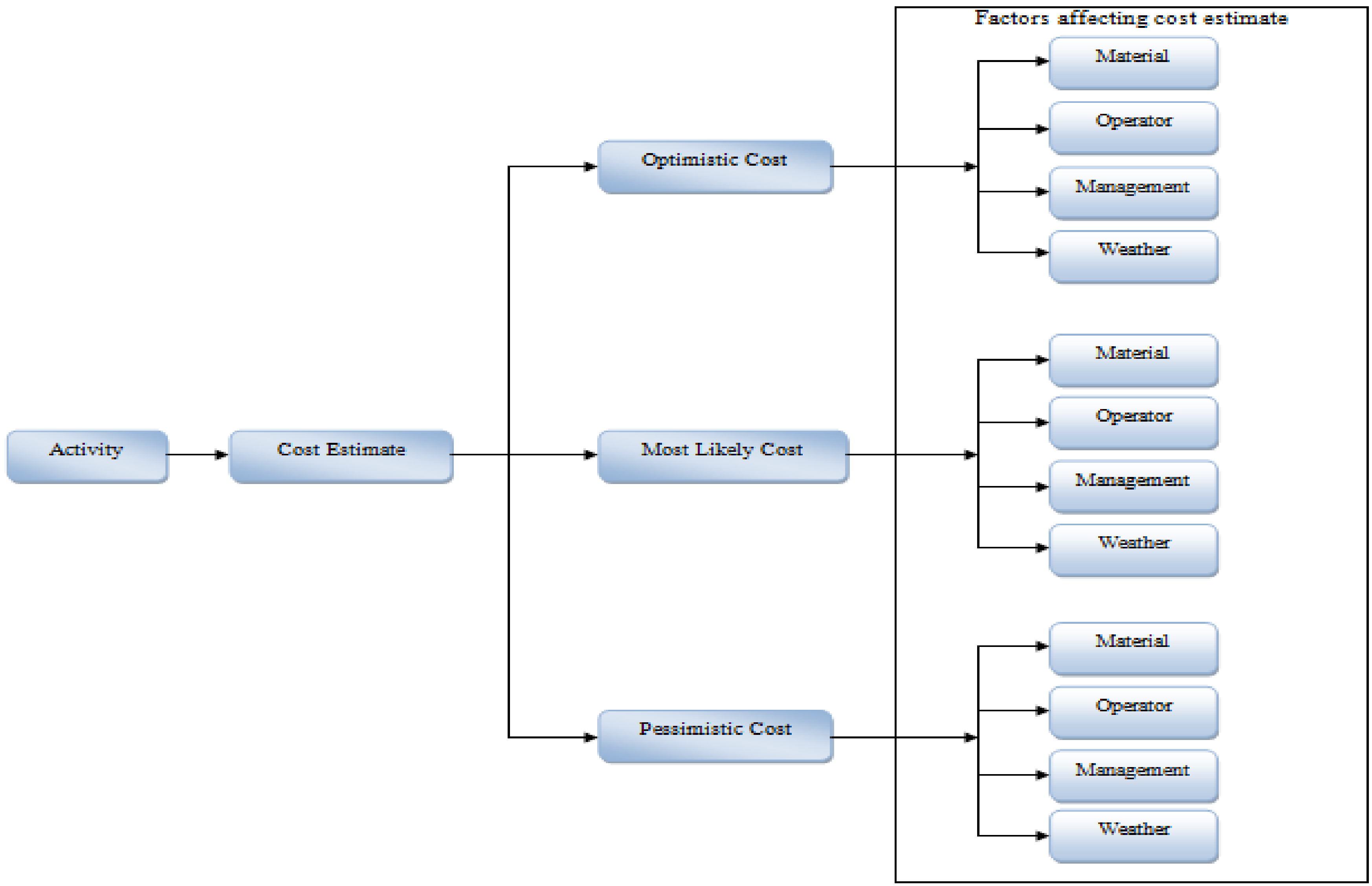


Figure 3.5 Stochastic Model of Estimating the Cost

3.4.4- Outputs:

The outcome of the proposed model is a cost report that is generated based on both the deterministic and stochastic methods. In the deterministic method, the cost report consists of three types. The first report type is a summary report of the project information, such as: project name, project type, exterior wall type, structure framing type, project size, project perimeter, floor to floor height, location factor and cost per square foot. The second report consists of the cost of each project division with their percentages and the final cost of the proposed project. The third type is a detailed report which includes the cost of each activity, division of the project and the total cost of the proposed project, whereas, the stochastic method generates a detailed cost report. This report consists of three cost values for each project activity. They are: optimistic, most likely and pessimistic and contain the factors that influence each activity of the project with their probabilistic percentages. All these reports are clarified in Appendix C.

3.5- The Components of the Time Model

The proposed time model relies on four fundamental components. These components are: 1- data inputs; 2- quantity of work; 3- methods of estimating the total duration of project; and 4- data output.

3.5.1- Data Inputs: Data inputs of the proposed model include all the factors that affect the construction duration of any building project, as illustrated in Figure 3.6.

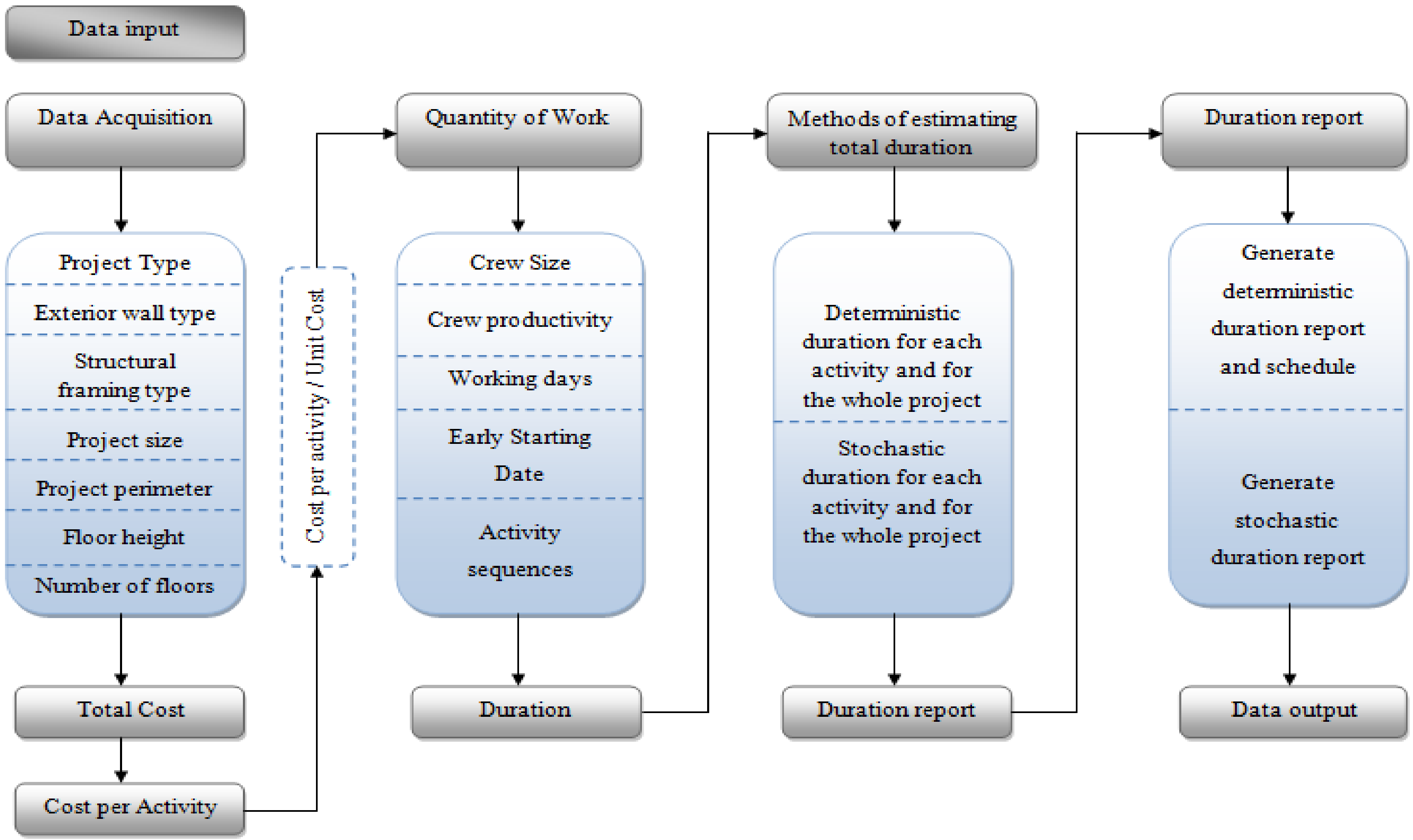


Figure 3.6 Process of the Duration Model

3.5.2- Quantity of Work:

The quantity of work needed for each project activity is obtained by dividing the total cost of that activity by its unit cost, besides considering the factors that have a high impact on estimating the duration of the project's activities. These factors include: crew size, crew productivity, working days, early starting date and activity sequence. Thus, the duration of the project and its associated activities will change if any changes in these factors occur.

1- Crew size & Crew productivity:

The number of crews needed depend on the type and size of the proposed project. The productivity of the selected crew is identified by determining the crew size. Yet, these factors are related to each other and their values are collected for each project activity from 2011 R.S.Means Construction Cost Data.

2- Working days:

The proposed model considers the working days to be five days per week, eight hours per day. Therefore, the generated schedule for the project excludes all the occasional vacations and weekends.

3- Early starting time:

The early starting time is used to determine the start and finish time for each proposed project activity. Moreover, it is utilized to identify the most crucial activities related to the proposed project. This is important for owners and investors because it will provide them with start and completion times for the project.

4- Sequence of the project's activities:

The sequence of activities for construction projects indicate how these activities are to be arranged and executed during the construction period. This arrangement depends on each activity's work type, and is implemented manually based on the estimator's experience.

3.5.3- Methods Used to Estimate the Total Duration:

There are two types of methods used to estimate the total duration of a project- deterministic and stochastic.

1- Deterministic Method:

This method relies on known values that are directly calculated with complete certainty. Thus, to calculate the quantity of each activity, the following equation is used:

- $$Q = \frac{\text{CPA}}{\text{UC}} \qquad 3.22$$

Where, Q = Quantity of each activity of the project.

UC = Unit cost per activity.

CPA is acquired from equation (3.17)

UC is collected from 2011 R.S.Means publications.

Then, the duration of each activity is calculated by using equation (3.23).

- $$D = \text{CPA} \times \left(\frac{\text{PD}}{\text{DC}}\right). \qquad 3.23$$

Where, D = Duration of each activity of the project.

CPA is calculated by using equation (3.17)

PD is computed from equation (3.7), and

DC is obtained from equation (3.5)

2- Stochastic Method:

In the stochastic method most of the durations have variable values due to the uncertainty inherent in calculating them. The duration of the activities consist of three time values: the optimistic, the most likely and the pessimistic. To apply this method we need to specify all the factors that affect each project activity and provide a weight to its value to derive probabilistic percentages that represent the impact of each factor on the activity, as illustrated in Figure 3.7. The model uses the Equations (3.24) through (3.27).

- WVD = PI × VP. 3.24

Where, WVD = the (%) weighted variation of the effective factors on the duration of each activity.

PI and VP are obtained from the factors that affect each activity of project during the implementation process. All these factors are identified from previous construction projects.

- OD = $D_V - (D_V \times$ WVD). 3.25

Where, OD = the optimistic duration value.

D_V = the duration value.

- MD = assumed to be similar to the deterministic duration value. 3.26

Where, MD = the most likely duration value.

- $PDU = D_V + (D_V \times WVD)$. 3.27

Where, PDU = the pessimistic duration value.

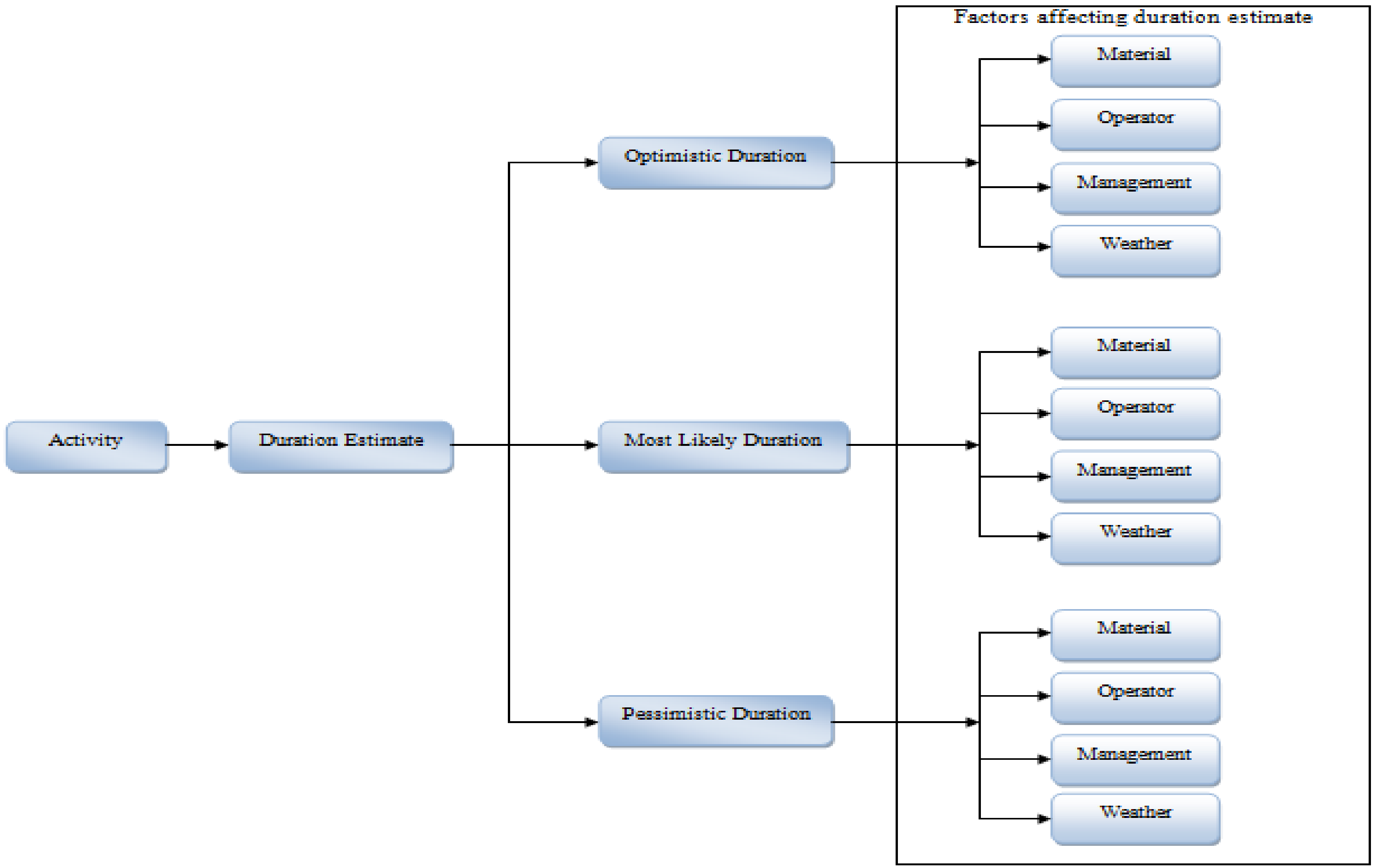


Figure 3.7 Stochastic Model of Estimating the Duration

3.5.4- Outputs:

The result of the proposed model is a duration report generated by using both the deterministic and stochastic methods. In the deterministic method, the duration report consists of three types. The first report provides the duration of each division with the total duration of the proposed project. The second report includes the duration of each project activity, division and the final duration of the proposed project. The third report is a detailed schedule that shows the sequence of project activities. On the other hand, the stochastic method generates a detailed duration report. This report provides three values for each project activity time frame. These values are: optimistic, most likely and pessimistic and include all the factors that affect each activity with their respective probabilistic percentages. All these reports are illustrated in Appendix C.

3.6- The Flow of Date for the Proposed Model:

To simplify the development process of the proposed model a flow chart is created as shown in Figure 3.8. The development is implemented through a series of steps. They are:

1. Identify all the factors that influence the cost and duration of the project. These factors are: Project type, project size, exterior wall type, structural framing type, project perimeter, floor height and number of floors.
2. Combine all these factors together by using functions created and inherited in Microsoft Excel 2007 to obtain the cost/ft^2 for each activity from previous projects. (Appendix A shows sample of these equations).
3. Do all the necessary adjustments for the square foot cost of the project. The adjusted values of the cost cover the adjustment for location and for size.

4. Calculate the total square foot cost of the project, after considering and implementing all the previously listed adjustments.
5. Derive the total cost of the project by using the deterministic and the stochastic methods.
6. The total cost obtained by using the deterministic method which is applied to get the cost for each division and each activity of the project.
7. The cost of each activity is used to gain its duration by using other types of adjustments. These adjustments are for crew size, crew productivity, working days, and early starting time.
8. Calculate the total duration of the project by using the deterministic and stochastic methods.

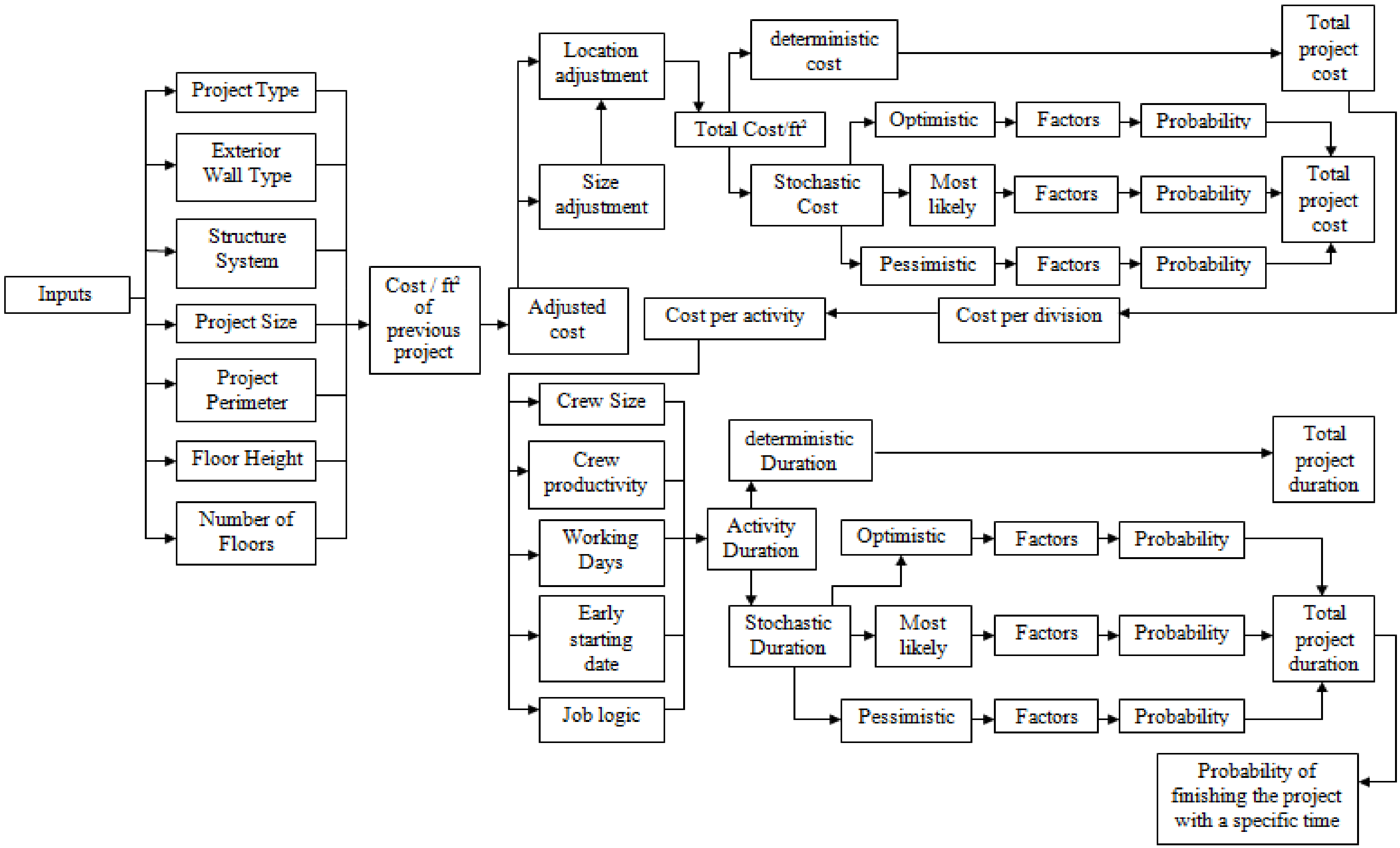


Figure 3.8 Flow Chart of the Model

3.7- Summary:

This chapter presented the methodology to be followed to design and implement a model to automate the process for estimating a proposed project's construction cost and duration. The methodology consists of many steps that must be considered to achieve the final project cost and duration, by using both deterministic and stochastic approaches. These steps consist of the following: 1- Knowing all the goals of the investors during the feasibility study. 2- Identifying all the factors that affect the cost and duration of the project, after collecting all necessary data. 3- Clarifying all components needed for the cost and duration model. 4- Creating all the equations that will be used in the model. Finally, designing a chart that represents the flow of data of the model to understand how this model works.

