Concrete Casting Process Simulation of A Mat Foundation.

by

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MASTER OF ENGINEERING IN CIVIL ENGINEERING

Department of Civil Engineering
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

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The project titled "Concrete Casting Process Simulation Of A Mat Foundation", Submitted by A.K.M Ruhul Amin, Roll No. 100504307P, Session: October 2005 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering (Civil and Structure) on 00st September, 2008.

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CANDIDATE'S DECLARATION

It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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A.K.M Ruhul Amin

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Thanks to the Omnipotent God for his graciousness, kindness and blessings for allowing me to do this work without which nothing happens in this world.

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ABSTRACT

Simulation Programming system is now a new concept of visualization of a real world work in visual platform where nothing exists. As a result any alternative option could be set and simulate the program for observing the project conditions. Construction Simulation is now also use for project scheduling. Simulation is a virtual process where a physical project can be model through programming or graphical user interface system. There are different simulation program for project simulation and from that a resource based simulation program is selected for simulation mat casting process. Foundation work of construction is the first step to start the work and it is a difficult part due to some factors. The factors are soil, available working space, communication system, skilled worker and also the type of foundation. The Mat foundation construction is always difficult in urban area due to scarcity of land and other working space. As a result some delays are always added in this part of construction. The implementation of simulation presents one possibility to support the planning of construction work and thus secure the construction operation. Critical path method and project evaluation and review technique are the most common methods for the construction scheduling works. Using these two methods construction schedule is prepared. The objectives in scheduling the construction cycle are to ensure smooth flows of resources and to optimize the use of formwork and other materials. The construction area is usually divided into zones to allow the labour forces and formwork materials moving between zones. The preparation of the mat construction cycle would therefore be a resources allocation exercise. However, the process is complex and difficult when it is done manually. Simulation is a program that can demonstrate the real world operation in an effective tool in handling this schedule problem. Every simulation program has two ways to model the construction projects. One is to use built in function and other is to use coding system. It is difficult to change the simulation program which is using built in function for execution, also difficult to add any local problems in it. It is easy to add local problems in coding system simulation program, or making new simulation program with local problem by coding. Usine the state and resource based simulation of construction process (STROBOSCOPE) for making the mat construction process simulation.

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CHAPTER 1
INTRODUCTION

1.1 General

Construction processes ranges from very simple to very complex. Complex processes are difficult to analyze and optimize using standard mathematical methods. Simulation is an alternative method of analysis that offers numerous benefits. Construction simulation systems previously available could not be the model of typical construction processes with the necessary level of detail. General-purpose simulation systems, generally based on the process interaction strategy, cannot easily be the model of multiple resource requirements and dynamic complexity of construction processes.

STate and **R**es**O**urce **B**ased **S**imulation of **CO**nstruction **P**roc**E**sses (STROBSCOPE) is a general purpose simulation programming language specifically designed to model construction operations. Stroboscope models consist of a series of programming statements that define a network of inter connected modeling elements, give the elements unique behavior, and control the simulation. Stroboscope's ability to dynamically access the state of the simulation and the properties of the resources involved in and operation differentiate it from other construction simulation tools. The state of the simulation refers to such things as the number of trucks waiting to be loaded, the current simulation time, the number of times an activity has occurred, and the last time a particular activity started. Access to the properties of resources means that can be sensitive to resource properties such as size, weight, and cost on an individual or an aggregate basis.

1.2 Background and Present State of the Problem

Critical Path Method and Project Evaluation and Review Technique are commonly used to prepare the project scheduling work. But complex problem and dynamic resource based work cannot be simulated in this technique. High-rise buildings are still the essential form of building structure, constructed extensively in urban areas, in particular, in the heart of the commercial zones of metropolitan cities. On the other hand scarcity of land supply encourages the construction of high-rise buildings. Many high-rise buildings are constructed in the major city of Bangladesh over the last 20 years. Residential buildings up to 6 storied are very common in Dhaka city, which most commonly use individual column footing foundation. But in the high rise building like 9 to 30 stories residential cum commercial buildings, use mat foundation with basement floors is a necessity. Usually for Mat foundation work total land is excavated and there is shortage of workspace and material storage facilities in the beginning of site work. Under this circumstance mat-casting work is critical. This paper evaluates the scheduling of Mat construction using network based simulation techniques, a more practical and easily apprehensible approach, to improve decision making in site planning in response to the changing site conditions.

Many works have been done to encourage simulation usage in the construction industry. Halpin (1973) pioneered the effort by introducing CYCLONE modeling elements. These CYCLONE elements conceptually match the construction operation and thus significantly reduce the complexity involved in modeling construction processes. CYCLONE modeling combined with computer technology has been instrumental in triggering improvements in the study of construction operations. DISCO (Huang, 1994) extended the capabilities of CYCLONE by allowing the user to design CYCLONE models graphically and see the simulation results. STROBOSCOPE (Martinez, 1996) is an advanced simulation language that can dynamically assess the state of the simulation and the properties of the resources involved in an operation. This allows simulation professionals to build complex construction process simulation models with greater ease.

1.3 Objectives with Specific Aims and Possible Outcomes:

The objectives in scheduling the construction cycle are to ensure smooth flows of resources and to optimize the use of formwork and other materials. The construction area is usually divided into zones to allow the labor force and formwork materials moving between zones. The preparation of the Mat construction cycle would therefore be a resources allocation exercise. However, the process is complex and difficult when it is done manually. Floats are created deliberately in the schedule to ensure the balance in resources and to provide buffers. Simulation that can demonstrate the real world operations is an effective tool in handling this scheduling problem. This study examines the constraints in planning the Mat cycle and the effects of working period on the overall schedule. Network based model is used to investigate the problems. It is noted that variations in working periods have significant impacts on the time schedule. A saving of 37.2% in time could be achieved when the working period is extended by 20% (Leung, W. T. and Tam, C. M. 2002). The findings indicate that simulation can be used to assist planners to improve their decisions and decide the strategies in scheduling and reviewing the Mat construction schedule

The specific objectives of the proposed study are as follows:

- To identify the problems and its effects on Mat construction process.
- To optimize the Mat construction process.

Possible Outcome:

Result obtained may be important for Mat construction management, time and cost analysis.

1.4 Outline of Methodology

Critical Path Method and Project Evaluation and Review Technique are the most Common methods for the construction Scheduling work. Using these two methods schedule of construction is prepared first and using an actual field data and time delay the difference between the activity may be compared and may find the delay causes.