Chapter Four

Model Development Process

4.1- Introduction:

This chapter illustrates the method used to develop the cost and duration model that incorporates both deterministic and stochastic approaches. The development process of the model consists of four main steps: 1- Collect all the data needed to develop the model. 2- Store the collected data in a database designed for that purpose (i.e. Microsoft Excel 2007) in order to calculate the deterministic cost and duration of the project. 3- Generate a deterministic schedule for the proposed project in an automatic way by linking the model with the scheduling tool (i.e. Microsoft Project 2007). 4- Obtain the probabilistic schedule of the project by integrating the model with Monte Carlo Simulation.

4.2- Data Collection:

All the data needed in the development process of the model is collected from the literature and publishers publications. The collected data is divided into several parts. These parts are related to the cost and duration model components, which include: project elements, cost data, location factors, crew specification and daily output per crew.

4.2.1- Project Elements:

Project elements are considered highly important factors influencing cost and duration. However, these elements vary from one project to another based on the function of that project. These elements include: project name, project type, project exterior wall type, project structure framing type, floor to floor height, number of floors, divisions, subdivisions and specifications. Figure 4.1 illustrates a list of these elements.

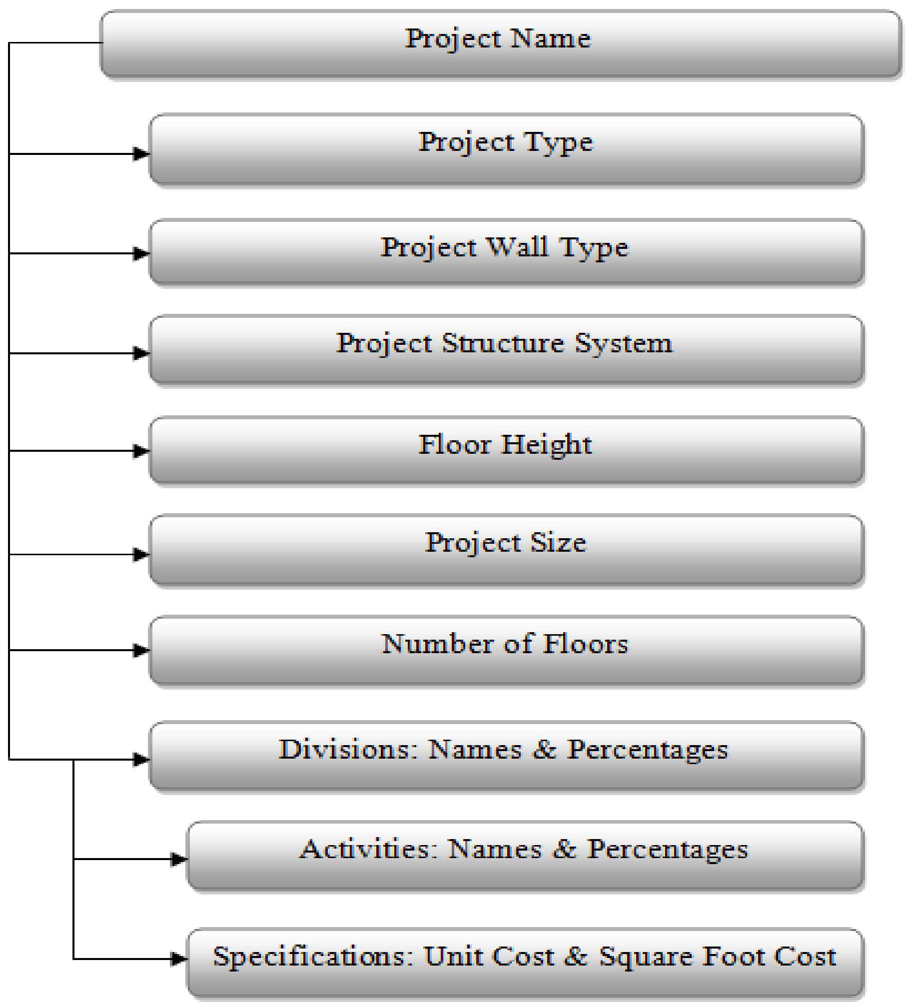


Figure 4.1 Project Elements

4.2.2- Cost Data:

This data is important during the estimation process because it provides all the information pertaining to the cost of each proposed project activity, including for example each activity's unit cost. It should therefore be considered the most effective step in the development process. Figure 4.2 provides an example of collected data. In addition, Appendix B provides more details about the cost data.

SubstructureDiv1Percentage	A1010	SubDiv1Elm1Name	SubDiv1Elm1Description	SubDiv1Elm1Unit	SubDiv1Elm1UnitCost	SubDiv1Elm1SFCos
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.21
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.10
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.05
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.96
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.94
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.93
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.88
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.87
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.86
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.22
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.12
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.08
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$2.01
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.99
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.98
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.94
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.93
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.92
4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97	$1.94

Figure 4.2 Sample of the Collected Cost Data (RSMeans-Square Foot Costs, 2011)

4.2.3- Location Factors:

The location factor is categorized as either, residential or commercial based on the project's purpose. The value of this factor differs from city to city, as shown in Figure 4.3.

Province Name & City Name	Province Name	City	Residential	Commercial
Alberta-(Calgary)	Alberta	(Calgary)	1.17	1.15
Alberta-(Edmonton)	Alberta	(Edmonton)	1.16	1.15
Alberta-(Fort McMurray)	Alberta	(Fort McMurray)	1.17	1.14
Alberta-(Lethbridge)	Alberta	(Lethbridge)	1.14	1.1
Alberta-(Lloydminster)	Alberta	(Lloydminster)	1.09	1.06
Alberta-(Medicine Hat)	Alberta	(Medicine Hat)	1.09	1.06
Alberta-(Red Deer)	Alberta	(Red Deer)	1.09	1.06
British Columbia-(Kamloops)	British Columbia	(Kamloops)	1.08	1.08
British Columbia-(Prince George)	British Columbia	(Prince George)	1.07	1.08
British Columbia-(Vancouver)	British Columbia	(Vancouver)	1.1	1.12
British Columbia-(Victoria)	British Columbia	(Victoria)	1.05	1.05
Manitoba-(Brandon)	Manitoba	(Brandon)	1.04	1
Manitoba-(Portage la Prairie)	Manitoba	(Portage la Prairie)	1.04	0.99
Manitoba-(Winnipeg)	Manitoba	(Winnipeg)	1.04	1.04
New Brunswick-(Bathurst)	New Brunswick	(Bathurst)	0.96	0.95
New Brunswick-(Dalhousie)	New Brunswick	(Dalhousie)	0.97	0.95
New Brunswick-(Fredericton)	New Brunswick	(Fredericton)	1.04	0.99
New Brunswick-(Moncton)	New Brunswick	(Moncton)	0.97	0.96
New Brunswick-(Newcastle)	New Brunswick	(Newcastle)	0.97	0.95
New Brunswick-(St. John)	New Brunswick	(St. John)	1.03	0.99

Figure 4.3 Location Factors (RSMeans-Building Construction Cost Data, 2011)

4.2.4- Crew Specification and Daily Output per Crew:

The information related to crew size and the number of crews needed to execute the construction of the project is of great importance when calculating cost and duration. This information consists of the crew labor type and the crew hourly and daily rates. Figure 4.4 provides a sample of the total daily cost per crew and the total hourly labor cost per crew. The values of these items are calculated by using Equations (3.5) and (3.6). On the other hand, Figure 4.5, provides all the information needed to acquire the (%) of the daily output per labor based on the daily output of material, labor and equipment. The (%) of daily output per labor is calculated by using equation (3.7). The data listed in these two figures is collected from 2011 RSMeans publications and stored in a database that was designed for that purpose.

Crew #	Labor Type	Hourly rate	Daily rate	Cost/Labor (hr)	Total daily cost	Total hourly labor cost
A-1	1 Building Laborer	34.35	274.8	34.35	338	42.25
A-1	1 Concrete saw, gas manual		63.2	7.9		
A-1A	1 Skiled Workers	44.4	355.2	44.4	571.4	71.42
A-1A	1 Shot Blaster, 20"		216.2	27.02		
A-1B	1 Building Laborer	34.35	274.8	34.35	409	51.13
A-1B	1 Concrete saw		134.2	16.77		
A-1C	1 Building Laborer	34.35	274.8	34.35	300.6	37.58
A-1C	1 Chain Saw, gas, 18"		25.8	3.23		
A-1D	1 Building Laborer	34.35	274.8	34.35	305.6	38.2
A-1D	1 Vibrating plate, gas, 18"		30.8	3.85		
A-1E	1 Building Laborer	34.35	274.8	34.35	313.8	39.23
A-1E	1 Vibrating plate, gas, 21"		39	4.88		
A-1F	1 Building Laborer	34.35	274.8	34.35	318.4	39.8
A-1F	1 Rammer/ tamper, gas, 8"		43.6	5.45		
A-1G	1 Building Laborer	34.35	274.8	34.35	324.4	40.55
A-1G	1 Rammer/ tamper, gas, 15"		49.6	6.2		
A-1H	1 Building Laborer	34.35	274.8	34.35	336.4	42.05
A-1H	1 Exterior steam cleaner		61.6	7.7		
A-1J	1 Building Laborer	34.35	274.8	34.35	333.25	41.66
A-1J	1 Cultivator, walk-behind, 5 H.P		58.45	7.31		
A-1K	1 Building Laborer	34.35	274.8	34.35	364.55	45.57
A-1K	1 Cultivator, walk-behind, 8 H.P		89.75	11.22		
A-1M	1 Building Laborer	34.35	274.8	34.35	327.9	40.99
A-1M	1 Snow blower, walk-behind		53.1	6.64		

Figure 4.4 Crew Specifications (RSMeans-Building Construction Cost Data, 2011)

Project Name	Division Name	Crew	Daily output	Unit	Material	Labor	Equipment	Total	Labor %
Apartment, 1-3 Story	Standard Foundations	C-14C	43	C.Y	185	108	0.55	293.55	36.79%
Apartment, 1-3 Story	Special Foundations	-	-	-	-	-	-	-	
Apartment, 1-3 Story	Slab on Grade	C-14E	60.75	C.Y	117	61.5	0.38	178.88	34.38%
Apartment, 1-3 Story	Basement Excavation	B-56	34.9	L.F		17.85	37	54.85	32.54%
Apartment, 1-3 Story	Basement Walls	C-6	140	C.Y		12.25	0.33	12.58	97.38%
Apartment, 1-3 Story	Floor Construction	E-4	3200	S.F	2.37	0.49	0.03	2.89	16.96%
Apartment, 1-3 Story	Roof Construction	E-4	4900	S.F	1.1	0.32	0.02	1.44	22.22%
Apartment, 1-3 Story	Exterior Walls	D-8	215	S.F	4.12	7.4		11.52	64.24%
Apartment, 1-3 Story	Exterior Windows	2 Sswk	10	Ea	209	77.5		286.5	27.05%
Apartment, 1-3 Story	Exterior Doors	2 Carp	4	Ea	1550	172		1722	9.99%
Apartment, 1-3 Story	Roof Coverings	J-1	390	S.F	2.09	3.86	0.32	6.27	61.56%

Figure 4.5 Daily output per Crew (RSMeans-Building Construction Cost Data, 2011)

4.3- Incorporate the Collected Data in the Database:

Once all the needed data is collected and stored in different databases (i.e. Excel) the aim is to integrate these data together in a user friendly model that automatically and accurately calculates the cost and duration of any construction project in a deterministic way. The model will guide users on how to enter and select information about the proposed project is such a way that all calculations are executed in an efficient and dependable manner. The process of implementing the model therefore consists of the following components:

4.3.1- Project Name and Project Type:

Users can easily select the project name from a dropdown list of projects incorporated in the model as shown in Figure 4.6. After that, users can choose the project type (commercial, industrial or institutional) from a list built in the model as shown in Figure 4.7.

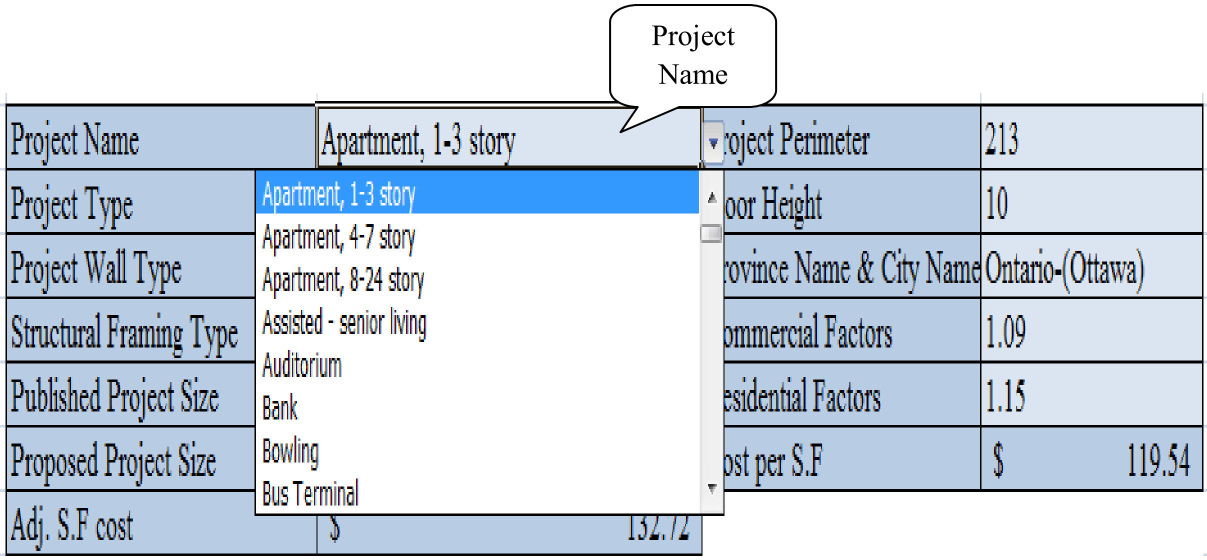


Figure 4.6 Project Name

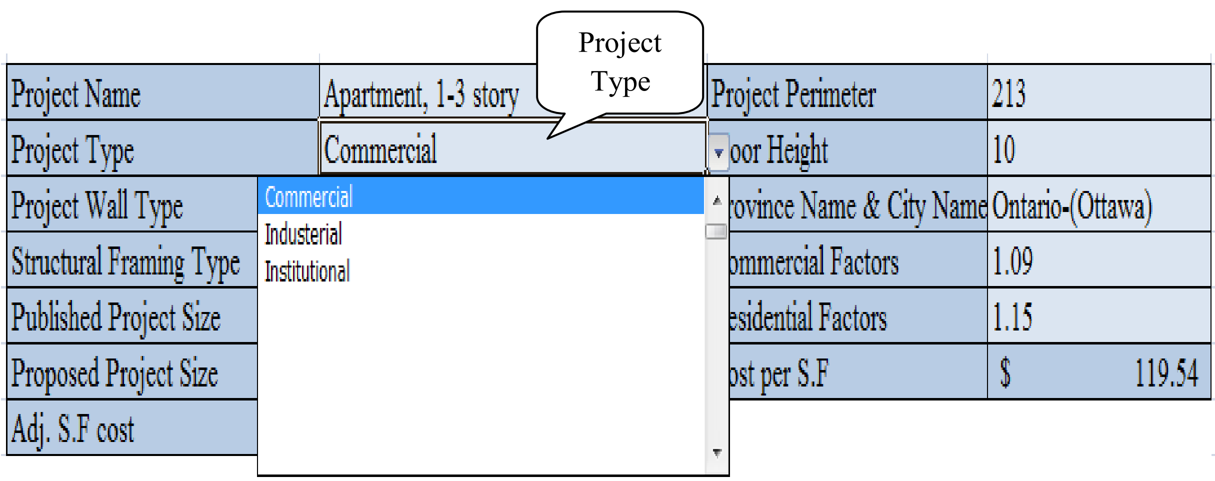


Figure 4.7 Project Type

4.3.2- Project Exterior Wall Type and Structure Framing Types:

Estimating the cost of proposed projects at the conceptual stage depends on the cost of similar projects built in the past. However, these two projects have to be similar in type. Most of the time, they have several parameter differences, such as exterior wall type and structural framing type. Therefore it is very important to take these differences into consideration and make the necessary adjustments to improve the level of accuracy of the estimate. Based on the collected data there is a relationship between the exterior wall and structural framing types, which vary from one project to another. Therefore, the model automates the selection process for these parameters by providing users with drop down lists to select the appropriate ones as illustrated in Figures 4.8 and 4.9. First, users have to select the project wall type and then select the project framing type.

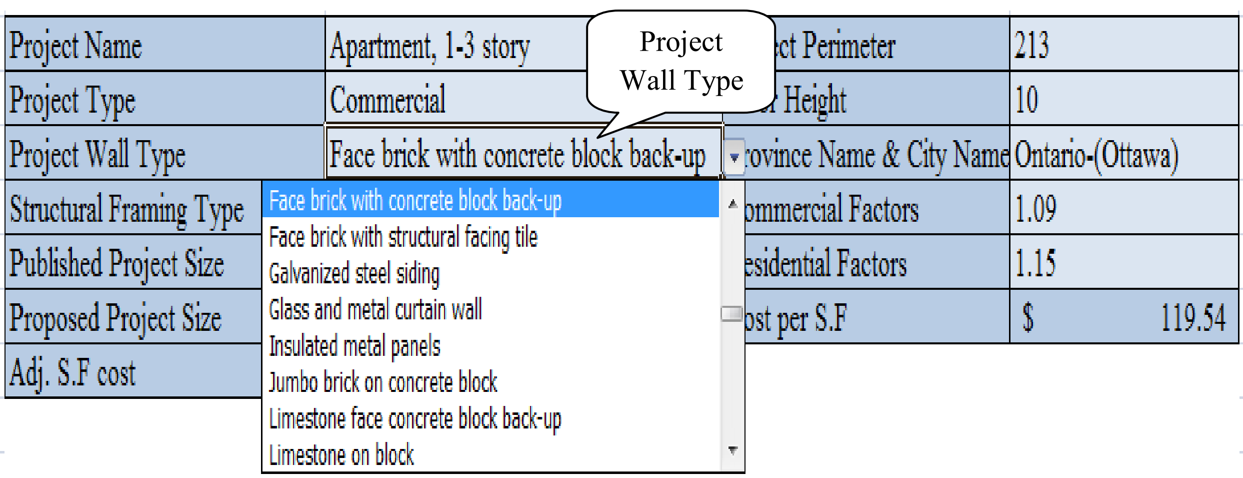


Figure 4.8 Exterior Wall Type

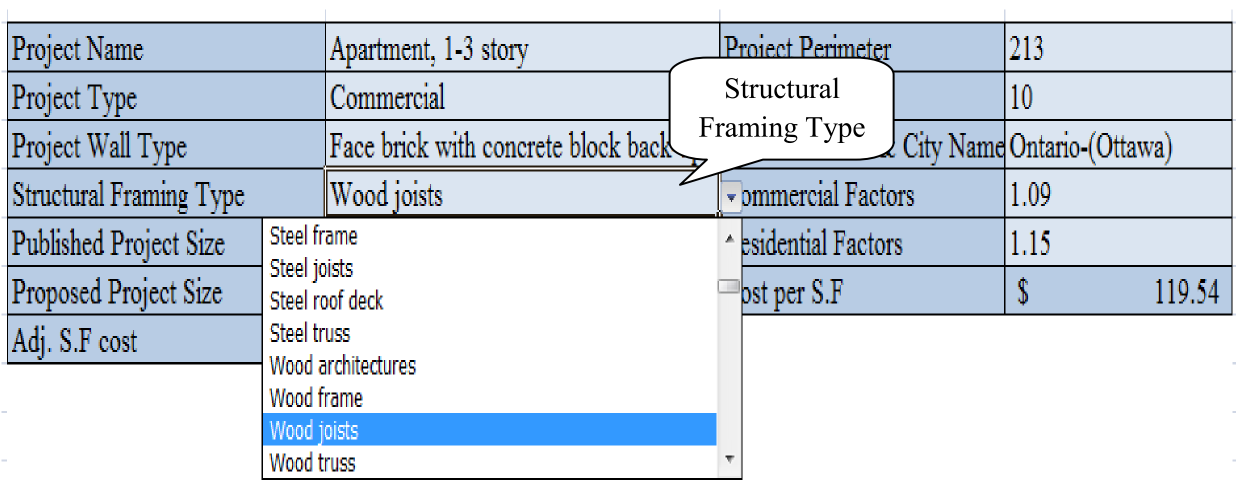


Figure 4.9 Structure Framing Types

4.3.3- Project Size and Location Factor:

Another important parameter that needs to be considered is the difference in size (gross area) between the previous and proposed projects. The data collected from RSMeans publications are based on gross area fixed values. Therefore if the size of the proposed project is different from these values, an adjustment has to be made so that the estimate would provide a better level of accuracy. In order to make this adjustment, users have to select a previous project that has its gross area as close as possible to the proposed one. Usually a bigger value is recommended and can be selected from a drop down list that has been incorporated in the model as shown in figure 4.10.

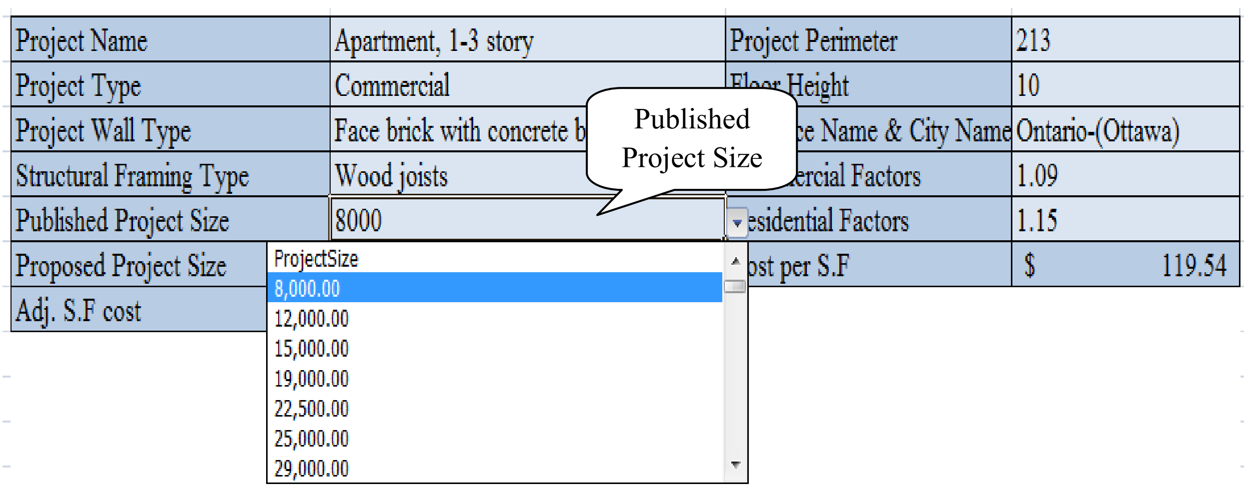


Figure 4.10 Project Size

Once this size is selected, the project size adjustment is automatically executed in the model by using Equations (3.8), (3.9), and (3.10).

In addition, there is another adjustment that should be considered during the estimating process because the collected data depends on RSMeans publications. This adjustment is for locations that reflect the difference in cost from city to city based on the proposed project. Moreover, the model allows the user to select the required city from an embedded drop down list as shown in Figure 4.11. This adjustment is implemented by the model using equation (3.12).

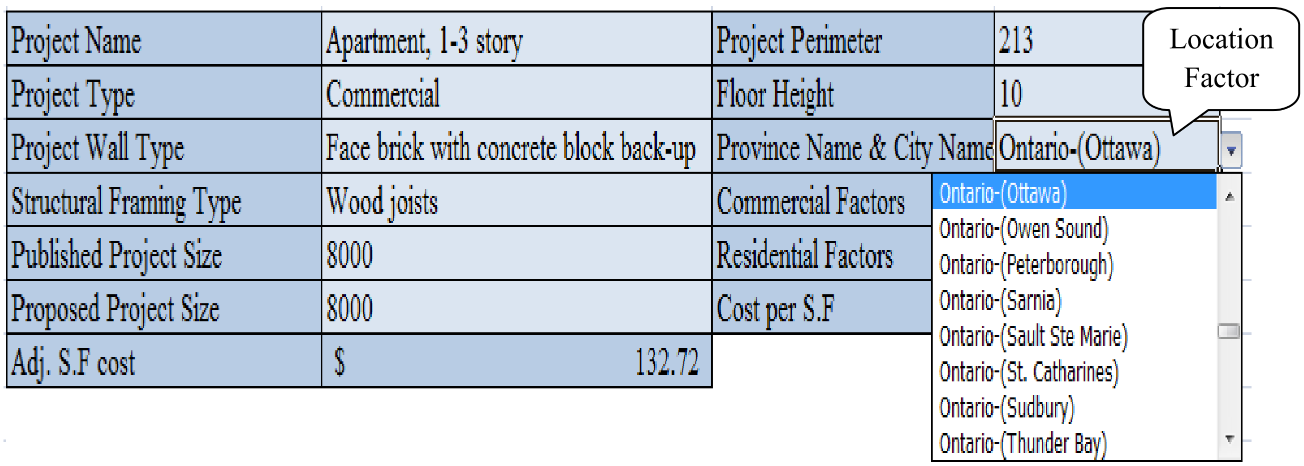


Figure 4.11 Location Factor

4.3.4- Project Perimeter and Floor to Floor Height:

The model allows users to choose the proposed project perimeter from the list as illustrated in figure 4.12. In addition, users can select the floor to floor height from another list created in the model as shown in figure 4.13.

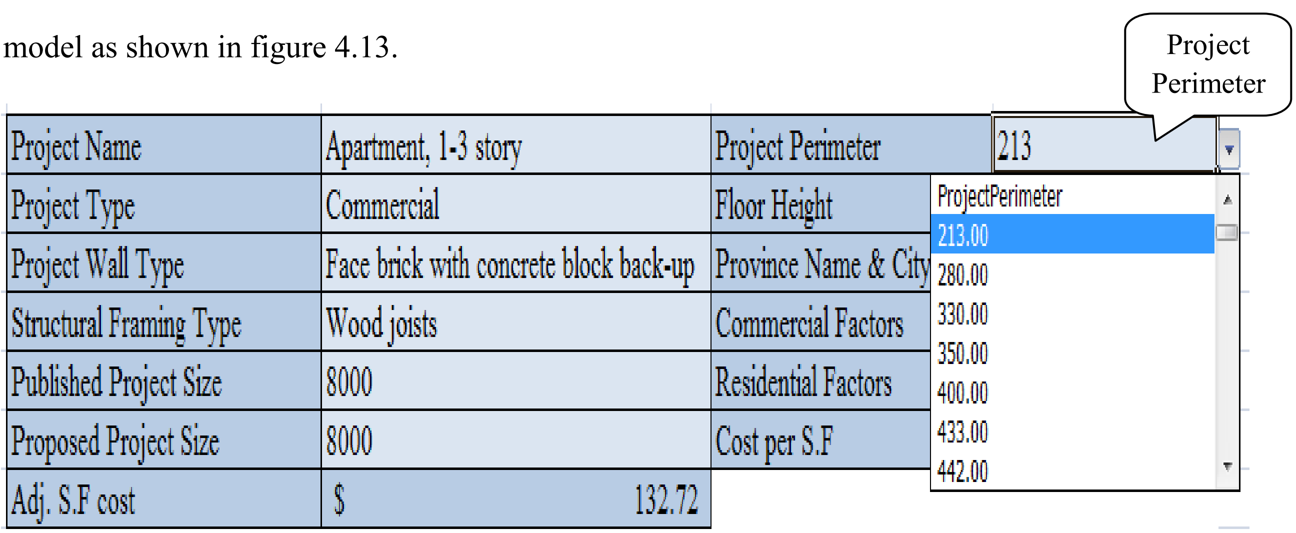
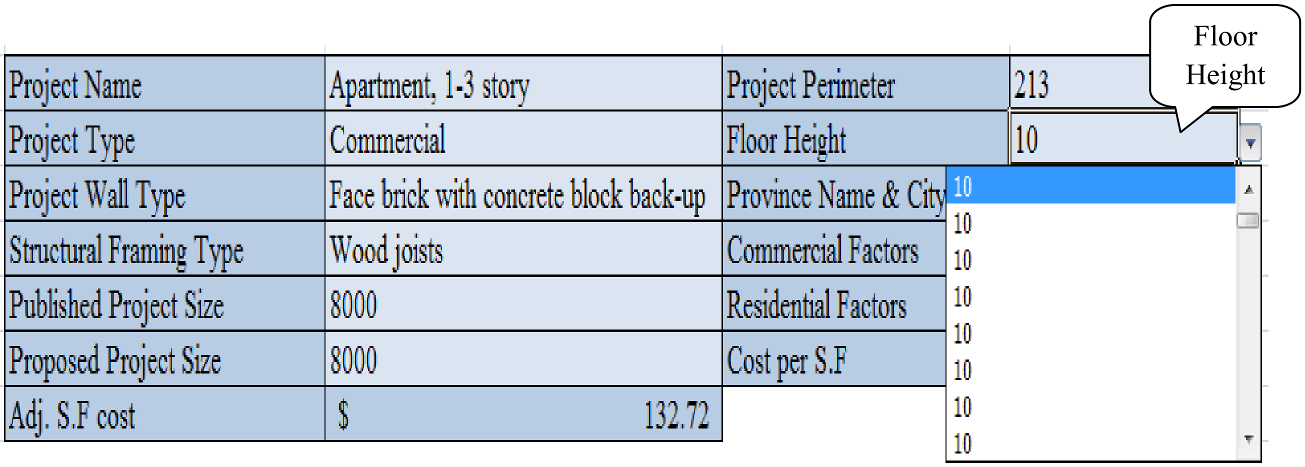


Figure 4.12 Project Perimeter

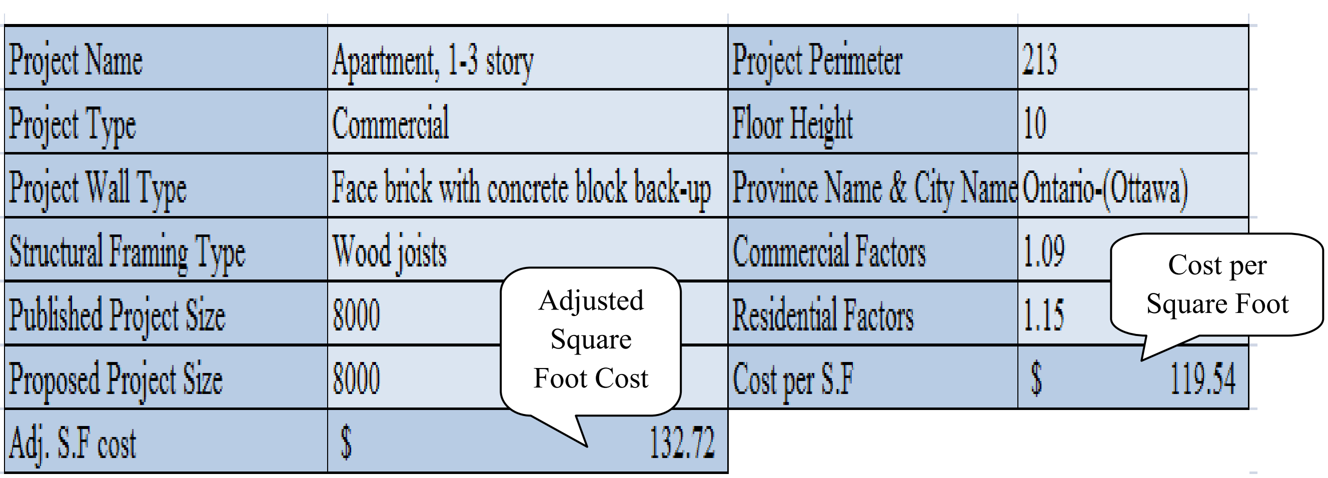


Project Name	Apartment, 1-3 story	Project Perimeter	213
Project Type	Commercial	Floor Height	10
Project Wall Type	Face brick with concrete block back-up	Province Name & City	10
Structural Framing Type	Wood joists	Commercial Factors	10
Published Project Size	8000	Residential Factors	10
Proposed Project Size	8000	Cost per S.F	10
Adj. S.F cost	$ 132.72		

Figure 4.13 Floor to Floor Height

4.3.5- Calculating the Cost per Square Foot and the Adjusted S. F. Cost:

After identifying all the factors that impact the construction cost and duration of the project, the model will calculate the total cost per square foot of the project by adding the cost per square foot of all the activities associated in that project. Also, the model computes the adjusted square foot cost of each activity by using equations (3.11) through (3.13) to gain the total adjusted square foot cost of the project as clarified in Figure 4.14.



Project Name	Apartment, 1-3 story	Project Perimeter	213
Project Type	Commercial	Floor Height	10
Project Wall Type	Face brick with concrete block back-up	Province Name & City Name	Ontario-(Ottawa)
Structural Framing Type	Wood joists	Commercial Factors	1.09
Published Project Size	8000	Residential Factors	1.15
Proposed Project Size	8000	Cost per S.F	$ 119.54
Adj. S.F cost	$ 132.72		

Figure 4.14 Cost per Square Foot and Adjusted S.F. Cost

4.3.6- The Output Report of the model:

The proposed model generates reports for the cost and duration of the proposed project using the deterministic approach. These values rely on known parameters. Their values are calculated in a systematic way with a sufficient level of accuracy as shown in figure 4.15. This figure consists of two parts; the first contains all the factors that influence the project as mentioned before. The second includes all the divisions of the proposed project with their percentages. All these information is based on 2011 R.S.Means publication data. It also includes the cost and duration values of each division and the proposed project's total cost and duration. These values were calculated by the model using equations (3.14), (3.15), (3.16), (3.17) & (3.23).

Project Name	Apartment, 1-3 story	Project Perimeter	213
Project Type	Commercial	Floor Height	10
Project Wall Type	Face brick with concrete block back-up	Province Name & City Name	Ontario-(Ottawa)
Structural Framing Type	Wood joists	Commercial Factors	1.09
Published Project Size	8000	Residential Factors	1.15
Proposed Project Size	8000	Cost per S.F	$ 119.54
Adj. S.F cost	$ 132.72		

Division Percentage

Cost Values

Duration Values

Deterministic Model for Cost & Duration

Division	Percentage (%)	Cost	Duration / Day
A- Substructure	4.30%	$ 49,765.08	9
B- Shell - B10 Superstructure	12.60%	$ 145,823.27	7
B- Shell - B20 Exterior Enclousr	11.00%	$ 127,306.03	7
B- Shell - B30 Roofing	1.70%	$ 19,674.57	3
C- Interiors	24.10%	$ 278,915.93	29
D- Services - D10 Conveying	3.80%	$ 43,978.45	2
D- Services - D20 Plumbing	15.80%	$ 182,857.75	10
D- Services - D30 HVAC	14.60%	$ 168,969.82	7
D- Service - D40 Fire Protection	2.70%	$ 31,247.84	4
D- Service - D50 Electrical	9.40%	$ 108,788.79	10
E- Equipment & Furnishings	0.00%	$ -	0
F- Special Construction	0.00%	$ -	0
Total		$ 1,157,327.52	88

Total Cost

Total Duration

Figure 4.15 the Output Report of the Model

On the other hand, all the model components are linked by using some built in functions in Microsoft Excel as shown in Appendix A.

4.4- Features of the Model:

Th developed model has lots of features that help users to generate cost and duration estimates in an easy, efficient and flexible way. One of these features is the potential to view either a summarized list of the costs based on the uniformat II work breakdown structure, by providing the cost and duration of each division separately; or a detailed list of the most common work items and the associated costs included in every division, as shown in Figure 4.16. This information is found in 2011 R.S.Means publications. Moreover, cost and duration of each proposed project activity are instantly calculated by the proposed model.