Simulation techniques have been used to predict activity duration and improve planning (Halpin and Riggs 1992), (Shi, J. 1999), and (Zhang, H., Shi, J. and Tam, C. M. 2002). However, the building up of Simulation models requires planners to have a good knowledge of simulation. A network based simulation has been used in this study. This simplifies the skills and knowledge required for modeling a simulation network as general simulation program can be difficult for general users (Shi, J. and AbouRiz, S. 1997). Planners who have the knowledge in constructing critical path network and bar charts should be able to use the simulation model. The constructing of simulation network for modeling is similar to the critical path network using the 'activity on node' format except that loops are allowed to show the re-cycling of resources. During the simulation process, the activities may either be in an active mode if the constraints are met or otherwise in an idle mode. The Mat construction cycle can be easily developed into a simulation network STROBOSCOPE (Martinez 1996) which is an advanced simulation language that can dynamically assess the state of the simulation and the properties of the resources involved in an operation. This allows simulation professionals to build simulation models for complex construction process with greater ease.

1.5 Outline of the thesis

The study of above objectives is presented in the several chapters of this paper. A diminutive description of each chapter is as follows:

- Chapter 1 is the introduction of the project; describes the objectives and outline of the projects.
- Chapter 2 describes literature review about simulation analysis, general purpose programming language, simulation specific tools and others simulation systems.
- Chapter 3 details about Activity Based Simulation Stroboscope and it's Networks Elements like Node, Queue, Combi, Normal etc..
- Chapter 4 describes Basic Simulation and Programming System, programming tokens, Different types of Variables, Logical instruction and outputs.
- Chapter 5 discussion on Activity of Mat Foundation, Identify the problems of each activity and listed the works in each activities.
- Chapter 6 shows verification of simulation programs with specific data in different program system to verify that the program is working perfect.
- Chapter 7 describes the parametric study and optimization of the mat casting process, weather case study also shown in this chapter.

  Chapter 8 Provides Conclusion and Recommendation of the project works.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the design of Mat construction operations it is often necessary to make decisions regarding complex processes. These decisions include determining crew sizes, selecting equipment, establishing operating logic, or selecting construction methods, associated with each decision are a series of outcomes such as construction cost and time. Decisions are made on the basis of their expected outcomes. For example, the equipment fleet to use in an earth moving operation may be the one associated with the lowest expected cost

Several techniques are available to asses the outcomes associated with particular methods of performing a process. Experiment with the real system on one extreme is very realistic but expensive, slow, lacks generality, and sometimes impossible to do. Mathematical modeling on the other extreme is very precise but requires that important aspects of the process be disregarded, requires a high degree of mathematical ability, and becomes too complex for most real life construction situations. Simulation is the third technique and it is very convenient because while being realistic. It is also inexpensive, fast, and flexible.

2.2 Simulation Analysis

Simulation is a descriptive technique in which a model of a process developed and then experiments are conducted on the model to evaluate its behavior under various conditions. Simulation models are fairly simple to use and understand. Extensive computer software packages make it easy to use fairly sophisticated models. Simulation is a modeling process that imitates a real or imaginary dynamic system. Simulation involves the design of a model of the system and the performance of experiments on that model. The behavior of the real or imaginary system can be predicted by observing the results of experiments in the model.

2.3 General Purpose Programming Languages

Model developed in general programming languages can represent almost any real life process. They can be tailored to the very precise requirements of the model in question and can work very fast. Their use in construction has been demonstrated with models for equipment selection (Teicholz 1963), for the assessment of uncertainty in time and cost of underground construction (Moavenzadeh and Markow, 1976) for the estimation of project durations (Carr 1979), for the evaluation of resource allocation strategies (Morua-Padilla, 1986), and for the modeling of underground geological conditions (Ioannou, 1984).

Although some libraries are available to ease development of simulation models using general purpose programming languages, models created with them require that many components be built from scratch. This requires a tremendous amount of effort that is seldom justified. Moreover, these models are geared towards a limited range of processes and are only useful for the particular model or class of models for which they are prepared.

2.4 Simulation Specific Tools

Many domains – specific and general purpose simulation tools exist. They can be classified as simulators or as simulation languages (Law and Kelton, 1991). Simulators are computer packages that allow the simulation of a specific class of systems with little or no programming. Simulation languages are general in nature but may have special features for certain types of applications. In general simulation languages have the ability to model almost any kind of system.

Simulators and simulation languages can adopt one of several approaches , strategies or decomposition methodologies. Three simulation strategies are commonly recognized: Event Scheduling (ES), Activity Scanning (AS) and Process Interaction (PI). The strategy used by the simulation tool has a strong impact on the way a model is presented to the computer and on how the modeler views the world (Evans 1989). For this reason, the superiority of one strategy over the others has been the source of much discussion and several comparisons have been made between them (Hills 1973, Zeiglier 1976, Hooper and Reilly 1982, Birtwistle et al 1985, Hooper 1986). All Strategies are considered equally general and powerful in terms of being or not being able to represents a particular problem. Particular strategies however lend themselves to model certain classes of models more easily.

ES is at the lowest level in terms of the support provided to the modeler and at the highest level in terms of efficiency. An event-based simulation model is driven by the scheduling and execution of subroutines (events) that in turn schedule the execution of other subroutines. Since the ES strategy is very efficient, simulation tools often combine it with the PI or AS strategy. A PI model is written from the point of view of the entities (transaction) that flow through a system. These entities undergo a process in which they attempt to acquire, take hold of, and release scarce resources. Consider as an example the loading of a steel shape onto a flatbed using a crane. A modeler using a PI approach may try to model this from the point of view of the steel shape. The steel shape (an entity) waits until it can acquire the crane (a resource). After it has acquired the crane it tries to acquire the flatbed (another resource). When the flatbed is acquired, the steel shape uses the crane for a period of time and then releases the crane.

An AS model is written from the point of view of the various activities that can take place. The modeler focuses on identifying activities and the conditions under which the activities can happen. There is no distinction between flowing entities and machines; they are all resources. An AS tool constantly scans the activities to see if they can take place. When an activity can take place, it is carried out. A model using as AS approach may represent the act of picking up a steel shape with a crane and placing it in a flatbed as an activity called “load”. The conditions necessary for “load” to happen are that a steel shape, a crane and a flatbed be available and in the correct state. If the conditions are met, then “load” happens and the steel shape, crane and flatbed are simultaneously acquired, held for some time and then released.