12	Deterministic Model for Cost & Duration				
	Division	Percentage (%)		Cost	Duration / Day
	A- Substructure	4.30%	$	49,765.08	9
	B- Shell - B10 Superstructure	12.60%	$	145,823.27	7
	B- Shell - B20 Exterior Enclousr	11.00%	$	127,306.03	7
27	**B- Shell - B30 Roofing**	1.70%	$	19,674.57	3
30	**C- Interiors**	24.10%	$	278,915.93	29
31	Partitions		$	54,090.08	8
32	Interior Doors		$	63,701.12	6
33	Fittings		$	27,380.31	2
34	Stair Construction		$	26,821.53	2
35	Wall Finishes		$	22,882.11	2
36	Floor Finishes		$	49,731.58	3
37	Ceiling Finishes		$	34,309.20	6
38	**D- Services - D10 Conveying**	3.80%	$	43,978.45	2
41	**D- Services - D20 Plumbing**	15.80%	$	182,857.75	10
45	**D- Services - D30 HVAC**	14.60%	$	168,969.82	7
51	**D- Service - D40 Fire Protection**	2.70%	$	31,247.84	4
54	**D- Service - D50 Electrical**	9.40%	$	108,788.79	10
59	**E- Equipment & Furnishings**	0.00%	$	-	0
64	**F- Special Construction**	0.00%	$	-	0
67	Total		$	1,157,327.52	88

Project Division

Project Activities

Figure 4.16 Features of the Model

4.5- Linking the Model with MS Project 2007:

Once users finish calculating the estimated costs of the proposed project, they can calculate the duration needed to build that project. To do so, users have to follow a few steps. The first is to create a project job logic by generating a list of associated activities in sequential order. This is accomplished by identifying the predecessors and successors of the project's activities. The second step is to establish an automatic link between the model and Microsoft project. For this reason, the model is coded in Microsoft Excel to achieve the link as shown in figure 4.17.

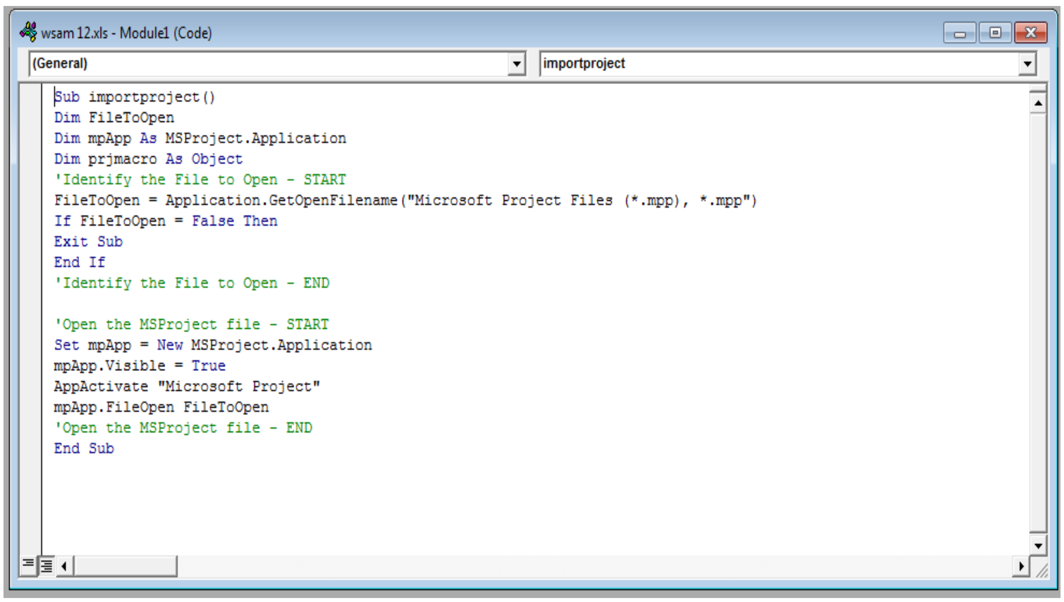


Figure 4.17 Writing a Code in Visual Basic Application

Then the model is run by one click on the MS project button created in MS excel as illustrated in figure 4.18. To open the schedule of the proposed project as illustrated in figure 4.19.

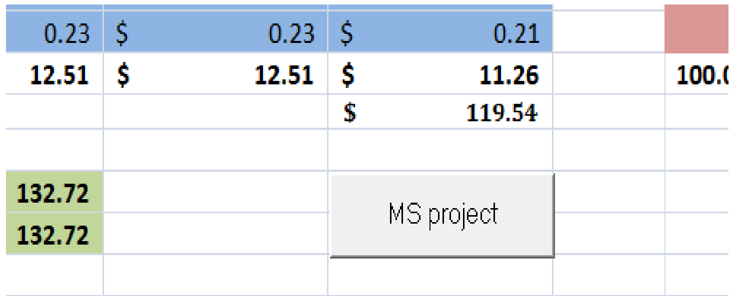
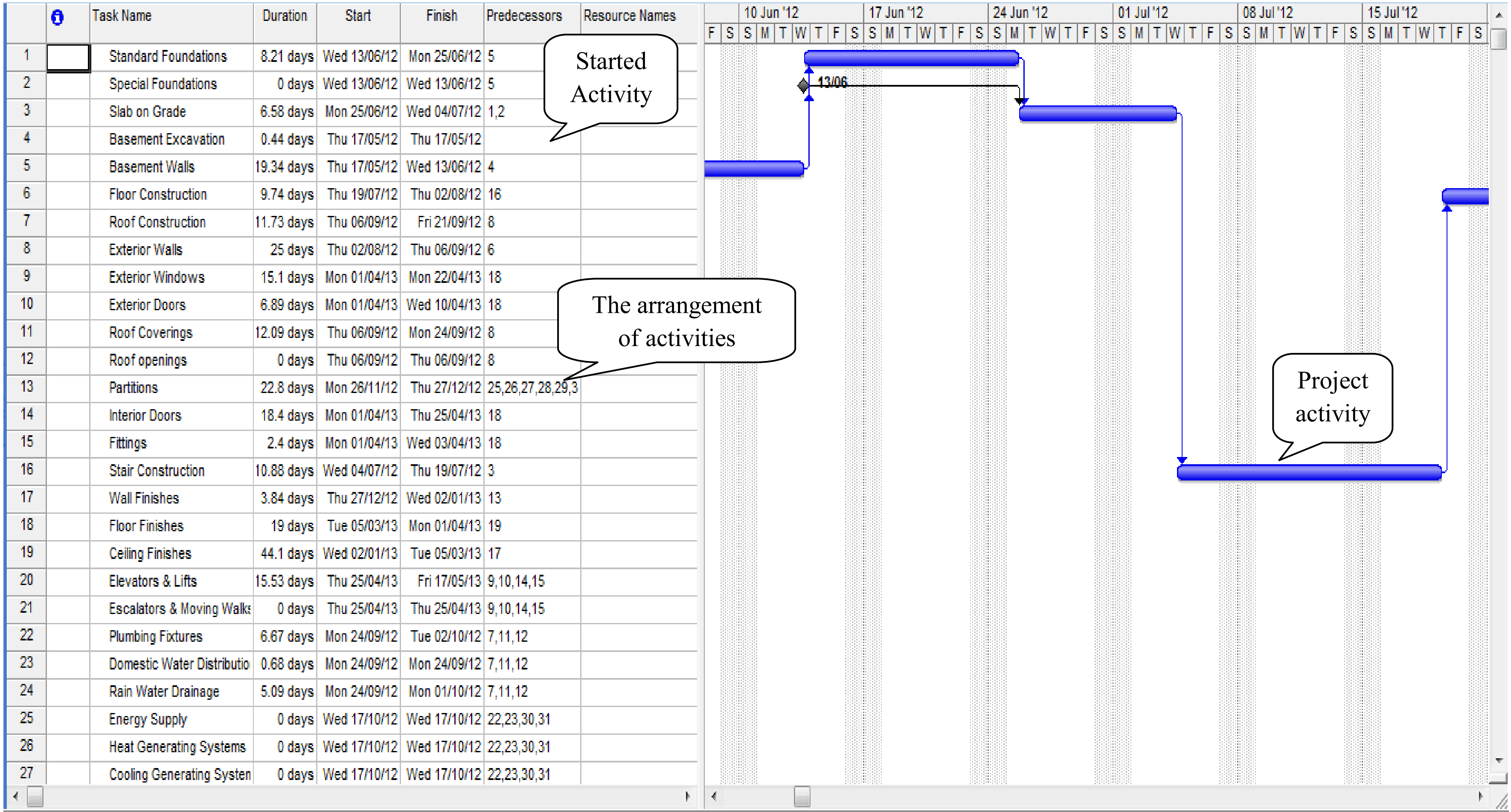


Figure 4.18 MS Project Button

The sequential order of the project activities is executed by identifying their predecessors and accordingly the schedule is created as shown in figure 4.19. This process is done manually based on the estimator's experience.



	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	Standard Foundations	8.21 days	Wed 13/06/12	Mon 25/06/12	5	
2	Special Foundations	0 days	Wed 13/06/12	Wed 13/06/12	5	
3	Slab on Grade	6.58 days	Mon 25/06/12	Wed 04/07/12	1,2	
4	Basement Excavation	0.44 days	Thu 17/05/12	Thu 17/05/12		
5	Basement Walls	19.34 days	Thu 17/05/12	Wed 13/06/12	4	
6	Floor Construction	9.74 days	Thu 19/07/12	Thu 02/08/12	16	
7	Roof Construction	11.73 days	Thu 06/09/12	Fri 21/09/12	8	
8	Exterior Walls	25 days	Thu 02/08/12	Thu 06/09/12	6	
9	Exterior Windows	15.1 days	Mon 01/04/13	Mon 22/04/13	18	
10	Exterior Doors	6.89 days	Mon 01/04/13	Wed 10/04/13	18	
11	Roof Coverings	12.09 days	Thu 06/09/12	Mon 24/09/12	8	
12	Roof openings	0 days	Thu 06/09/12	Thu 06/09/12	8	
13	Partitions	22.8 days	Mon 26/11/12	Thu 27/12/12	25,26,27,28,29,3	
14	Interior Doors	18.4 days	Mon 01/04/13	Thu 25/04/13	18	
15	Fittings	2.4 days	Mon 01/04/13	Wed 03/04/13	18	
16	Stair Construction	10.88 days	Wed 04/07/12	Thu 19/07/12	3	
17	Wall Finishes	3.84 days	Thu 27/12/12	Wed 02/01/13	13	
18	Floor Finishes	19 days	Tue 05/03/13	Mon 01/04/13	19	
19	Ceiling Finishes	44.1 days	Wed 02/01/13	Tue 05/03/13	17	
20	Elevators & Lifts	15.53 days	Thu 25/04/13	Fri 17/05/13	9,10,14,15	
21	Escalators & Moving Walks	0 days	Thu 25/04/13	Thu 25/04/13	9,10,14,15	
22	Plumbing Fixtures	6.67 days	Mon 24/09/12	Tue 02/10/12	7,11,12	
23	Domestic Water Distributio	0.68 days	Mon 24/09/12	Mon 24/09/12	7,11,12	
24	Rain Water Drainage	5.09 days	Mon 24/09/12	Mon 01/10/12	7,11,12	
25	Energy Supply	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	
26	Heat Generating Systems	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	
27	Cooling Generating Systen	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	

Figure 4.19 Sample of the Project Schedule

4.6- Stochastic Method in Estimating the Project Cost and Duration:

The stochastic method is one of the methods used to estimate the cost and duration of a proposed project by taking into consideration the inherent determining estimates. This method is used to identify estimates' occurrence probability. The probabilistic method is applied to the critical activities of the project. It can be implemented by utilizing the following steps:

1- Identify three different values for the cost and duration of every critical activity in the proposed project, these values are: optimistic, most likely and pessimistic. Furthermore, determine the factors that influence each project activity and give a weight to each value to derive a probabilistic percentage that represents the impact of each factor on the activity, based on the different conditions that face each activity during the implementation. Then, multiply the cost and duration of every project activity by the corresponding probabilistic percentage. After that, add the new values for each activity to acquire the pessimistic values. In addition, subtract the same new values in order to gain the optimistic values. The most likely values are considered to be equal to the deterministic values calculated by the model. Figure 4.20 provides a sample of this step. In addition, all the cost values of each activity shown in figure 4.20 are computed from equations (3.18), (3.19) and (3.21). Whereas, the duration values of each activity are calculated by using equations (3.24), (3.25) and (3.27).

2- Load the new calculated project values of the cost and duration automatically in Monte Carlo Simulation by using the built in functions of Microsoft Excel as shown in Appendix A. These values are used to compute cost and duration probability accuracy calculated by the model, as well as the range of variation in their values.

Assumption
Equations 3.18 and 3.24
Assumption
Assumption
Equations 3.18, 3.24
Assumption
Equation 3.25
Equation 3.27
Equation 3.19
Equation 3.21

ID	Activity	Cost and Duration Type	Event Type	Probability	Variation	Weighted % Variation	Cost	Duration	Cost and Duration Type	Event Type	Probability	Variation	Weighted % Variation	Cost	Duration
1	**Standard Foundations**	**Optimistic**	site preparation	0.1	0.2	0.02	79959	7	**Pessimistic**	site preparation	0.05	0.2	0.01	123584	11
			Equipment	0.15	0.025	0.00375				Equipment	0.15	0.25	0.0375		
			operator	0.15	0.25	0.0375				operator	0.15	0.5	0.075		
			management	0.15	0.15	0.0225				management	0.15	0.2	0.03		
			size	0.05	0.05	0.0025				size	0.05	0.2	0.01		
			soil type	0.3	0.15	0.045				soil type	0.3	0.45	0.135		
			Weather	0.1	0.05	0.005				Weather	0.15	0.25	0.0375		
2	**Slab on grade**	**Optimistic**	material	0.3	0.15	0.045	66267	7	**Pessimistic**	material	0.35	0.5	0.175	111232	
			operator	0.15	0.025	0.00375				operator	0.15	0.1	0.015		
			management	0.35	0.2	0.07				management	0.3	0.75	0.225		
			Equipment	0.025	0.02	0.0005				Equipment	0.05	0.08	0.004		
			Weather	0.175	0.1	0.0175				Weather	0.15	0.2	0.03		
3	**Basement Excavation**	**Optimistic**	Equipment	0.25	0.05	0.0125	2185	1	**Pessimistic**	Equipment	0.3	0.7	0.21	3940	2
			operator	0.2	0.2	0.04				operator	0.15	0.2	0.03		
			management	0.3	0.45	0.135				management	0.3	0.45	0.135		
			soil type	0.15	0.15	0.0225				soil type	0.2	0.2	0.04		
			size	0.05	0.025	0.00125				size	0.025	0.1	0.0025		
			Weather	0.05	0.025	0.00125				Weather	0.025	0.1	0.0025		
4	**Basement Walls**	**Optimistic**	Equipment	0.2	0.05	0.01	57578	17	**Pessimistic**	Equipment	0.2	0.15	0.03	90740	27
			operator	0.2	0.15	0.03				operator	0.25	0.35	0.0875		
			management	0.3	0.35	0.105				management	0.35	0.5	0.175		
			soil type	0.15	0.1	0.015				soil type	0.1	0.15	0.015		
			size	0.05	0.02	0.001				size	0.05	0.1	0.005		
			Weather	0.1	0.03	0.003				Weather	0.05	0.1	0.005		
5	**Floor Construction**	**Optimistic**	material	0.3	0.2	0.06	457678	10	**Pessimistic**	material	0.35	0.3	0.105	752562	16
			operator	0.25	0.15	0.0375				operator	0.2	0.15	0.03		
			management	0.4	0.25	0.1				management	0.4	0.45	0.18		
			Weather	0.05	0.025	0.00125				Weather	0.05	0.05	0.0025		
6	**Roof Construction**	**Optimistic**	material	0.25	0.1	0.025	116042	16	**Pessimistic**	material	0.3	0.2	0.06	170353	23
			operator	0.25	0.15	0.0375				operator	0.25	0.35	0.0875		
			management	0.35	0.2	0.07				management	0.35	0.3	0.105		
			Weather	0.15	0.05	0.0075				Weather	0.1	0.1	0.01		

Figure 4.20 Stochastic Method

4.7- Monte Carlo Simulation:

This simulation tool is used to obtain the proposed project's cost and duration probabilistic values by using the work item variable values needed to finish the construction process, and it deals with risk analysis and uncertainty. This process starts by loading the cost and duration values of each project activity automatically into Monte Carlo Simulation to simulate the cost and duration values. After that, the simulation will run by using thousands of variable values based on the number of trials. At the end of the simulation process, probabilistic values of the cost and duration of the project and certainty percentage based on the cost and duration values are provided. In addition, a range of the cost and duration values that generated by the model is presented as shown in figures 4.21 and 4.22. Furthermore, the simulation provides statistical results for the cost and duration of the project as clarified in tables 4.1 and 4.2. These results consist of: the number of trials during the simulation, the expected mean values of the cost and duration of the project, the standard deviation (the square root of the summation of all the variances of the activities on the critical path), the variance, the skewness, kurtosis, coefficient of variability, the minimum values of the cost and duration, the maximum values of the cost and duration and the error of standard deviation.