The PI strategy is very effective in the modeling of systems where the entities that move have many attributes that differentiate them and where the machines or resources that serve the entities have few attributes, a limited number of states and do not interact too much. These systems are common in manufacturing and other industries that have been traditional users of simulation. For this reason, the PI strategy alone or combined with ES are the basis of most simulation tools and languages in use in the United States. In most construction processes there is heavy interaction between machines, each of which can occupy several locations, have many attributes and be in several states. This makes it very difficult to use PI tools in construction. Despite theses difficulties languages based on the PI strategy have been used for earth-moving operations (Willenbrock 1972) and repetitive housing unit construction (Ashley 1980).

Simulation languages based on the AS strategy, in contrast, are very strong in modeling systems with highly interdependent components subject to complex activity startup conditions (i.e. many machines with distinct properties and states that must collaborate according to highly dynamic conditions). Since this is the very nature of construction operations, it is no surprise that construction academics and practitioners have used AS tools almost exclusively. The section that follows describes specific AS simulation tools.

2.5 Review of Activity Based Simulation

Civil engineers and construction practitioners make heavy use of graphical sketches and drawings to visualize problems and specify details. Networks are a form of graphical sketch capable of communicating complex concepts that would otherwise require lengthy explanations. In project level planning for example networks are very effectively used in the Critical Path Method (CPM) and the Project Evaluation Review Technique (PERT). All the AS simulation tools described here make use of networks that consist of nodes (Activities and Queues) connected together directionally (Arcs or Links) as an aid in describing simulation models. Some describe simulation models entirely through a network.

In addition, most of these tools combine AS with ES into what is known as Three-Phase AS (Tocher and Owen 1960). A three-phase activity scanner distinguishes between conditional activities (C-Activities or Combis) and bound activities (B-Activities or Normals). Conditional activities need to be scanned to see if they can take place, while bound activities are simply scheduled to occur. This division allows for significant improvements in speed since no time is spent scanning bound activities.

2.6 General Simulation Program - GSP

The General Simulation Program (GSP) (Tocher and Owen 1960) introduced the concept of three-phase AS. GSP was regarded as a “machine based” (the original name for AS) ”automatic programming”. The main design objective of GSP was runtime efficiency. As a consequence, a program written in GSP resembles a cipher with many single letter identifiers and keywords (Evans 1988). Wheel-charts were the first AS simulation networks, which later became known as Activity Cycle Diagrams (ACDs). Wheel-charts were developed by (Tocher 1964) as an aid in indentifying conditional activities (C-Activities in GSP) and bound activities (B-Activities in GSP). A wheel –chart consists of a set of boxes linked by arcs that represent a sequence of activities for each machine.

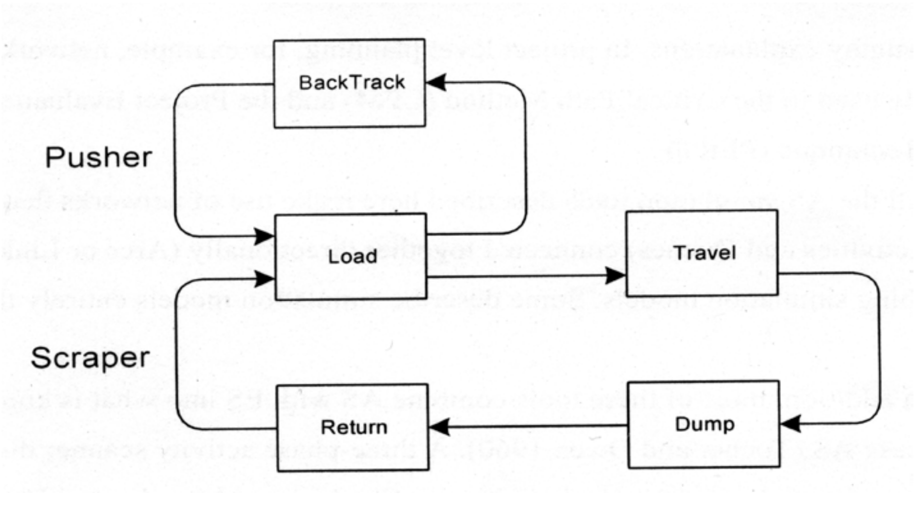

Figure 2.1: Wheel-chart involving two machines with intersecting cycles

When the number of arcs entering a node is one the activity is bound (the activity can be scheduled to start as soon as the predecessor finishes) . When more than one arc enters a node the activity is conditional (a scan needs to be made to determine if all of its predecessors have finished). Thus Figure 2.1 identifies activity “load” as a conditional activity and the rest as bound activities. When the sequence of activities in which a machine participates can change, wheel-charts include circles. Figure 2.2 shows a star –shaped wheel-chart involving a crane. The crane may perform any of the activities (load , unload or reposition) in any sequence. When an arc enters an activity from a circle , the activity is conditional regardless of the number of arcs that enter it.

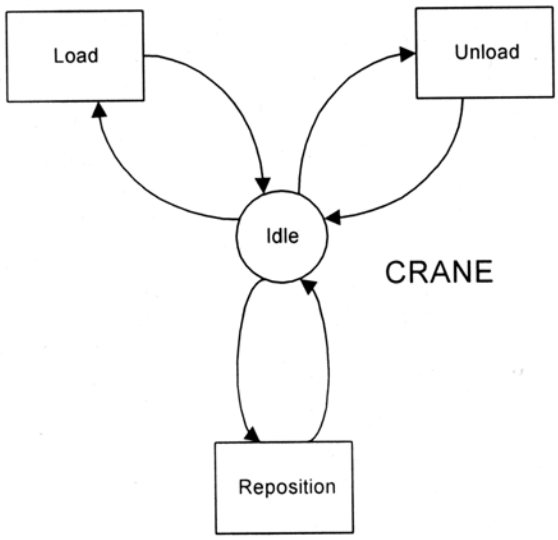

Figure 2.2: Wheel Charts

Tocher (1964) used wheel-charts to describe GSP programs. An actual GSP program would contain instructions such as the following (for the coding of a activity involving cranes similar to one of those shown in Figure-2.2) from (Tocher 1964).It is clear that GSP models while quite simple to understand as networks become indecipherable when represented in machine readable form.

2.7 Hand Or Computer Universal Simulator - HOCUS

Hand or Computer Universal Simulator (HOCUS)(Hills 1971) enhanced and popularized the concept of Activity Cycle Diagrams. A HOCUS ACD consists of Queues (Circles) and Activities (boxes) connected by arrows. In contrast to wheel-chart, the path followed by entities must alternate between queues and Activities. Figure 3 shows a HOCUS ACD. The connection between the nodes have a pattern that indicates the type of entity that flows through it. Queues and Activities are identified by their numbers which are placed towards the top on queues and towards top-left on activities. A HOCUS model is conveyed to the computer through interactive input forms where the details of the nodes and the entities of the model are specified. The information specified inside the Activity usually describes it completely. For example, Activity 10 (load), requires that a pusher exist in Queue 2 (E2) and that a scraper exist in Queue 3 (E3). When Activity 10 finishes, the pusher is released to the tail of Queue 1 (T1) and scraper is released to the tail of Queue 4 (T4). The “x10” on top of Activity 10 indicates that up to 10 instances of the Activity can be active at the same time. When different Activities compete for resources from the same Queues, HOCUS gives priority to the Activity with the lowest number.

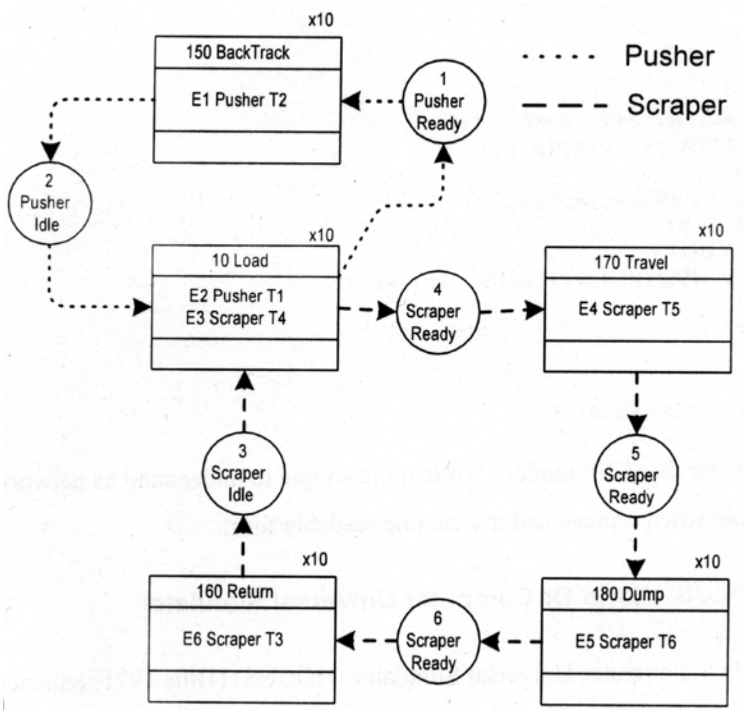

Figure 2.3 : HOCUS Activity cycle diagram

The entities in the system can have several integer-valued attributes identified with letters. The specification for Activities allows the manipulation of these attributes through two-letter options. The specification for Activity 10, for example, could be "E2 Pusher T1 L TR – 20" and "E3 Scraper T4 K TR +20", to specify that 20% of the "L" attribute of the pusher be moved to the "accumulator" and then transferred to the "K" attribute of the scraper. It is also possible to override the implicit "AND" operator among the specifications with "OR" and to repeat the same entity type more than once to indicate that more than one entity of the given type is required in order to start the Activity. Although HOCUS is not well known in the United States, it is popular in Europe where it has been the subject of several books (Poole and Szymankiewicz 1977; McDonald, Turner and Szymankiewicz 1988) and has been numerous large scale simulations in several industries.

2.8 Cyclic Operation Network – CYCLONE

Cyclic Operations Network (CYCLONE) (Halpin & Woodhea 1976) was specifically designed for construction. CYCLONE is purely network base (i.e., the network contains the complete model) and as a consequence is very simple. A CYCLONE network is an extended version of an ACD. Conditional activities are called Combis and are drawn with a slash on the top left corner of the box. Bound activities are called Normals, they are distinguished from conditional activities and are drawn as plain rectangles. Queues are drawn as circles but with a slash in the bottom right corner so as to resemble the letter Q. All the nodes in a CYCLONE network are identified by a unique integer. Figure 2.4 shows a CYCLONE network.

In CYCLONE, only the conditional Activities (Combis) need to be preceded exclusively by Queues. Combis start when none of the preceding Queues are empty. When several Combis contend for the resources in a Queue, priority is given to the Combi with lowest number. Bound Activities (Normals) can be preceded by any node but a Queue and start immediately after a predecessor finishes.

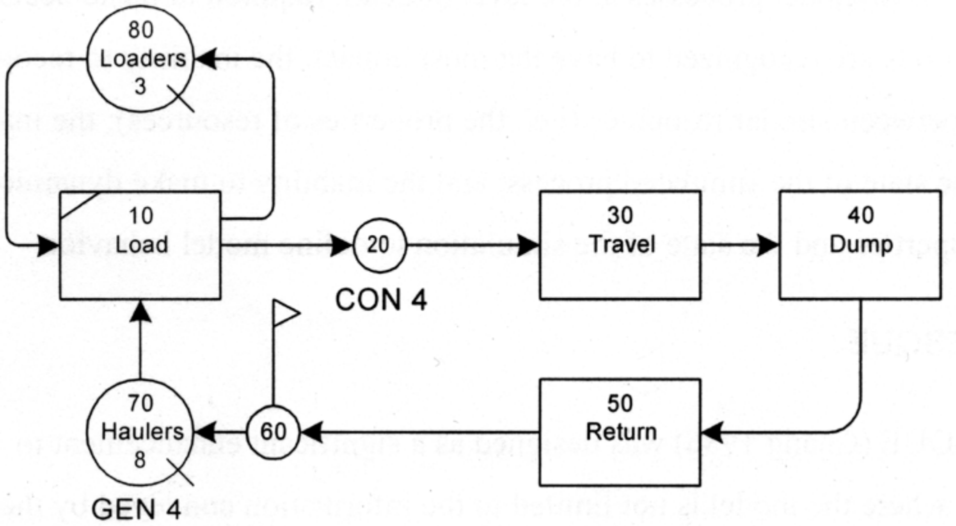

Figure 2.4 : CYCLONE NETWORK

The entities that flow through a CYCLONE network are indistinguishable and interchangeable. They cannot have properties assigned to them. Special function nodes can multiply and consolidate entities as well as control the simulation run length. The "GEN 4" in Queue number 70, for example, indicates that every entity that enters the Queue is converted into 4 entities. The "CON 4" in, node number 20 indicates that the node will accumulate 4 entities and then release one. The small number of nodes and simple rules of CYCLONE make it very easy to use as both an analysis and communication tool. Numerous construction processes have been modeled using CYCLONE. they include concrete batch plant operations (Woods and Harris 1980, Lluch and Halpin 1982), and tunneling (Touran and Asai 1987). There are at least four CYCLONE implementations: main-frame CYCLONE (Halpin 1976), Insight(Kalk 1980), UM-CYCLONE (Ioannou 1989), and Micro-CYCLONE (Halpin 1990). Unfortunately, the pure network characteristic of CYCLONE imposes limits that do not allow us to model processes at the level of detail required to make decisions. Three limitations are recognized to have the most impact: the inability to recognize differences between similar resource (i.e., the properties of resources); the inability to recognize the state of the simulated process; and the inability to make dynamic use of resource properties and the state of the simulation to define model behavior.