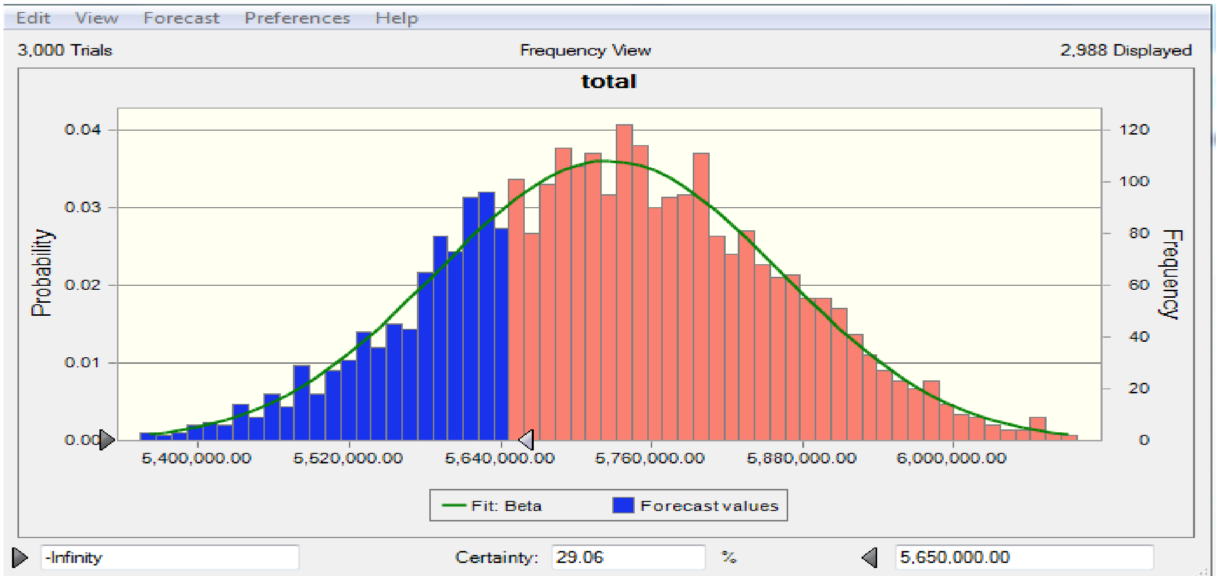


Figure 4.21 Probabilistic Cost

Table 4.1 Statistical Cost Information

Statistic	Forecast Values
Trials	3,000
Base Case	0.00
Mean	5,725,862.37
Median	5,724,690.60
Mode	---
Standard Deviation	132,654.52
Variance	17,597,222,156.67
Skewness	0.0040
Kurtosis	2.89
Coeff. of Variability	0.0232
Minimum	5,268,395.76
Maximum	6,166,062.19
Mean Std. Error	2421.93

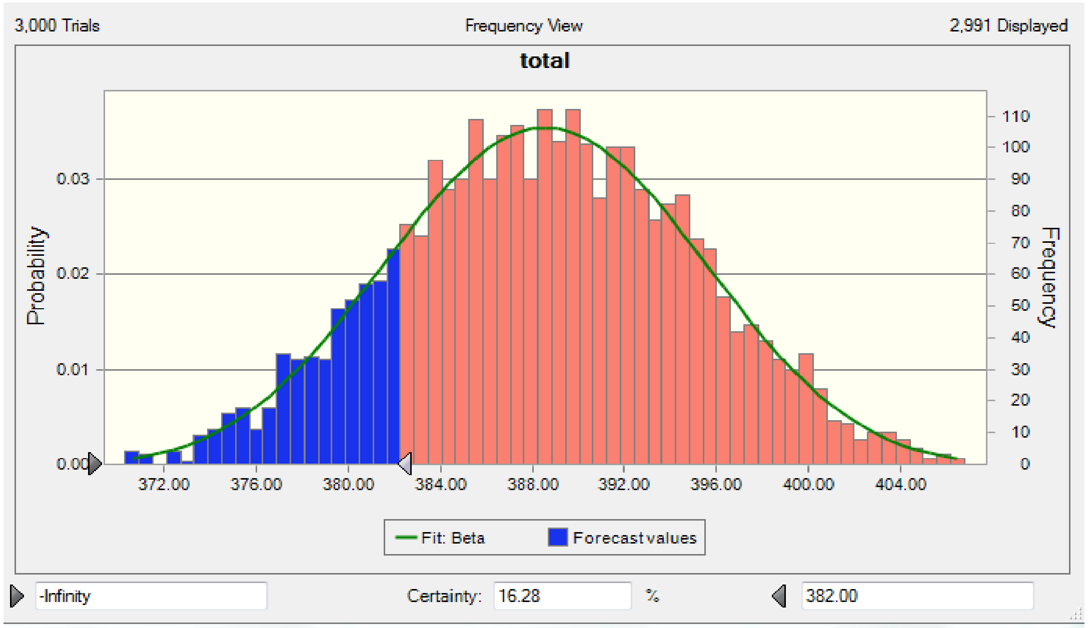


Figure 4.22 Probabilistic Duration

Table 4.2 Statistical Duration Information

Statistic	Forecast Values
Trials	3,000
Base Case	0.00
Mean	388.54
Median	388.58
Mode	---
Standard Deviation	6.51
Variance	42.42
Skewness	-0.0016
Kurtosis	2.76
Coeff. of Variability	0.0168
Minimum	364.89
Maximum	409.88
Mean Std. Error	0.12

Another analysis of the duration values by using Monte Carlo simulation is made to identify if the probability of finishing the project will change or not. This analysis is carried out by changing the values of the critical activities. This change relies on an increase or decrease in the number of crews. The probability of finishing the project on time was increased by 18.44 % by increasing the number of crew during the simulation, as shown in figure 4.23. The probability of completing the project on time was decreased by 16.89 % by decreasing the number of crew, as illustrated in figure 4.24. The number of crew therefore is an important factor because it influences the time required to finish the project.

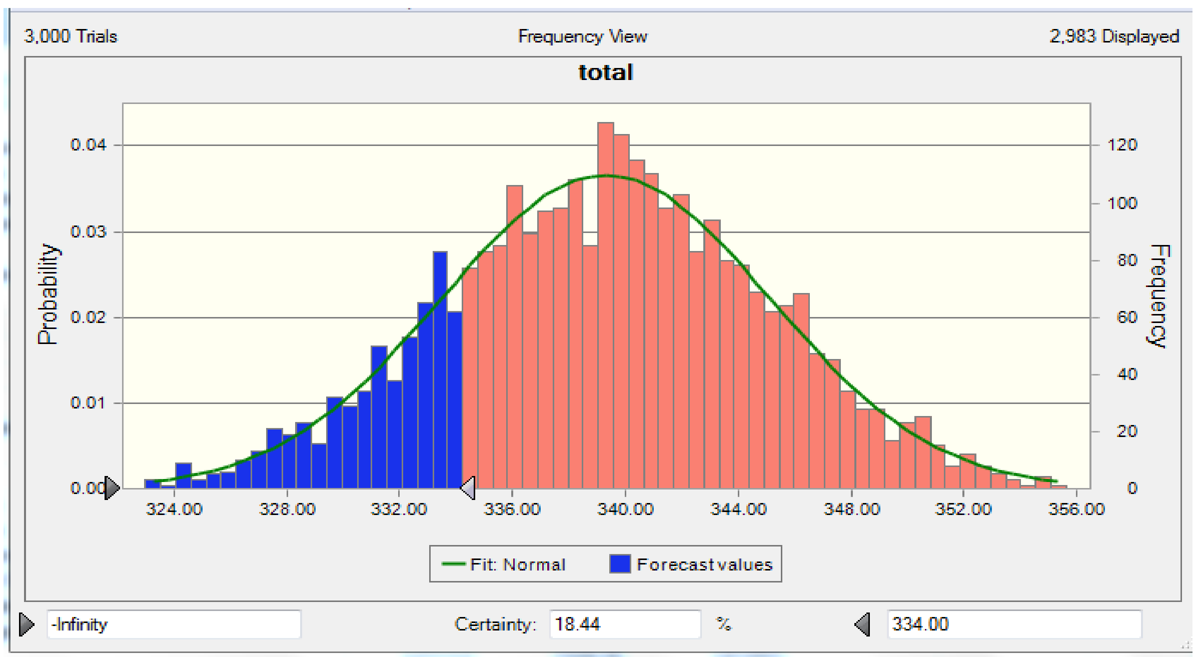


Figure 4.23 the Probability of Increasing the Number of Crews

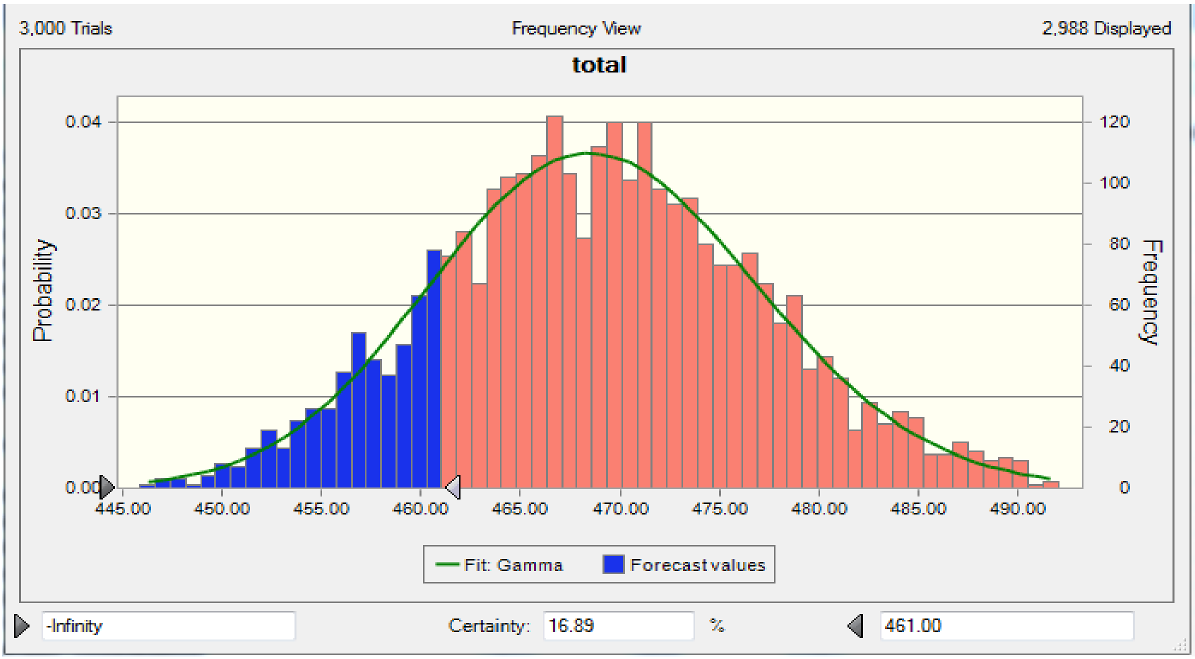


Figure 4.24 the Probability of Decreasing the Number of Crews

4.8- Summary:

This chapter presented the process of developing the proposed model, which incorporates the deterministic and stochastic methods. This process utilized several steps. The first started with the collection of the desired data to develop the model. The second involved loading the collected data in MS Excel 2007 by using the deterministic method and built in functions that generated cost and duration reports for the proposed project. The third linked the proposed model with MS Project 2007 in order to acquire the project schedule. The fourth step considered three different cost and duration values for each project activity and give them a weight to obtain probabilistic percentages by using the stochastic method. Finally, the process involved loading the new cost and duration project values in the Monte Carlo Simulation to acquire the probabilistic values of the cost and duration of the project with their range of variation.

Chapter Five

Model Performance and Validation

5.1- Introduction:

This chapter tests the capability of the developed model to estimate the cost and duration of an actual project at the feasibility stage. Therefore, the validation is specified through a comparison between the values generated by the model and the actual project. The actual project is a three stories office building built in year 2007 in Ottawa, Ontario. The actual construction cost, duration and main project information is shown in table 5.1.

Table 5.1 Three Stories Office Building in Ottawa, Ontario

Project Information	
Project Type	Office Building
Year of Construction	2007
Project Location (State / City)	Ottawa / Ontario
Number of stories	3
Project Size	44,151 S. F
Floor Area	14,717 S. F
Building perimeter	490 L. F
Floor to Floor height	12 ft
Exterior Wall Type	Face Brick with Concrete Block Back-up
Total Occupancy	441 (Persons)
Occupancy per Floor	147 (Persons)
Construction Duration	365 Working Days
Total cost	$ 5,381,765

5.2- Estimating the Project Cost and Duration Using the Model:

To test whether the model will work, two steps have to be considered. First, select the elements similar to the ones in the actual project, from the model. These elements include: Project name, project type, project size, project perimeter, floor to floor height, project system and exterior wall type as illustrated in figure 5.1. Second, compute the construction cost and duration of the project using the model based on both the deterministic and stochastic methods.

Project Name	Office, 2-4 story	Project Perimeter	490
Project Type	Commercial	Floor Height	12
Project Wall Type	Face brick with concrete block back-up	Province Name & City Name	Ontario-(Ottawa)
Structural Framing Type	Wood joists	Commercial Factors	1.09
Published Project Size	50000	Residential Factors	1.15
Proposed Project Size	44151	Cost per S.F	$ 130.33
Adj. S.F cost	$ 117.40		

Figure 5.1 Project Elements Selection

5.3- Deterministic Method for Estimating the Project Cost and Duration:

The process of estimating the construction cost and duration of the project starts by calculating the cost and duration of every single activity associated with each division of the Uniformat II work breakdown structure. Adding the costs and durations of these activities will give the cost and duration of each division. Summing up the cost and duration of all divisions will result in identifying the total construction cost and duration of the project as shown in figure 5.2. In addition, the project schedule is obtained by an automatic transfer of the data generated by the model to MS project 2007 as illustrated in figure 5.3.

Deterministic Model for Cost & Duration			
Division	Percentage (%)	Cost	Duration
A- Substructure	4.40%	$ 248,596.73	37
B- Shell - B10 Superstructure	10.10%	$ 570,642.51	22
B- Shell - B20 Exterior Enclous	15.80%	$ 892,688.28	48
B- Shell - B30 Roofing	1.70%	$ 96,048.74	13
C- Interiors	23.20%	$ 1,310,782.78	124
D- Services - D10 Conveying	8.80%	$ 497,193.47	16
D- Services - D20 Plumbing	3.40%	$ 192,097.48	13
D- Services - D30 HVAC	12.40%	$ 700,590.80	16
D- Service - D40 Fire Protectio	3.30%	$ 186,447.55	24
D- Service - D50 Electrical	16.90%	$ 954,837.46	69
E- Equipment & Furnishings	0.00%	$ -	0
F- Special Construction	0.00%	$ -	0
Total		$ 5,649,925.79	382

Figure 5.2 Deterministic Method for Estimating the Project Cost and Duration

		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		Standard Foundations	8.21 days	Wed 13/06/12	Mon 25/06/12	5	
2		Special Foundations	0 days	Wed 13/06/12	Wed 13/06/12	5	
3		Slab on Grade	6.58 days	Mon 25/06/12	Wed 04/07/12	1,2	
4		Basement Excavation	0.44 days	Thu 17/05/12	Thu 17/05/12		
5		Basement Walls	19.34 days	Thu 17/05/12	Wed 13/06/12	4	
6		Floor Construction	9.74 days	Thu 19/07/12	Thu 02/08/12	16	
7		Roof Construction	11.73 days	Thu 06/09/12	Fri 21/09/12	8	
8		Exterior Walls	25 days	Thu 02/08/12	Thu 06/09/12	6	
9		Exterior Windows	15.1 days	Mon 01/04/13	Mon 22/04/13	18	
10		Exterior Doors	6.89 days	Mon 01/04/13	Wed 10/04/13	18	
11		Roof Coverings	12.09 days	Thu 06/09/12	Mon 24/09/12	8	
12		Roof openings	0 days	Thu 06/09/12	Thu 06/09/12	8	
13		Partitions	22.8 days	Mon 26/11/12	Thu 27/12/12	25,26,27,28,29,3	
14		Interior Doors	18.4 days	Mon 01/04/13	Thu 25/04/13	18	
15		Fittings	2.4 days	Mon 01/04/13	Wed 03/04/13	18	
16		Stair Construction	10.88 days	Wed 04/07/12	Thu 19/07/12	3	
17		Wall Finishes	3.84 days	Thu 27/12/12	Wed 02/01/13	13	
18		Floor Finishes	19 days	Tue 05/03/13	Mon 01/04/13	19	
19		Ceiling Finishes	44.1 days	Wed 02/01/13	Tue 05/03/13	17	
20		Elevators & Lifts	15.53 days	Thu 25/04/13	Fri 17/05/13	9,10,14,15	
21		Escalators & Moving Walk	0 days	Thu 25/04/13	Thu 25/04/13	9,10,14,15	
22		Plumbing Fixtures	6.67 days	Mon 24/09/12	Tue 02/10/12	7,11,12	
23		Domestic Water Distributio	0.68 days	Mon 24/09/12	Mon 24/09/12	7,11,12	
24		Rain Water Drainage	5.09 days	Mon 24/09/12	Mon 01/10/12	7,11,12	
25		Energy Supply	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	
26		Heat Generating Systems	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	
27		Cooling Generating Systen	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	

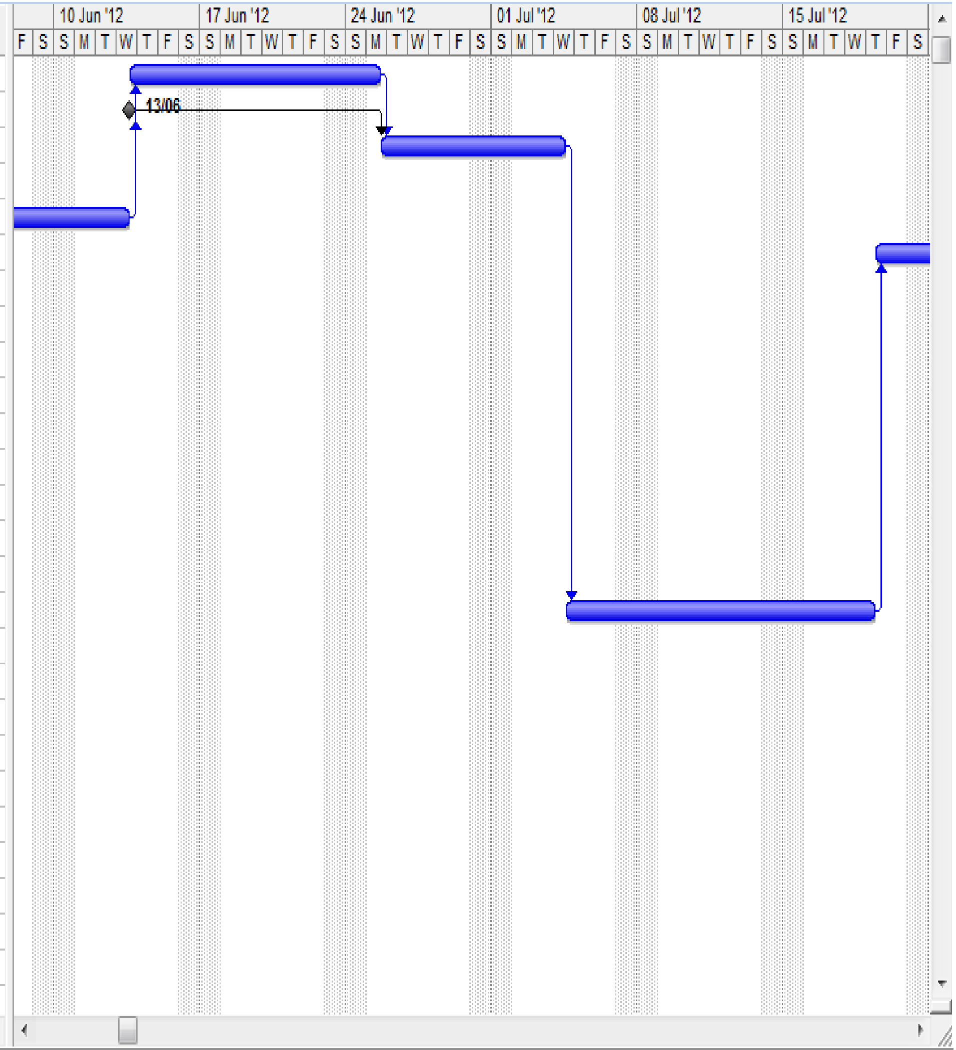


Figure 5.3 the Project Schedule

One adjustment need to be applied on the actual project cost so it will be compatible with the model's values. Therefore we need to bring the information of Ottawa city from year 2007 to year 2011. This adjustment will be for time.

1- To do time adjustment, the cost of the project built in Ottawa city has to be brought from year 2007 to year 2011 by using the following equation.

$$\text{Total project cost of year 2011} = P\,(1 + i)^{n} \qquad 5.1$$

Where, P = Past cost of completed project at year 2007, in this case \$ 5,381,765.

I = Inflation rate assumed to be (3%) because it is a common and practical value in the Canadian Industry.

N = Number of years among the known and the forecasted year, in this case is 4.

Therefore, the total project cost in Ottawa of year 2011 = \$ 5,381,765 $(1 + 0.03)^4$ = \$ 6,057,224.