2.9 RESQUE

RESQUE (Chang 1986) was designed as a significant enhancement to CYCLONE where the model is not limited to the information conveyed by the network. In addition to the CYCLONE network, a RESQUE model has an overlay that defines resource distinctions and increases simulation control. The overlay follows a process Description Language (PDL) specific to RESQUE. RESQUE Sought to overcome the resource characterization capabilities missing in Cyclone. The solution presented by RESQUE through PDL is a significant improvement over CYCLONE insofar as recognizing distinctions among resources that flow through the same path.

RESQUE identifies resources through a single integer identifier. This identifier represents all the properties of a resource. The PDL statements use the identifier, called attribute in RESQUE, to look up the appropriate probability distributions for activity durations and to look up resource routing rules (RDVLIST). RESQUE activities can be subject to conditional tests (CONDLIST) that can compare the current and total number of resources at a Queue, or the number of instantiations of an activity, to a constant. In addition, the RESQUE PDL has statements to manage assembly and disassembly of resources into and from sets.

2.10 COOPS

The COOPS construction simulation system (Liu 1991) is an extension to CYCLONE that was completely designed and implemented using an object oriented programming language. The simulation network is a collection of objects such as activities, queues, and links that are drawn interactively on the screen. These perform the simulation by reacting to messages sent from other objects. Moreover, “specific resources” are represented as separate objects to allow the collection of statistical information at the individual level. In addition, COOPS uses calendars to preempt activities during breaks and has the ability to generate and consolidate resources at links.

COOPS’ interactive graphical model definition is a great improvement over previous construction simulation systems. Modeling elements are picked, placed and moved directly on the screen, and the need to enter a textual equivalent of the network is removed.

2.11 CIPROS

CIPROS (Odeh 1992) is both a process level and project level planning tool. It contains an expandable knowledge base of construction techniques and methods; and makes ample use of a hierarchical object oriented representation for resources and their properties. CIPROS extends its resource characterization capabilities beyond RESQUE by allowing multiple real properties for resources as well as more complex resource selection schemes. It integrates process level and project level planning by representing activities through process networks, all of which can use a common resource pool. CIPROS does not provide access to the state of the simulation.

2.12 AP3

AP3 (Sawhney and Abourizk 1994) is a three-tiered planner that divides work into project, operation, and process level. The process level component is based on CYCLONE. AP3 generates SLAM code.

2.13 STROBOSCOPE

STROBOSCOPE (Martinez, 1996) is an acronym for State and Resource Based Simulation of Construction Processes. It is a general-purpose simulation programming language that has been designed for the simulation of very complex construction processes that involve many different types of resources. STROBOSCOPE models are based on a network of interconnected modeling elements and on a series of programming statements that give the elements unique behavior and control the simulation.

At the conceptual level, the elements used in a STROBOSCOPE model are a superset of those in CYCLONE. For example, STROBOSCOPE allows for the explicit identification of bound activities with the elimination of the corresponding superfluous queues. In addition, STROBOSCOPE introduces five new nodes and four special types of links of conceptual significance. STROBOSCOPE models, however, do not rely on functional CYCLONE elements (e.g., Generate, Consolidate, Counter) and are not subject to any of the simplifying assumptions found in functional CYCLONE models (for example, resources of the same type can be distinguished from one another and each can have individual properties).

The character of STROBOSCOPE arises from its ability to dynamically access the state of the simulation and the properties of the resources involved in an operation. The state of the simulation refers to such things as the number of trucks waiting to be loaded; the current simulation time; the number of times an activity has occurred; and the last time a particular activity started. Access to the properties of resources means that operations can be sensitive to properties-such as size, weight, and cost-on an individual (the size of the specific loader used in an operation) or an aggregate basis (the sum of the weights of a set of steel shapes waiting to be erected).

STROBOSCOPE modeling elements have attributes-defined through programming statements-that define how they behave throughout a simulation. Attributes represent such things as the duration or priority of an activity, the discipline of a queue, and the amount of resource that flows from one element to another. Most attributes can be specified with expressions and have default values that provide the expected behavior. Expressions are composed of constants; system maintained variables that access the state of the simulation and the properties of resources; user-defined variables; logical, arithmetic, and conditional operators; and scientific, statistical, and mathematical functions.

The attributes of STROBOSCOPE modeling elements allow simulation models to consider uncertainty in any aspect (not just time), such as the quantities of resources produced or consumed (example, the volume of rock resulting from a dynamic blast). Attributes also allow models to dynamically select the routing of resources and the sequence of operations; to allocate resources to activities based on complex selection schemes; to combine resources and dynamically assign properties to the resulting compound resource; and to activate operations subject to complex startup conditions not directly related to resource availability (example, do not blast rock until all crews of all trades have left the vicinity, the wiring has been inspected, and there are less than 10 minutes left in the current shift).

STROBOSCOPE was designed as a simulation programming language that provides seamless and dynamic access to the state of the simulation and the properties of resources. It is capable of modeling the highly complex and dynamic processes encountered in construction with unprecedented ease.

The STROBOSCOPE simulation system offers a number of benefits including:

- A framework that provides dynamic and comprehensive access to the state of the simulation through pre-defined, system-maintained variables.
- A framework that provides dynamic access to the properties of resources at the individual and set level through pre-defined, system-maintained variables.
- An add-on Interface Specification that allows STROBOSCOPE to be extended seamlessly using high-level compiled languages and without the need to statically link with the STROBOSCOPE engine.
- A Three-Phase Activity Scanning executive that prevents zero-duration activities from introducing undesirable side effects in the simulation logic.
- An Integrated Development Environment that allows simulation models to be edited, run, and debugged easily.

A Graphical User Interface that can be used to create simulation networks using drag and drop drawing. The GUI can run models directly and can also generate the STROBOSCOE source code for simulation models.

The STROBOSCOPE system is very robust, can handle extremely large and complex situations, and is available for immediate industrial use. It has been used to model numerous construction field operations in addition to construction business processes. STROBOSCOPE has been used to teach advanced simulation in several of the leading construction programs in the United States in addition to several other countries. It has also been used by researchers to create higher-level systems and to solve complex problems.

STROBOSCOPE requires dedication for mastery and effective use. The EZStrobe user interface is very easy to use and can be learned quickly, but modeling systems where the properties of individual (but similar) resources are important (e.g., trucks of different sizes) becomes cumbersome.

Using Microsoft VISIO for comparison of same problems.

2.14 Comparison to Other Construction Simulation Tools With Stroboscope

Stroboscope simulation systems specifically designed for the modeling of construction processes. This can address selected project level problems, and in those terms compares it to tools specifically designed for those problems. All construction process simulation tools are based on Activity Cycle Diagrams (ACDs) and on the Activity Scanning (AS) simulation strategy. As a consequence they are similar at an abstract level. Stroboscope differs from all other tools in that it is a simulation programming language and not a simulator. The following definitions and observations about simulation languages and simulators, from (Law and Kelton 1992), are applicable to construction systems and worth citing:

"A simulation language is a computer package that is general in nature but may have special features for certain types of applications." ..."A model is developed in a simulation language by writing a program using the language's modeling constructs. The major strength of most languages is their ability to model almost any kind of system, regardless of the system's operating procedures or control logic."

"A simulator is a computer package that allows one to simulate a system contained in a specific class of systems with little or no programming." ... "The major drawback of many simulators is that they are limited to modeling only those system configurations allowed by their standard features."

In addition, construction process simulation systems differ in their underlying philosophy, modeling power, and ease of use.

2.14.1 Comparison of cyclone with stroboscope

Cyclic Operations Network (CYCLONE) (Halpin & Woodhead 1976) model is represented entirely on a network; there are no model details that do not appear in the graphic representation. All the modeling element parameters are numerical (i.e., no variables, operators or function calls), except for the names of the probability distributions used for Activity durations.

CYCLONE resources are similar to Stroboscope generic resources, except that they have no type, are limited to integer amounts, and always flow one by one (there is no Draw Amount, DrawUntil, or ReleaseAmount). CYCLONE Queues have a parameter called “GENerate” that multiplies incoming resources by the specified integer value. CYCLONE Consolidators finish when their content reaches the value specified by the “CONsolidate" parameter. “GENerates” are used in conjunction with “CONsolidates” to multiply or divide the number of resources in certain parts of a path; this is used to model fundamental issues such as resource unit matching. Stroboscope Queues do not need a “GENerate” attribute. Resources travel in their real amounts, which can be very precisely controlled via link attributes such as DrawUntil, Draw Amount, and ReleaseAmount.

CYCLONE simulations stop when the first of two possible conditions are reached. The first is when the simulation clock reaches the simulation time limit. The second is when a special node marked as the “Counter” has been activated a specified number of times. Stroboscope does not need a “Counter” node since the condition for a Stroboscope simulation to stop can be defined by any arbitrary expression. CYCLONE resources have no type or properties, and cannot be distinguished between each other. As a consequence, similar resources must follow different paths. The CYCLONE network is set to give priority to the big haulers because “get 5 CY hauler” is numbered lower than “get 3 CY hauler”. It is not possible to model FIFO service order using CYCLONE. One type of hauler must have priority over the other (this priority cannot change throughout the simulation). The complexity and size of CYCLONE networks for cases with several types of haulers and several types of loaders increases exponentially. Thus, realistic models of construction operations can be so large and complex that they become unmanageable.

2.14.2 Comparison of rescue with stroboscope

RESource based QUEueing network simulation (RESQUE) (Chang 1986) is significantly more powerful than CYCLONE because it can recognize the state of the simulation and that similar resources can be different. It is similar to Stroboscope in that the entire model is not represented exclusively by a network. The network is only a high level representation of the actual process. In RESQUE, the details of the process are defined via its own Process Description Language (PDL).

Stroboscope and RESQUE are superficially similar in that they address most of the same issues. They both recognize that resources of the same type may have different properties that the state of the simulation is an important factor in determining whether an Activity should or should not be performed, and that resources are often grouped and for some time thereafter act as a single resource.

Despite the remarkable number of superficial similarities, Stroboscope and RESQUE are very different in terms of design, capabilities, and feel. The following essential differences are the root of numerous other differences:

- RESQUE resources are discrete entities that differ only in their “type” (analogous to a Stroboscope characterized resource type) and their “attribute” (a single integer identifier analogous to a Stroboscope SubType). This is in contrast to Stroboscope, where resources can be bulk (i.e., can exist in fractional amounts)or discrete. Stroboscope's discrete resources can be characterized with an unlimited number of properties of four kinds: system-defined and maintained properties, properties common among all resources belonging to the same SubType, properties where information can be stored or retrieved, and properties expressed as functions of other properties and the state of the simulation.

- RESQUE's access to the state of the simulation is limited to the current and unt of resources at Queues and to the total number of Activity instances. These values can only be compared to a fixed number, and used as a pre-condition for the activation of a Combi. This is in contrast to Stroboscope, where numerous aspects of the state of the simulation are available for use in any expression.

- In RESQUE, the resource assembly/disassembly mechanism is implemented as part of the Activity functionality, where some resources can be held by a node for several cycles (activations) before they are assembled. As a consequence, RESQUE Activities that assemble/disassemble are limited to one simultaneous instance. In addition, RESQUE models require assembly/ disassembly to represent even very simple operations, such as loading a hauler with several scoops of soil. This is in contrast to Stroboscope, where resource assembly and disassembly are handled by separate nodes in a graphically intuitive manner.

- The only non-numeric identifiers in the RESQUE PDL are the names of the resource types and the keywords for the several PDL statements. As a consequence, a RESQUE PDL file is very difficult to follow, and contains a large sequence of numbers separated by commas. This is in contrast to a Stroboscope file, which consists mainly of user-defined identifiers, and meaningful statement and function names.

Since RESQUE resources do not have real properties, it cannot model situations that depend of resource properties acquired during simulation runtime, such as the amount of fuel left in a loader's tank, or the amount of dirt carried in a hauler. In addition, situations that require the aggregation of a property over several resources, such the total weight of the steel shapes carried in a flatbed, cannot be modeled.

The description above was based on determining the duration of an Activity that can use similar resources of different types. RESQUE models face many of the same issues that must be addressed by Stroboscope, such as resource selection, routing, assembly and disassembly. The comparison of the two systems along those lines is of the same nature as the one discussed here. For the sake of brevity, these comparisons will not be made here. Another issue that merits comparison is how RESQUE uses the state of the simulation as a precondition to activate a Combi, which is analogous to a Stroboscope Semaphore. In RESQUE, the condition can only access four aspects of the state of the simulation.