The project cost that was obtained from the model is \$ 5,649,925.79 as illustrated in figure 5.2, comparing this value to the actual project cost, after bringing it to the city of Ottawa shows a difference of \$ 407,298.21 in the cost. That reflects a 7.2% less than the actual cost, which is acceptable for parametric estimates. This difference in the cost is due to many reasons; the most important being that the model is based on published cost value, accumulated from 30 different cities in North America. Whereas, the actual project cost value is coming from actual quotations taken from suppliers and vendors, which reflect a higher level of accuracy. In addition, the model calculated the project duration to be 382 days while the actual project duration was 365 days. The duration generated by the model relies on its generated cost estimate. Comparing the calculated project duration by the model to the actual one shows an addition of 17 days, which reflects a 4.45% difference between the two. This difference is little and therefore it is acceptable at the project's conception stage especially that the duration is completely obtained from the cost estimate.

5.4- Stochastic Method for Estimating the Project Cost and Duration:

To apply the stochastic method few steps have to be taken. These steps are:

1- Consider three different values for the cost and duration of each project activity. In addition, specify all the factors that affect each project activity and give a weight for its value and accordingly derive a probabilistic percentage that represents the influence of each factor on the activity. Then, multiply the cost and duration of each activity by the probabilistic percentage. Next add the new values of each activity to gain the pessimistic values. On the other hand, subtract the new values to acquire the optimistic values. The most likely values are considered to be equal to the deterministic values generated by the model. Figure 5.4 exemplifies a sample of this step.

2- Load the optimistic, most likely and pessimistic values of the cost and duration in Monte Carlo simulation. These values are needed to simulate the cost and duration values of the project generated in section 5.3, and to calculate their probability of occurrence. Furthermore, the simulation is used to identify the range of variation for the project's cost and duration values.

ID	Activity	Cost and Duration Type	Event Type	Probability	Variation	Weighted % Variation	Cost	Duration	Cost and Duration Type	Event Type	Probability	Variation	Weighted % Variation	Cost	Duration
1	**Standard Foundations**	**Optimistic**	site preparation	0.1	0.2	0.02	89594	8	**Pessimistic**	site preparation	0.05	0.2	0.01	138475	11
			Equipment	0.15	0.025	0.00375				Equipment	0.15	0.25	0.0375		
			operator	0.15	0.25	0.0375				operator	0.15	0.5	0.075		
			management	0.15	0.15	0.0225				management	0.15	0.2	0.03		
			size	0.05	0.05	0.0025				size	0.05	0.2	0.01		
			soil type	0.3	0.15	0.045				soil type	0.3	0.45	0.135		
			Weather	0.1	0.05	0.005				Weather	0.15	0.25	0.0375		
2	**Slab on grade**	**Optimistic**	material	0.3	0.15	0.045	62346	6	**Pessimistic**	material	0.35	0.5	0.175	104650	10
			operator	0.15	0.025	0.00375				operator	0.15	0.1	0.015		
			management	0.35	0.2	0.07				management	0.3	0.75	0.225		
			Equipment	0.025	0.02	0.0005				Equipment	0.05	0.08	0.004		
			Weather	0.175	0.1	0.0175				Weather	0.15	0.2	0.03		
3	**Basement Excavation**	**Optimistic**	Equipment	0.25	0.05	0.0125	2056	0.5	**Pessimistic**	Equipment	0.3	0.7	0.21	3708	2
			operator	0.2	0.2	0.04				operator	0.15	0.2	0.03		
			management	0.3	0.45	0.135				management	0.3	0.45	0.135		
			soil type	0.15	0.15	0.0225				soil type	0.2	0.2	0.04		
			size	0.05	0.025	0.00125				size	0.025	0.1	0.0025		
			Weather	0.05	0.025	0.00125				Weather	0.025	0.1	0.0025		
4	**Basement Walls**	**Optimistic**	Equipment	0.2	0.05	0.01	58552	17	**Pessimistic**	Equipment	0.2	0.15	0.03	92275	26
			operator	0.2	0.15	0.03				operator	0.25	0.35	0.0875		
			management	0.3	0.35	0.105				management	0.35	0.5	0.175		
			soil type	0.15	0.1	0.015				soil type	0.1	0.15	0.015		
			size	0.05	0.02	0.001				size	0.05	0.1	0.005		
			Weather	0.1	0.03	0.003				Weather	0.05	0.1	0.005		
5	**Floor Construction**	**Optimistic**	material	0.3	0.2	0.06	386212	8	**Pessimistic**	material	0.35	0.3	0.105	635050	13
			operator	0.25	0.15	0.0375				operator	0.2	0.15	0.03		
			management	0.4	0.25	0.1				management	0.4	0.45	0.18		
			Weather	0.05	0.025	0.00125				Weather	0.05	0.05	0.0025		
6	**Roof Construction**	**Optimistic**	material	0.25	0.1	0.025	76224	11	**Pessimistic**	material	0.3	0.2	0.06	111898	15
			operator	0.25	0.15	0.0375				operator	0.25	0.35	0.0875		
			management	0.35	0.2	0.07				management	0.35	0.3	0.105		
			Weather	0.15	0.05	0.0075				Weather	0.1	0.1	0.01		
7	**Exterior Walls**	**Optimistic**	material	0.35	0.15	0.0525	564782	21	**Pessimistic**	material	0.3	0.2	0.06	809492	30
			operator	0.25	0.1	0.025				operator	0.2	0.15	0.03		
			management	0.35	0.25	0.0875				management	0.4	0.25	0.1		
			Weather	0.05	0.025	0.00125				Weather	0.1	0.05	0.005		

Perimeter and Area | Range of Cost | crew | Daily output | cost | Sheet1 | sheet2 | Crystale ball | Sheet3

Figure 5.4 Stochastic Method for Estimating the Project Cost and Duration

5.5- Forecasting the project Cost by Using the Simulation:

This step starts by entering the three calculated cost values in Monte Carlo Simulation in an attempt to simulate the project cost. This simulation provides the range of the cost of the project obtained from the model. By running the simulation we find that the range of costs is between $ 5,268,395.76 and $ 6,166,062.19. As a result, the cost generated by the model which is $ 5,649,925.79 is within the range and the percentage of certainty is 29.06 % as shown in figure 5.5. Moreover, the simulation generates a statistical output for the cost as illustrated in table 5.2.

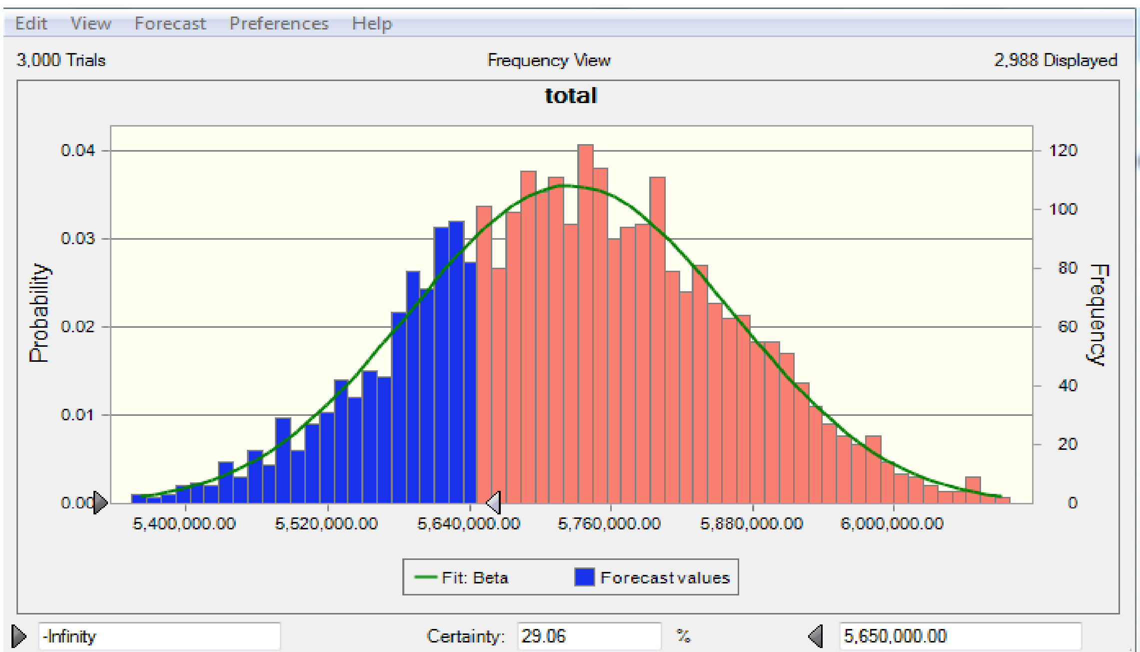


Figure 5.5 Forecasted Cost

Table 5.2 Statistical Output Cost Report

Statistic	Forecasted Values
Trials	3,000
Base Case	0.00
Mean	5,725,862.37
Median	5,724,690.60
Mode	---
Standard Deviation	132,654.52
Variance	17,597,222,156.67
Skewness	0.0040
Kurtosis	2.89
Coeff. of Variability	0.0232
Minimum	5,268,395.76
Maximum	6,166,062.19
Mean Std. Error	2421.93

5.6- Forecasting the Project Duration by Using the Simulation:

This part is similar to the previous one except it focuses on the duration. First we start by entering the three calculated values of the duration in the simulation, which simulates the project duration to acquire its range. After running the simulation, the duration range is between 365 days and 410 days. Based on this result, the duration acquired from the model, which was 382 days, falls within the range and with a percentage of certainty of 16.28 % as shown in figure 5.6. On the other hand, the generated statistical output for the duration of the project is illustrated in table 5.3.

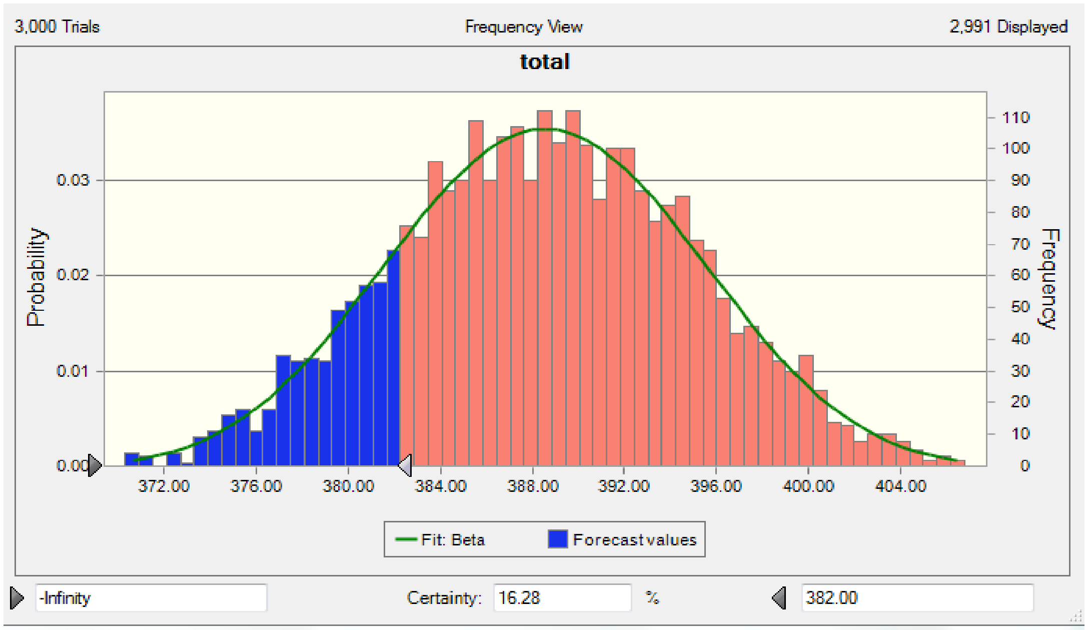


Figure 5.6 Forecasted Duration

Table 5.3 Statistical Output Duration Report

Statistic	Forecasted Values
Trials	3,000
Base Case	0.00
Mean	388.54
Median	388.58
Mode	---
Standard Deviation	6.51
Variance	42.42
Skewness	-0.0016
Kurtosis	2.76
Coeff. of Variability	0.0168
Minimum	364.89
Maximum	409.88
Mean Std. Error	0.12

The model's results are dependable and provide acceptable accuracy especially when applied at the project's conceptual stage where 0% to 2% information is known. Owners and investors are provided with a vital tool based on budget and time constraints that can be used at the project's conceptual stage when evaluating the feasibility of investing in its construction.

5.7- Summary:

This chapter validated the performance of the model by estimating the cost and duration of an actual project. This performance is measured by comparing the model's results with the actual project values. The actual project was a three stories office building built in 2007 in Kalamazoo, Michigan. The comparison between both the actual and model's construction cost and duration showed closed values with a small difference. The estimate was calculated by using both the deterministic and stochastic approaches. In the deterministic approach the generated cost and duration results were close to the real values, which are acceptable because at the conceptual stage there is not enough information known about the project. The stochastic approach was used to check if the deterministic values of the cost and duration are within the range or not. This was achieved by loading the cost and duration stochastic values in the Monte Carlo simulation. The cost and duration values generated by the model were in the range, which proves the feasibility and reliability of the developed model.

Chapter Six

Conclusion and Recommendations

6.1- Conclusion:

This thesis described the steps followed in developing an integrated model used to estimate the construction cost and duration of building projects at the feasibility stage of their expected life cycle. These steps were implemented based on two well known approaches, deterministic and stochastic which are used in calculating the cost and duration of construction projects. These approaches rely on historical data of previous projects, estimators' experiences and estimation methods are used during the feasibility study of a proposed project. On the other hand, the benefits of using two approaches during the estimating process is to provide more accurate information to owners and investors about the cost and duration of the project and to help them make vital decisions.

The developed model has the following advantages:

1. Its data relies on 2011 RSMeans publications where information from up to 4,000 projects was collected.
2. It has the ability to produce deterministic and stochastic estimates at the building project's conceptual stage.
3. It is easy, user friendly, flexible and executes quick calculations.
4. It generates professional output reports in a quick and efficient way.

6.2- Research Contributions:

Research contributions include the following:

1. An integrated model has been developed in which two approaches were combined to estimate the cost and duration at the feasibility stage of the project.
2. A workable database system has been designed and implemented using the windows environment, in which different Microsoft products (MS Excel and MS Project) were utilized and linked with Monte Carlo simulation to forecast the range of the cost and duration of the proposed project.

The intention of developing this model is to help owners, investors, and engineers generate an idea about the desired budget and the time needed to complete the proposed project before the actual designs are prepared. The model provides users with the option to select any type of building project similar to the proposed one from the detailed list that was entered in the model; and to implement all necessary adjustments in an easy and efficient way, by changing the elements values associated with the project. On the other hand, this model is easy to use, it is flexible and it executes necessary calculations in a quick and accurate way.

6.3- Limitation of the Developed model:

The model, based on R.S.Means publications, can be used for estimating the cost and duration at the conceptual stage for commercial, industrial, institutional and residential buildings. General contractors cannot use this model to prepare cost estimate of any project for bidding purposes. Moreover, the model does not execute any adjustment for differences in perimeter, floor to floor height and time difference.

6.4- Recommendations for Future Expansion:

Despite the ability of the developed model to generate conceptual estimates for the cost and duration of the proposed building projects, the model can be enhanced by adding the following features:

1. Include more equations to adjust the values that are not entered in the model such as, floor to floor height, perimeter and time.
2. Incorporate the sensitivity analysis method to determine the crucial activities that have high influence on the cost and duration of the project.
3. Integrate the model with 3D modeling by using the Building Information Modeling concepts.
4. Incorporate the model with 4D and 5D modeling for clash detection and cost control.

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Appendix A

Some Functions Used in the Model

1. VLOOKUP (C4, allprojects, 22, 0).

This function is used to find specific information in large data tables.

2. IF(H4<=1,0.097*(H4)^2-(H4*0.345)+1.248,IF(H4>=1,-0.07*LN(H4)+0.997)).

If function allows users to merge more than two equations together.

3. CEILING(((N12*'Daily output'!L2)/crew!F1538),1).

It is used to round numbers up to the nearest values.

4. cost!N17.

This function is used to link data from different sheets in Excel.

5. Data Validation, group function and filter function as shown in figure 1.

Data Validation is used to make the collected data as drop down list.

Group Function is used to hide and unhide some activities of the project.

Filter is used to provide non repeated data.

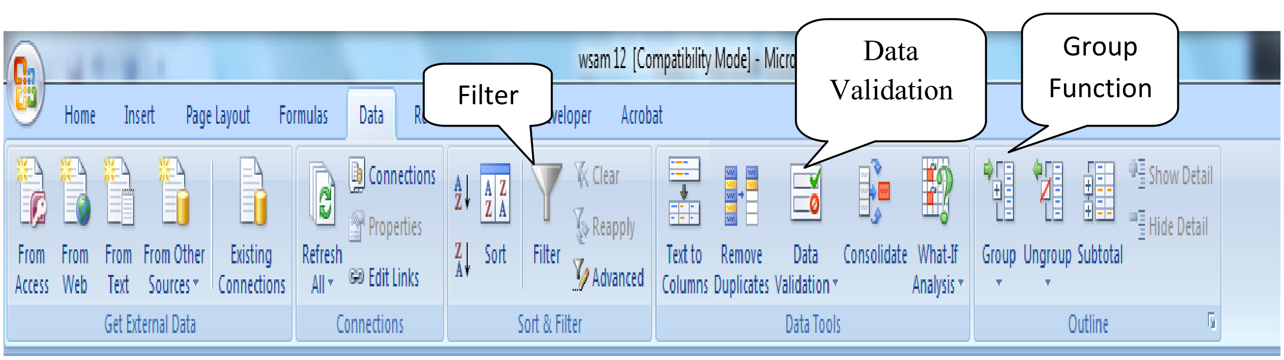


Figure 1

Appendix B

Sample of Database

Join	ProjectNumber	TypeNumber	ProjectType	ProjectName	ProjectExteriorWallType	ProjectStructureSystem	ProjectSize
COMA1001-Apartment, 1-3 Story	COMA1001	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	8,000.00
COMA1002-Apartment, 1-3 Story	COMA1002	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	12,000.00
COMA1003-Apartment, 1-3 Story	COMA1003	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	15,000.00
COMA1004-Apartment, 1-3 Story	COMA1004	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	19,000.00
COMA1005-Apartment, 1-3 Story	COMA1005	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	22,500.00
COMA1006-Apartment, 1-3 Story	COMA1006	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	25,000.00
COMA1007-Apartment, 1-3 Story	COMA1007	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	29,000.00
COMA1008-Apartment, 1-3 Story	COMA1008	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	32,000.00
COMA1009-Apartment, 1-3 Story	COMA1009	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Wood Joists	36,000.00
COMA1010-Apartment, 1-3 Story	COMA1010	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	8,000.00
COMA1011-Apartment, 1-3 Story	COMA1011	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	12,000.00
COMA1012-Apartment, 1-3 Story	COMA1012	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	15,000.00
COMA1013-Apartment, 1-3 Story	COMA1013	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	19,000.00
COMA1014-Apartment, 1-3 Story	COMA1014	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	22,500.00
COMA1015-Apartment, 1-3 Story	COMA1015	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	25,000.00
COMA1016-Apartment, 1-3 Story	COMA1016	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	29,000.00
COMA1017-Apartment, 1-3 Story	COMA1017	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	32,000.00
COMA1018-Apartment, 1-3 Story	COMA1018	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Face Brick with Concrete Block Back-up	Steel Joists	36,000.00
COMA1019-Apartment, 1-3 Story	COMA1019	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Stucco on Concrete Block	Wood Joists	8,000.00
COMA1020-Apartment, 1-3 Story	COMA1020	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Stucco on Concrete Block	Wood Joists	12,000.00
COMA1021-Apartment, 1-3 Story	COMA1021	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Stucco on Concrete Block	Wood Joists	15,000.00
COMA1022-Apartment, 1-3 Story	COMA1022	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Stucco on Concrete Block	Wood Joists	19,000.00
COMA1023-Apartment, 1-3 Story	COMA1023	COMA0001	COMMERCIAL	Apartment, 1-3 Story	Stucco on Concrete Block	Wood Joists	22,500.00