1. The current value of the simulation clock (CT), which is equivalent to SimTime in Stroboscope.

2. The current number of resources at a Queue (CC), which is equivalent to *QueueName.CurCount* in Stroboscope.

3. The total number of resources that have entered a Queue (TC), which is equivalent to *QueueName.TotCount* in Stroboscope.

4. The total number of instantiations of an Activity (TA), which is equivalent to *AcitivityName.Toilnst* in Stroboscope.

In addition, RESQUE cannot use the state of the simulation for the determination of Activity durations or any other issues. RESQUE, for example, cannot model learning curves or non-stationary travel times. The above discussion on RESQUE makes it obvious that it is a significant improvement over CYCLONE. At the same time, it shows some of its modeling limitations, which do not exist in Stroboscope.

2.14.3 Comparison of coops with stroboscope

Construction Object-Oriented Process Simulation System "COOPS" (Liu 1991) was design objectives were ease of use and the application of object-oriented technology and interactive graphics to the design of construction simulation systems. Additionally, its design incorporates facilities to "alleviate some of the existing difficulties in construction simulation [CYCLONE], such as break time modeling, resource tracking, and difficulty in modeling different resource units" (Liu 1991). From the perspective of the user, "COOPS" graphical user interface is similar to Stroboscope's. The user interfaces, however, are implemented differently. In COOPS, the graphical objects are the same as the modeling objects. Thus, for example, the rectangle that represents a Normal Activity is the same object that reacts to messages as the simulation runs. The objects in Stroboscope's graphical user interface are separate from those that do simulation. They are based on client-server architecture. In fact, the graphical objects are not essential.

COOPS have two classes of resources, generic and specific. Generic resources are similar to the resources in CYCLONE. Specific resources are tracked individually (i.e., the system keeps separate statistics for each such resource) but cannot be characterized. As a consequence, for example, a COOPS earth-moving model with two types of haulers must use different sets of Activities and Queues for each type. COOPS have Link Resource Requirements (LRR) that are similar to Stroboscope's Enough, DrawAmount, and ReleaseAmt. As a result, a COOPS network does not require "GENerates" and "CONsolidates".

COOPS use calendars, which are cyclic patterns of work time - idle time pairs. Calendars can be attached to Queues and to specific resources. An Activity will not start unless all its preceding Queues are currently in working time and all the specific resources required for the Activity are also in working time. If a COOPS Activity has started, and resources are not available at particular times during the duration, the Activity ending time is adjusted according to common working time for all required resources, skipping all the break time on the resource's calendars. Thus, COOPS networks do not need to be complicated in order to consider break times. In terms of not allowing Activities to start, Stroboscope Semaphores accomplish the same task. In terms of extending an Activity's duration, Stroboscope's programmability must be used to specify an appropriate duration expression for the Activity.

A potential problem with COOPS approach to extending Activity durations is that it cannot be turned off. As a consequence, COOPS Activities always assume that interruptions in the work do not affect the total work time required to complete the task. For example, COOPS assumes that a 20 minute task can be accomplished by working 4 minutes at the end of the day, and 16 minutes at the beginning of the next day. COOPS calendars are limited to modeling break times. They cannot be used to control Activity instantiations due to complex startup logic that depends on the state of the simulation, and which do not follow a predetermined on-off pattern based on time.

2.14.4 Comparison of cipros with stroboscope

Knowledge-Based Construction Integrated Project and Process Planning Simulation System (CIPROS) (Odeh 1992), is both a process level and project level planner. This section compares Stroboscope to CIPROS in terms of process level capabilities. CIPROS models are like Stroboscope models in that the network only specifies high-level aspects of a process. The information that complements a CIPROS model is not contained in a text file. Instead, it is saved in binary form and can only be examined by opening appropriate dialog boxes via CIPROS' interface. This is unlike RESQUE and Stroboscope, where the complementary information is contained in a text file following the system's syntax. As a consequence, it is very difficult to communicate a complete CIPROS model in printed form.

CIPROS has discrete as well as bulk resources. The bulk resources are similar to Stroboscope's generic resources. They can exist in fractional amounts and represent construction materials and other bulk items. The discrete resources can be represented hierarchically and can have any number of real properties. They are similar to characterized resources in Stroboscope, except that all the properties must be defined along with their values before simulation runtime (i.e., they only support SubType properties). It is not possible to attach information to a resource while the simulation is running, or to define properties as a function of other properties. In addition, CIPROS does not maintain properties such as ResNum, Timeln, and BirthTime, that are specific to individual resources.

In most respects, CIPROS process level architecture is similar to RESQUE's. The CIPROS literature (Odeh 1992) enumerates several of CIPROS' key advantages over RESQUE. Most of these advantages are matters of degree, such as being able to order the resources within a Queue based on any property and not just the "attribute" of the resource. A similar statement could be made about Stroboscope as compared to CIPROS: resources in Stroboscope Queues can be ordered according to any dynamic function that relates any number of properties of the resource with any aspect of the state of the simulation or any of the properties of resources located anywhere in the system. A similar statement can be made about every other aspect of a simulation model. Such issues are too numerous. They were not listed when comparing RESQUE and Stroboscope, and are not listed in this section either.

While CIPROS improves substantially over RESQUE in terms of resource characterization, the improvements are at a level that does not make a comparison between Stroboscope and CIPROS any different than a comparison between Stroboscope and RESQUE. The CIPROS approach requires a specific entry and search path for each possible combination of attributes (resource properties). If the flatbed can carry several shapes with different weights, it is not possible to establish an accurate distribution. This is because only the attributes of the "set header" and the shape count are available. CIPROS does not incorporate the limited access to the state of the simulation provided by RESQUE, nor does it allow conditional activation of Combis. As a consequence, a CIPROS model incorporating break times or complex logic is as complicated as the corresponding CYCLONE model.

CHAPTER 3

ACTIVITY BASED SIMULATION STROBOSCOPE

3.1 Intruduction

STate and **R**es**O**urce **B**ased **S**imulation of **CO**nstruction **P**roc**E**sses (**STROBSCOPE**) is a general purpose simulation programming language specifically designed to model construction operations. Stroboscope models consist of a series of programming statements that define a network of inter connected modeling elements, give the elements unique behavior, and control the simulation. Stroboscope's ability to dynamically access the state of the simulation and the properties of the resources involved in and operation differentiate it from other construction simulation tools. The state of the simulation refers to such things as the number of trucks waiting to be loaded, the current simulation time, the number of times an activity has occurred, and the last time a particular activity started. Access to the properties of resources means that can be sensitive to resource properties such as size, weight, and cost on an individual or an aggregate basis.