ProjectExteriorWallTypeNumber	ProjectStructureSystemNumber	ProjectPerimeter	PerimeterAdjustmentFactorPer100Lft	StoryHeightAdjustemntPer1ft	BasementAdjustmentPer1sqtf	ProjectFloorsNumber
1.00	1.00	213.00	$20.60	$3.85	$33.80	3.00
1.00	1.00	280.00	$13.75	$3.45	$33.80	3.00
1.00	1.00	330.00	$11.00	$3.25	$33.80	3.00
1.00	1.00	350.00	$8.70	$2.70	$33.80	3.00
1.00	1.00	400.00	$7.30	$2.60	$33.80	3.00
1.00	1.00	433.00	$6.65	$2.60	$33.80	3.00
1.00	1.00	442.00	$5.70	$2.25	$33.80	3.00
1.00	1.00	480.00	$5.20	$2.25	$33.80	3.00
1.00	1.00	520.00	$4.50	$2.10	$33.80	3.00
1.00	2.00	213.00	$20.60	$3.85	$33.80	3.00
1.00	2.00	280.00	$13.75	$3.45	$33.80	3.00
1.00	2.00	330.00	$11.00	$3.25	$33.80	3.00
1.00	2.00	350.00	$8.70	$2.70	$33.80	3.00
1.00	2.00	400.00	$7.30	$2.60	$33.80	3.00
1.00	2.00	433.00	$6.65	$2.60	$33.80	3.00
1.00	2.00	442.00	$5.70	$2.25	$33.80	3.00
1.00	2.00	480.00	$5.20	$2.25	$33.80	3.00
1.00	2.00	520.00	$4.50	$2.10	$33.80	3.00
2.00	1.00	213.00	$20.60	$3.85	$33.80	3.00
2.00	1.00	280.00	$13.75	$3.45	$33.80	3.00
2.00	1.00	330.00	$11.00	$3.25	$33.80	3.00
2.00	1.00	350.00	$8.70	$2.70	$33.80	3.00
2.00	1.00	400.00	$7.30	$2.60	$33.80	3.00

ProjectHeight	ProjectSqftCost	ProjectTotalSqFtCost	SubstructureDiv1Percentage	A1010	SubDiv1Elm1Name	SubDiv1Elm1Description	SubDiv1Elm1Unit	SubDiv1Elm1UnitCost
10	$132.85	$179.35	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$126.04	$170.15	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$123.30	$166.45	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$118.00	$159.30	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$116.67	$157.50	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$115.74	$156.25	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$112.89	$152.40	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$112.33	$151.65	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$111.48	$150.50	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$133.48	$180.20	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$127.52	$172.15	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$125.15	$168.95	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$120.70	$162.95	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$119.52	$161.35	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$118.74	$160.30	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$116.44	$157.20	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$115.96	$156.55	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$115.19	$155.50	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$116.78	$157.65	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$111.41	$150.40	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$109.30	$147.55	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$105.59	$142.55	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97
10	$104.56	$141.15	4.30%	1.99	Standard Foundations	Poured concrete; strip and spread footings	S.F. Ground	$5.97

A1030	SubDiv1Elm2Name	SubDiv1Elm2Description	SubDiv1Elm2Unit	SubDiv1Elm2UnitCost	SubDiv1Elm2SFCost	A2010	SubDiv1Elm3Name	SubDiv1Elm3Description
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.83	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.74	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.70	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.63	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.61	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.60	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.56	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.55	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.54	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.84	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.76	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.73	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.67	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.65	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.64	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.61	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.60	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.59	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.61	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.54	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.51	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.46	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.44	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.43	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.41	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing
1.65	Slab on Grade	4" Reinforced Concrete with vapor barrier and granular base	S.F. Slab	$4.96	$1.40	0.06	Basement Excavation	Site preparation for slab and trench for foundation wall and footing

SubDiv1Elm3Unit	SubDiv1Elm3UnitCost	SubDiv1Elm3SFCost	A2020	SubDiv1Elm4Name	SubDiv1Elm4Description	SubDiv1Elm4Unit	SubDiv1Elm4UnitCost	SubDiv1Elm4SFCost	ShellDiv1Percentage	B1010	ShellDiv1Elm1Name
S.F. Ground	$0.17	$0.07	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.65	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.56	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.53	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.46	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.44	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.43	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.40	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.39	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.38	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.07	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.65	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.58	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.55	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.49	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.48	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.47	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.44	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.44	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.43	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.45	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.06	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.38	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.05	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.35	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.05	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.31	12.60%	12.19	Floor Construction
S.F. Ground	$0.17	$0.05	1.48	Basement Walls	4' foundation wall	L.F. Wall	$72.00	$1.29	12.60%	12.19	Floor Construction

ShellDiv1Elm1Description	ShellDiv1Elm1Unit	ShellDiv1Elm1UnitCost	ShellDiv1Elm1SFCost	B1020	ShellDiv1Elm2Name	ShellDiv1Elm2Description	ShellDiv1Elm2Unit
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$13.55	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.85	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.57	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.03	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.90	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.80	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.51	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.46	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.37	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$13.61	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$13.00	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.76	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.31	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.19	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$12.11	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.88	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.83	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.75	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.91	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.36	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$11.15	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$10.77	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$10.66	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$10.60	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$10.39	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof
Open web steel joists, slab form, concrete, interior steel columns	S.F. Floor	$18.29	$10.35	2.88	Roof Construction	Open web steel joists with rib metal deck, interior steel columns	S.F. Roof

ShellDiv1Elm2Unit	ShellDiv1Elm2UnitCost	ShellDiv1Elm2SFCost	ShellDiv2Percentage	B2010	ShellDiv2Elm1Name	ShellDiv2Elm1Description	ShellDiv2Elm1Unit	ShellDiv2Elm1UnitCost	ShellDiv2Elm1SFCost
S.F. Roof	$8.64	$3.20	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$11.82
S.F. Roof	$8.64	$3.04	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$11.22
S.F. Roof	$8.64	$2.97	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.97
S.F. Roof	$8.64	$2.84	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.50
S.F. Roof	$8.64	$2.81	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.38
S.F. Roof	$8.64	$2.79	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.30
S.F. Roof	$8.64	$2.72	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.05
S.F. Roof	$8.64	$2.71	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.00
S.F. Roof	$8.64	$2.69	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.92
S.F. Roof	$8.64	$3.22	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$11.88
S.F. Roof	$8.64	$3.07	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$11.35
S.F. Roof	$8.64	$3.01	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$11.14
S.F. Roof	$8.64	$2.91	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.74
S.F. Roof	$8.64	$2.88	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.64
S.F. Roof	$8.64	$2.86	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.57
S.F. Roof	$8.64	$2.81	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.36
S.F. Roof	$8.64	$2.79	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.32
S.F. Roof	$8.64	$2.77	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.25
S.F. Roof	$8.64	$2.81	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$10.39
S.F. Roof	$8.64	$2.68	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.91
S.F. Roof	$8.64	$2.63	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.73
S.F. Roof	$8.64	$2.54	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.40
S.F. Roof	$8.64	$2.52	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.30
S.F. Roof	$8.64	$2.50	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.25
S.F. Roof	$8.64	$2.46	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.07
S.F. Roof	$8.64	$2.44	11.00%	10.63	Exterior Walls	Face brick with concrete block backup. 88% of wall	S.F. Wall	$22.65	$9.03

B2020	ShellDiv2Elm2Name	ShellDiv2Elm2Description	ShellDiv2Elm2Unit	ShellDiv2Elm2UnitCost	ShellDiv2Elm2SFCost	B2030	ShellDiv2Elm3Name	ShellDiv2Elm3Description
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.38	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.26	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.21	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.11	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.09	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.07	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.02	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.01	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.00	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.39	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.28	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.24	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.16	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.14	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.13	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.09	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.08	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.06	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.09	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$2.00	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$1.96	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$1.89	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$1.87	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$1.86	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$1.83	0.35	Exterior Doors	Aluminum and glass
2.14	Exterior Windows	Aluminum horizontal sliding, 12% of wall	Each	$502.00	$1.82	0.35	Exterior Doors	Aluminum and glass

ShellDiv2Elm3Unit	ShellDiv2Elm3UnitCost	ShellDiv2Elm3SFCost	ShellDiv3Percentage	B3010	ShellDiv3Elm1Name	ShellDiv3Elm1Description	ShellDiv3Elm1Unit
Each	$1,965.00	$0.39	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.37	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.36	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.35	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.34	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.34	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.33	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.33	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.33	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.39	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.37	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.37	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.35	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.35	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.35	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.34	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.34	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.34	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.34	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.33	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.32	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.31	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof
Each	$1,965.00	$0.31	1.70%	1.99	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation	S.F. Roof

ShellDiv3Elm1UnitCost	ShellDiv3Elm1SFCost	B3020	ShellDiv3Elm2Name	ShellDiv3Elm2Description	ShellDiv3Elm2Unit	ShellDiv3Elm2UnitCost	ShellDiv3Elm2SFCost	InterDiv1Percentage	C1010	InterDiv1Elm1Name
$5.97	$2.21	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$2.10	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$2.05	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.96	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.94	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.93	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.88	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.87	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.86	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$2.22	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$2.12	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$2.08	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$2.01	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.99	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.98	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.94	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.93	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.92	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.94	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.85	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.82	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.76	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions
$5.97	$1.74	0.00	Roof Openings	N/A	-	$0.00	$0.00	24.10%	5.58	Partitions

InterDiv1Elm1Description	InterDiv1Elm1Unit	InterDiv1Elm1UnitCost	InterDiv1Elm1SFCost	C1020	InterDiv1Elm2Name	InterDiv1Elm2Description
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$6.20	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.88	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.75	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.51	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.44	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.40	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.27	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.24	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.20	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$6.23	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.95	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.84	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.63	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.58	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.54	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.43	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.41	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.37	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.45	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.20	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$5.10	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$4.93	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$4.88	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$4.85	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$4.76	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door
Gypsum board and sound deadening board on metal studs; 10 S.F. of Floor/L.F Partition	S.F. Partition	$6.28	$4.73	6.57	Interior Doors	15% solid core wood, 85% hollow core wood; 80 S.F. Floor/Door

InterDiv1Elm2Unit	InterDiv1Elm2UnitCost	InterDiv1Elm2SFCost	C1030	InterDiv1Elm3Name	InterDiv1Elm3Description	InterDiv1Elm3Unit	InterDiv1Elm3UnitCost	InterDiv1Elm3SFCost	C2010
Each	$526.00	$7.30	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$3.14	2.78
Each	$526.00	$6.93	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.98	2.78
Each	$526.00	$6.77	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.91	2.78
Each	$526.00	$6.48	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.79	2.78
Each	$526.00	$6.41	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.76	2.78
Each	$526.00	$6.36	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.73	2.78
Each	$526.00	$6.20	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.67	2.78
Each	$526.00	$6.17	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.65	2.78
Each	$526.00	$6.13	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.63	2.78
Each	$526.00	$7.33	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$3.15	2.78
Each	$526.00	$7.01	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$3.01	2.78
Each	$526.00	$6.88	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.96	2.78
Each	$526.00	$6.63	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.85	2.78
Each	$526.00	$6.57	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.82	2.78
Each	$526.00	$6.52	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.80	2.78
Each	$526.00	$6.40	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.75	2.78
Each	$526.00	$6.37	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.74	2.78
Each	$526.00	$6.33	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.72	2.78
Each	$526.00	$6.42	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.76	2.78
Each	$526.00	$6.12	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.63	2.78
Each	$526.00	$6.01	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.58	2.78
Each	$526.00	$5.80	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.49	2.78
Each	$526.00	$5.75	2.84	Fittings	Kitchen Cabinets	S.F. Floor	$2.84	$2.47	2.78

InterDiv1Elm4Name	InterDiv1Elm4Description	InterDiv1Elm4Unit	InterDiv1Elm4UnitCost	InterDiv1Elm4SFCost	C3010	InterDiv1Elm5Name	InterDiv1Elm5Description	InterDiv1Elm5Unit
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$3.07	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.92	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.85	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.73	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.70	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.68	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.61	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.60	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.58	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$3.09	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.95	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.90	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.79	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.77	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.75	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.69	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.68	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.66	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.70	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.58	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.53	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.44	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface
Stair Construction	Concrete filled metal pan	Flight	$12,525.00	$2.42	2.36	Wall Finishes	70% paint, 25% vinyl wall covering, 5% ceramic tile	S.F. Surface

InterDiv1Elm5UnitCost	InterDiv1Elm5SFCost	C3020	InterDiv1Elm6Name	InterDiv1Elm6Description	InterDiv1Elm6Unit	InterDiv1Elm6UnitCost	InterDiv1Elm6SFCost	C3030	InterDiv1Elm7Nam
$1.33	$2.62	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.70	3.54	Ceiling Finishes
$1.33	$2.49	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.41	3.54	Ceiling Finishes
$1.33	$2.43	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.29	3.54	Ceiling Finishes
$1.33	$2.33	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.06	3.54	Ceiling Finishes
$1.33	$2.30	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.00	3.54	Ceiling Finishes
$1.33	$2.28	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.97	3.54	Ceiling Finishes
$1.33	$2.23	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.84	3.54	Ceiling Finishes
$1.33	$2.22	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.82	3.54	Ceiling Finishes
$1.33	$2.20	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.78	3.54	Ceiling Finishes
$1.33	$2.63	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.73	3.54	Ceiling Finishes
$1.33	$2.52	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.47	3.54	Ceiling Finishes
$1.33	$2.47	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.37	3.54	Ceiling Finishes
$1.33	$2.38	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.18	3.54	Ceiling Finishes
$1.33	$2.36	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.13	3.54	Ceiling Finishes
$1.33	$2.34	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.09	3.54	Ceiling Finishes
$1.33	$2.30	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.00	3.54	Ceiling Finishes
$1.33	$2.29	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.97	3.54	Ceiling Finishes
$1.33	$2.27	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.94	3.54	Ceiling Finishes
$1.33	$2.30	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$5.01	3.54	Ceiling Finishes
$1.33	$2.20	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.78	3.54	Ceiling Finishes
$1.33	$2.16	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.69	3.54	Ceiling Finishes
$1.33	$2.08	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.53	3.54	Ceiling Finishes
$1.33	$2.06	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.49	3.54	Ceiling Finishes
$1.33	$2.05	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.46	3.54	Ceiling Finishes
$1.33	$2.01	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.37	3.54	Ceiling Finishes
$1.33	$2.00	5.13	Floor Finishes	60% carpet, 30% vinyl composition tile, 10% ceramic tile	S.F. Floor	$5.13	$4.35	3.54	Ceiling Finishes

InterDiv1Elm7Description	InterDiv1Elm7Unit	InterDiv1Elm7UnitCost	InterDiv1Elm7SFCost	ServDiv1Percentage	D1010	ServDiv1Elm1Name	ServDiv1Elm1Description
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.93	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.73	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.65	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.49	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.45	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.43	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.34	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.32	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.30	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.95	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.77	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.70	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.57	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.54	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.51	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.45	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.43	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.41	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.46	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.30	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.23	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.12	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.09	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.07	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.02	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator
Painted gypsum board on resilient channels	S.F. Ceiling	$3.54	$3.00	3.80%	4.57	Elevators & Lifts	One hydraulic passenger elevator

ServDiv1Elm1Unit	ServDiv1Elm1UnitCost	ServDiv1Elm1SFCost	D1020	ServDiv1Elm2Name	ServDiv1Elm2Description	ServDiv1Elm2Unit	ServDiv1Elm2UnitCost	ServDiv1Elm2SFCost	ServDiv2Percentage	D2010
Each	$102,825.00	$5.05	0.00	Escalators & Moving Walks	N/A	-	$0.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.79	0.00	Escalators & Moving Walks	N/A	-	$1.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.69	0.00	Escalators & Moving Walks	N/A	-	$2.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.48	0.00	Escalators & Moving Walks	N/A	-	$3.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.43	0.00	Escalators & Moving Walks	N/A	-	$4.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.40	0.00	Escalators & Moving Walks	N/A	-	$5.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.29	0.00	Escalators & Moving Walks	N/A	-	$6.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.27	0.00	Escalators & Moving Walks	N/A	-	$7.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.24	0.00	Escalators & Moving Walks	N/A	-	$8.00	$0.00	15.80%	13.99
Each	$102,825.00	$5.07	0.00	Escalators & Moving Walks	N/A	-	$9.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.85	0.00	Escalators & Moving Walks	N/A	-	$10.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.76	0.00	Escalators & Moving Walks	N/A	-	$11.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.59	0.00	Escalators & Moving Walks	N/A	-	$12.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.54	0.00	Escalators & Moving Walks	N/A	-	$13.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.51	0.00	Escalators & Moving Walks	N/A	-	$14.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.42	0.00	Escalators & Moving Walks	N/A	-	$15.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.41	0.00	Escalators & Moving Walks	N/A	-	$16.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.38	0.00	Escalators & Moving Walks	N/A	-	$17.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.44	0.00	Escalators & Moving Walks	N/A	-	$18.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.23	0.00	Escalators & Moving Walks	N/A	-	$19.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.15	0.00	Escalators & Moving Walks	N/A	-	$20.00	$0.00	15.80%	13.99
Each	$102,825.00	$4.01	0.00	Escalators & Moving Walks	N/A	-	$21.00	$0.00	15.80%	13.99
Each	$102,825.00	$3.97	0.00	Escalators & Moving Walks	N/A	-	$22.00	$0.00	15.80%	13.99

ServDiv2Elm1Name	ServDiv2Elm1Description	ServDiv2Elm1Unit	ServDiv2Elm1UnitCost	ServDiv2Elm1SFCost	D2020	ServDiv2Elm2Name	ServDiv2Elm2Description	ServDiv2Elm2Unit
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$15.55	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$14.75	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$14.43	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.81	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.65	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.55	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.21	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.15	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.05	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$15.62	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$14.92	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$14.65	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$14.13	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.99	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.90	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.63	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.57	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.48	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.67	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$13.04	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$12.79	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$12.36	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$12.24	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$12.16	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$11.93	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor
Plumbing Fixtures	Kitchen, bathroom & service fixtures, supply&drainage; 1Fixture/200sft	Each	$2,798.00	$11.88	4.41	Domestic Water Distribution	Gas fired water heater	S.F. Floor

ServDiv2Elm2Unit	ServDiv2Elm2UnitCost	ServDiv2Elm2SFCost	D2040	ServDiv2Elm3Name	ServDiv2Elm3Description	ServDiv2Elm3Unit	ServDiv2Elm3UnitCost	ServDiv2Elm3SFCost	ServDiv3Percentage	D3010
S.F. Floor	$4.41	$4.90	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.51	14.60%	8.46
S.F. Floor	$4.41	$4.65	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.48	14.60%	8.46
S.F. Floor	$4.41	$4.55	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.47	14.60%	8.46
S.F. Floor	$4.41	$4.35	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.45	14.60%	8.46
S.F. Floor	$4.41	$4.30	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.45	14.60%	8.46
S.F. Floor	$4.41	$4.27	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.44	14.60%	8.46
S.F. Floor	$4.41	$4.16	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.43	14.60%	8.46
S.F. Floor	$4.41	$4.14	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.43	14.60%	8.46
S.F. Floor	$4.41	$4.11	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.43	14.60%	8.46
S.F. Floor	$4.41	$4.92	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.51	14.60%	8.46
S.F. Floor	$4.41	$4.70	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.49	14.60%	8.46
S.F. Floor	$4.41	$4.62	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.48	14.60%	8.46
S.F. Floor	$4.41	$4.45	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.46	14.60%	8.46
S.F. Floor	$4.41	$4.41	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.46	14.60%	8.46
S.F. Floor	$4.41	$4.38	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.46	14.60%	8.46
S.F. Floor	$4.41	$4.29	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.45	14.60%	8.46
S.F. Floor	$4.41	$4.28	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.45	14.60%	8.46
S.F. Floor	$4.41	$4.25	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.44	14.60%	8.46
S.F. Floor	$4.41	$4.31	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.45	14.60%	8.46
S.F. Floor	$4.41	$4.11	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.43	14.60%	8.46
S.F. Floor	$4.41	$4.03	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.42	14.60%	8.46
S.F. Floor	$4.41	$3.89	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.41	14.60%	8.46
S.F. Floor	$4.41	$3.86	0.46	Rain Water Drainage	Roof drains	S.F. Roof	$1.38	$0.40	14.60%	8.46

ServDiv3Percentage	D3010	ServDiv3Elm1Name	ServDiv3Elm1Description	ServDiv3Elm1Unit	ServDiv3Elm1UnitCost	ServDiv3Elm1SFCost	D3020	ServDiv3Elm2Name	ServDiv3Elm2Description
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$9.40	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.92	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.73	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.35	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.26	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.19	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.99	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.95	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.89	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$9.45	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$9.02	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.86	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.54	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.46	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.40	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.24	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.21	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.15	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$8.26	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.88	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.73	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.47	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.40	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.35	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.21	0.00	Heat Generating Systems	N/A
14.60%	8.46	Energy Supply	Oil fired hot water, baseboard radiation	S.F. Floor	$8.46	$7.18	0.00	Heat Generating Systems	N/A

ServDiv3Elm2Unit	ServDiv3Elm2UnitCost	ServDiv3Elm2SFCost	D3030	ServDiv3Elm3Name	ServDiv3Elm3Description	ServDiv3Elm3Unit	ServDiv3Elm3UnitCost	ServDiv3Elm3SFCost	D3050	ServDiv3Elm4Name
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.95	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.44	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.23	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.83	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.73	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.67	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.45	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.41	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.35	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.99	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.55	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.37	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$9.04	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.95	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.89	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.72	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.68	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.62	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.74	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.34	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$8.18	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$7.91	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$7.83	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$7.78	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$7.63	0.00	Terminal & Package Units
-	$0.00	$0.00	8.95	Cooling Generating Systems	Chilled water, air cooled condenser system	S.F. Floor	$8.95	$7.60	0.00	Terminal & Package Units

ServDiv3Elm4Description	ServDiv3Elm4Unit	ServDiv3Elm4UnitCost	ServDiv3Elm4SFCost	D3090	ServDiv3Elm5Name	ServDiv3Elm5Description
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A
N/A	-	$0.00	$0.00	0.00	Other HVAC Sys. & Equipment	N/A

ServDiv3Elm5Unit	ServDiv3Elm5UnitCost	ServDiv3Elm5SFCost	ServDiv4Percentage	D4010	ServDiv4Elm1Name	ServDiv4Elm1Description	ServDiv4Elm1Unit	ServDiv4Elm1UnitCost
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28
-	$0.00	$0.00	2.70%	3.28	Sprinklers	Wet pipe sprinkler system	S.F. Floor	$3.28

ServDiv4Elm1SFCost	D4020	ServDiv4Elm2Name	ServDiv4Elm2Description	ServDiv4Elm2Unit	ServDiv4Elm2UnitCost	ServDiv4Elm2SFCost	ServDiv5Percentage	D5010	ServDiv5Elm1Name
$3.59	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.40	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.33	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.19	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.15	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.13	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.05	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.03	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.01	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.60	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.44	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.38	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.26	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.23	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.21	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.14	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.13	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.11	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.15	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$3.01	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$2.95	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$2.85	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution
$2.82	0.00	Standpipes	N/A	-	$0.00	$0.00	9.40%	2.56	Electrical Service/Distribution

ServDiv5Elm1Description	ServDiv5Elm1Unit	ServDiv5Elm1UnitCost	ServDiv5Elm1SFCost	D5020	ServDiv5Elm2Name	ServDiv5Elm2Description
600 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.84	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
601 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.70	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
602 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.64	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
603 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.53	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
604 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.50	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
605 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.48	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
606 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.42	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
607 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.41	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
608 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.39	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
609 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.86	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
610 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.73	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
611 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.68	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
612 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.58	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
613 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.56	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
614 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.54	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
615 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.49	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
616 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.48	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
617 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.47	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
618 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.50	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
619 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.39	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
620 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.34	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
621 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.26	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
622 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.24	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
623 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.22	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
624 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.18	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power
625 ampere service, panel board and feeders	S.F. Floor	$2.56	$2.17	6.80	Lighting & Branch Wiring	Incandescent fixtures, recepracles, switches, A.C. and misc. power

ServDiv5Elm2Unit	ServDiv5Elm2UnitCost	ServDiv5Elm2SFCost	D5030	ServDiv5Elm3Name	ServDiv5Elm3Description	ServDiv5Elm3Unit	ServDiv5Elm3UnitCost
S.F. Floor	$6.80	$7.56	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$7.17	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$7.01	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.71	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.64	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.58	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.42	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.39	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.34	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$7.59	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$7.25	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$7.12	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.87	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.80	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.75	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.62	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.60	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.55	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.64	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.34	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.22	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$6.01	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$5.95	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$5.91	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$5.80	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69
S.F. Floor	$6.80	$5.77	1.69	Communications & Security	Alarm systems, internet wiring, and emergency lighting	S.F. Floor	$1.69

ServDiv5Elm3SFCost	D5090	ServDiv5Elm4Name	ServDiv5Elm4Description	ServDiv5Elm4Unit	ServDiv5Elm4UnitCost	ServDiv5Elm4SFCost
$1.88	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.23
$1.78	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.22
$1.74	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.22
$1.67	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.21
$1.65	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.64	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.59	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.59	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.58	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.19
$1.89	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.23
$1.80	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.22
$1.77	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.22
$1.71	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.21
$1.69	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.21
$1.68	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.21
$1.65	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.64	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.63	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.65	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.20
$1.57	0.21	Other Electrical Systems	Emergency Generator, 11.5KW	S.F. Floor	$0.21	$0.19

Appendix C

The Output Reports of the Model

1- Summary report of the project information:

Project Name	Office, 2-4 story	Project Perimeter	490
Project Type	Commercial	Floor Height	12
Project Wall Type	Face brick with concrete block back-up	Province Name & City Name	Ontario-(Ottawa)
Structural Framing Type	Wood joists	Commercial Factors	1.09
Published Project Size	50000	Residential Factors	1.15
Proposed Project Size	44151	Cost per S.F	$ 130.33
Adj. S.F cost	$ 117.40		

2- Report consists of cost and duration values of each division and the total cost and duration of the proposed project:

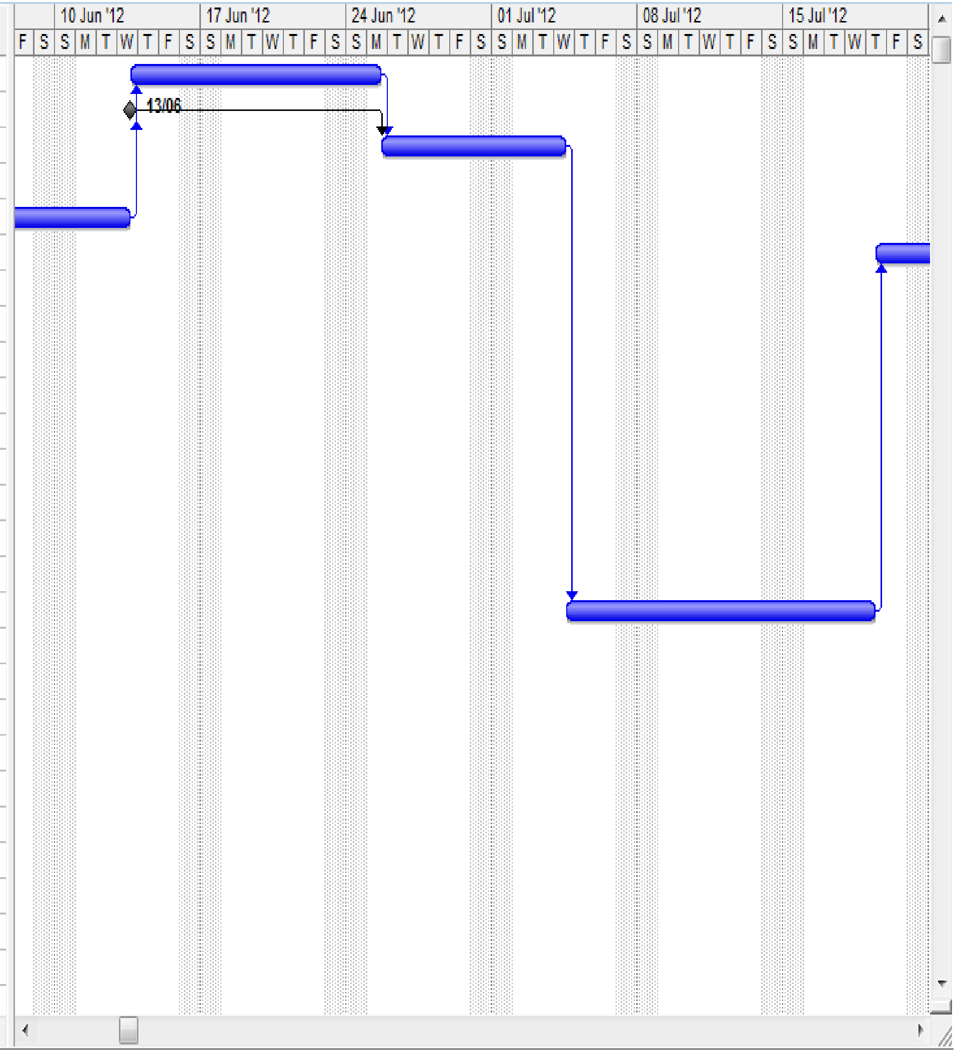
Deterministic Model for Cost & Duration				
Division	Percentage (%)		Cost	Duration
A- Substructure	4.40%	$	248,596.73	37
B- Shell - B10 Superstructure	10.10%	$	570,642.51	22
B- Shell - B20 Exterior Enclous	15.80%	$	892,688.28	48
B- Shell - B30 Roofing	1.70%	$	96,048.74	13
C- Interiors	23.20%	$	1,310,782.78	124
D- Services - D10 Conveying	8.80%	$	497,193.47	16
D- Services - D20 Plumbing	3.40%	$	192,097.48	13
D- Services - D30 HVAC	12.40%	$	700,590.80	16
D- Service - D40 Fire Protectio	3.30%	$	186,447.55	24
D- Service - D50 Electrical	16.90%	$	954,837.46	69
E- Equipment & Furnishings	0.00%	$	-	0
F- Special Construction	0.00%	$	-	0
Total		$	5,649,925.79	382

3- Detailed report which includes the cost and duration of each activity and division of the project and the total cost and duration of the proposed project.

Deterministic Model for Cost & Duration				
Division	Percentage (%)		Cost	Duration / Day
A- Substructure	4.40%	$	248,596.73	37
Standard Foundations		$	103,726.32	9
Special Foundations		$	-	0
Slab on Grade		$	72,221.83	7
Basement Excavation		$	2,610.73	1
Basement Walls		$	70,037.86	20
B- Shell - B10 Superstructure	10.10%	$	570,642.51	22
Floor Construction		$	482,010.68	10
Roof Construction		$	88,631.83	12
B- Shell - B20 Exterior Enclousr	15.80%	$	892,688.28	47
B- Shell - B30 Roofing	1.70%	$	96,048.74	13
C- Interiors	23.20%	$	1,310,782.78	124
D- Services - D10 Conveying	8.80%	$	497,193.47	16
D- Services - D20 Plumbing	3.40%	$	192,097.48	14
D- Services - D30 HVAC	12.40%	$	700,590.80	16
D- Service - D40 Fire Protection	3.30%	$	186,447.55	24
D- Service - D50 Electrical	16.90%	$	954,837.46	69
E- Equipment & Furnishings	0.00%	$	-	0
F- Special Construction	0.00%	$	-	0
Total		$	5,649,925.79	382

4- Detailed schedule of the project that shows the sequences of the project's activities.

	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	Standard Foundations	8.21 days	Wed 13/06/12	Mon 25/06/12	5	
2	Special Foundations	0 days	Wed 13/06/12	Wed 13/06/12	5	
3	Slab on Grade	6.58 days	Mon 25/06/12	Wed 04/07/12	1,2	
4	Basement Excavation	0.44 days	Thu 17/05/12	Thu 17/05/12		
5	Basement Walls	19.34 days	Thu 17/05/12	Wed 13/06/12	4	
6	Floor Construction	9.74 days	Thu 19/07/12	Thu 02/08/12	16	
7	Roof Construction	11.73 days	Thu 06/09/12	Fri 21/09/12	8	
8	Exterior Walls	25 days	Thu 02/08/12	Thu 06/09/12	6	
9	Exterior Windows	15.1 days	Mon 01/04/13	Mon 22/04/13	18	
10	Exterior Doors	6.89 days	Mon 01/04/13	Wed 10/04/13	18	
11	Roof Coverings	12.09 days	Thu 06/09/12	Mon 24/09/12	8	
12	Roof openings	0 days	Thu 06/09/12	Thu 06/09/12	8	
13	Partitions	22.8 days	Mon 26/11/12	Thu 27/12/12	25,26,27,28,29,3	
14	Interior Doors	18.4 days	Mon 01/04/13	Thu 25/04/13	18	
15	Fittings	2.4 days	Mon 01/04/13	Wed 03/04/13	18	
16	Stair Construction	10.88 days	Wed 04/07/12	Thu 19/07/12	3	
17	Wall Finishes	3.84 days	Thu 27/12/12	Wed 02/01/13	13	
18	Floor Finishes	19 days	Tue 05/03/13	Mon 01/04/13	19	
19	Ceiling Finishes	44.1 days	Wed 02/01/13	Tue 05/03/13	17	
20	Elevators & Lifts	15.53 days	Thu 25/04/13	Fri 17/05/13	9,10,14,15	
21	Escalators & Moving Walks	0 days	Thu 25/04/13	Thu 25/04/13	9,10,14,15	
22	Plumbing Fixtures	6.67 days	Mon 24/09/12	Tue 02/10/12	7,11,12	
23	Domestic Water Distributio	0.68 days	Mon 24/09/12	Mon 24/09/12	7,11,12	
24	Rain Water Drainage	5.09 days	Mon 24/09/12	Mon 01/10/12	7,11,12	
25	Energy Supply	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	
26	Heat Generating Systems	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	
27	Cooling Generating Systen	0 days	Wed 17/10/12	Wed 17/10/12	22,23,30,31	



5- Stochastic cost and duration report.

ID	Activity	Cost and Duration Type	Event Type	Probability	Variation	Weighted % Variation	Cost	Duration	Cost and Duration Type	Event Type	Probability	Variation	Weighted % Variation	Cost	Duration
1	**Standard Foundations**	**Optimistic**	site preparation	0.1	0.2	0.02	89594	8	**Pessimistic**	site preparation	0.05	0.2	0.01	138475	11
			Equipment	0.15	0.025	0.00375				Equipment	0.15	0.25	0.0375		
			operator	0.15	0.25	0.0375				operator	0.15	0.5	0.075		
			management	0.15	0.15	0.0225				management	0.15	0.2	0.03		
			size	0.05	0.05	0.0025				size	0.05	0.2	0.01		
			soil type	0.3	0.15	0.045				soil type	0.3	0.45	0.135		
			Weather	0.1	0.05	0.005				Weather	0.15	0.25	0.0375		
2	**Slab on grade**	**Optimistic**	material	0.3	0.15	0.045	62346	6	**Pessimistic**	material	0.35	0.5	0.175	104650	10
			operator	0.15	0.025	0.00375				operator	0.15	0.1	0.015		
			management	0.35	0.2	0.07				management	0.3	0.75	0.225		
			Equipment	0.025	0.02	0.0005				Equipment	0.05	0.08	0.004		
			Weather	0.175	0.1	0.0175				Weather	0.15	0.2	0.03		
3	**Basement Excavation**	**Optimistic**	Equipment	0.25	0.05	0.0125	2056	0.5	**Pessimistic**	Equipment	0.3	0.7	0.21	3708	2
			operator	0.2	0.2	0.04				operator	0.15	0.2	0.03		
			management	0.3	0.45	0.135				management	0.3	0.45	0.135		
			soil type	0.15	0.15	0.0225				soil type	0.2	0.2	0.04		
			size	0.05	0.025	0.00125				size	0.025	0.1	0.0025		
			Weather	0.05	0.025	0.00125				Weather	0.025	0.1	0.0025		
4	**Basement Walls**	**Optimistic**	Equipment	0.2	0.05	0.01	58552	17	**Pessimistic**	Equipment	0.2	0.15	0.03	92275	26
			operator	0.2	0.15	0.03				operator	0.25	0.35	0.0875		
			management	0.3	0.35	0.105				management	0.35	0.5	0.175		
			soil type	0.15	0.1	0.015				soil type	0.1	0.15	0.015		
			size	0.05	0.02	0.001				size	0.05	0.1	0.005		
			Weather	0.1	0.03	0.003				Weather	0.05	0.1	0.005		
5	**Floor Construction**	**Optimistic**	material	0.3	0.2	0.06	386212	8	**Pessimistic**	material	0.35	0.3	0.105	635050	13
			operator	0.25	0.15	0.0375				operator	0.2	0.15	0.03		
			management	0.4	0.25	0.1				management	0.4	0.45	0.18		
			Weather	0.05	0.025	0.00125				Weather	0.05	0.05	0.0025		
6	**Roof Construction**	**Optimistic**	material	0.25	0.1	0.025	76224	11	**Pessimistic**	material	0.3	0.2	0.06	111898	15
			operator	0.25	0.15	0.0375				operator	0.25	0.35	0.0875		
			management	0.35	0.2	0.07				management	0.35	0.3	0.105		
			Weather	0.15	0.05	0.0075				Weather	0.1	0.1	0.01		
7	**Exterior Walls**	**Optimistic**	material	0.35	0.15	0.0525	564782	21	**Pessimistic**	material	0.3	0.2	0.06	809492	30
			operator	0.25	0.1	0.025				operator	0.2	0.15	0.03		
			management	0.35	0.25	0.0875				management	0.4	0.25	0.1		
			Weather	0.05	0.025	0.00125				Weather	0.1	0.05	0.005		

Perimeter and Area | Range of Cost | crew | Daily output | cost | Sheet1 | sheet2 | Crystale ball | Sheet3