A network is a high level representation of a simulation model. Networks in Stroboscope consist of nodes connected by links through which resources of different types flow. The purpose of this chapter is to provide an introduction to Stroboscope networks. At the essence of networks are resources and resource types. These are the units of traffic that flow through networks. Resources and resource types will be discussed in this section. Resources flow from one node to another through links. The basic network elements, namely the nodes and links that compose a network, will also be discussed in section. Resources, nodes, and links are put together to form a simulation network. This section presents a small but complete network and discusses the process modeled by the network.

3.2 Resources and Resource Types

Resources are things required to perform tasks. These can be machinery, space, materials, labor, permits, or anything else needed to perform a particular task. The most important characteristic of a resource is its type. The type of a resource places the resource within a category of resources that share common traits or characteristics. Truck, Bulldozer, Loader, Cement, Water, and Mason are examples of resource types. Note that the resource types listed as examples do not represent specific resources they represent a class of resources. The CAT D8 with serial number 211-RDQ that is sitting in Joe Contractor's back yard is a resource of type Bulldozer. A construction setting may include several resources of type “Bulldozer”, all of which share common traits and can be used for similar purposes. Some resources represent unique individual entities. Such is the case of the bulldozer mentioned above, a specific truck, a particular concrete block, etc. These resources are examples of discrete or non-bulk resources. Other resources do not represent individual entities that can be uniquely identified. These resources are bulk. Sand and water are examples of bulk resources. It is impossible to refer to a bulk resource. In order to be specific when referring to a bulk resource, it is typically necessary to specify its quantity using suitable units, its location, or the container it is in. Examples of valid references to bulk resources are “add 3.75 cubic meters of sand to 87.5 liters of water,” or “empty the cement in this bag to the pile in front of the mixer.” Statements such as “order a sand”, or “we need a water’, are not meaningful. Stroboscope strongly enforces the types of resources. The concept of resource type is at the heart of a Stroboscope simulation model. In Stroboscope it is easy to represent discrete as well as bulk resources.

3.3 Network Elements

The different kinds of modeling elements are interrelated. In order to fully define one kind, it is necessary to use another. There is a circular definition involved. This makes it necessary to take a quick glimpse at the network fragment shown in Figure 3.1.

Figure 3.1 is a simplified model of a bank. Customers arrive to make deposits or withdrawals and then leave. The bank has separate lines (queues) for deposits and withdrawals. The customers are served by a pool of tellers. When the tellers serve clients that wish to make a deposit, they receive money and put the money in the cash register. When the tellers serve clients that wish to make a withdrawal, they remove money from the cash register and give it to the customers.

Three types of resources are involved in the banking model project: customers, tellers, and cash. Customers and tellers are discrete resources whereas cash is a bulk resource.

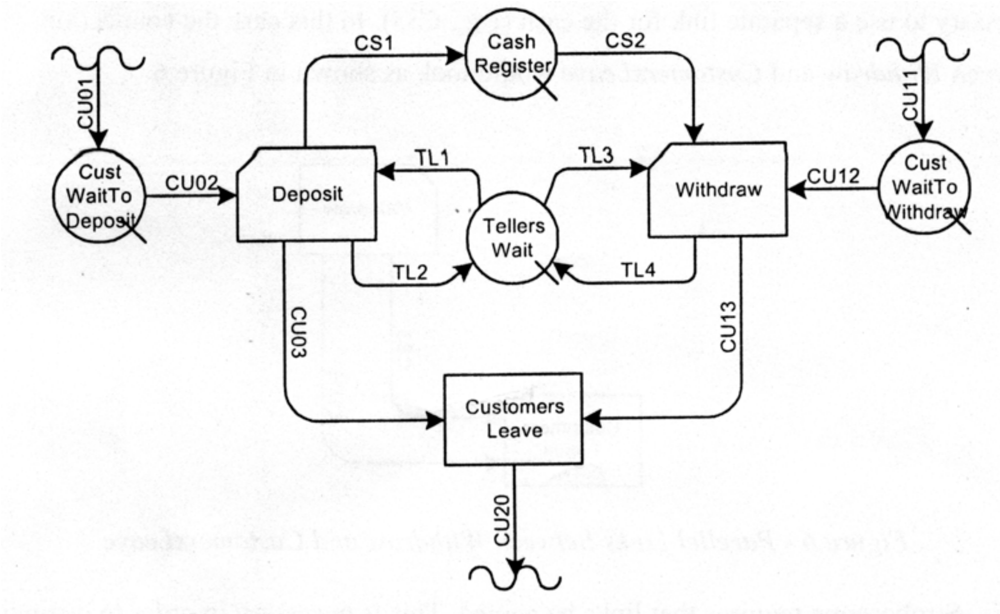

Figure 3.1 : Simplified Model of a Bank

3.4 Links

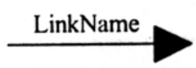

Figure 3.2 : Links

Links connect network nodes and indicate the direction and type of resources that flow through them. The node at the tail of the link is the predecessor and the node at the head (where the arrow) is the successor. Resources flow from the predecessor node to the successor node. The most important characteristic of a link is its resource type, only resources of the specified type flow through it. For example, link TL2 in Figure 3.1 is for tellers. It indicates that tellers flow from Deposit to TellersWait, two of the nodes in the network. Deposit is the predecessor and TellersWait is the successor (Deposit precedes TellersWait). Any teller can flow through TL2. Resources of other types, such as cash and customers, cannot flow through TL2. Sometimes resources of different types need to flow from the same predecessor node to the same successor node. In these cases it is necessary to connect the two nodes with more than one link, one for each resource type. In Figure 5, link CU13 is for customers. It assumes that the withdrawn cash is carried implicitly by the customer. In order to model the cash flowing from Withdraw to Customers Leave explicitly, it is necessary to use a separate link for the cash (e.g., CS3). In this case the connection between Withdraw and Customers Leave would look as shown in Figure 3.3.

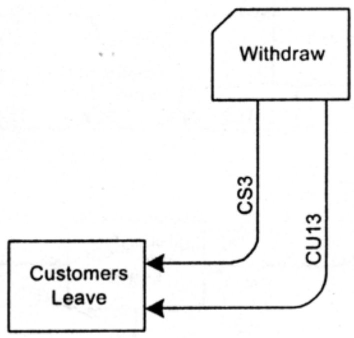

Figure 3.3 : Parallel Links Between Withdraw and Customers Leave

Stroboscope requires that links be named. This is necessary in order to distinguish one link from another. It is convenient to name a link in a manner that indicates the type of resource that flows through it. Although there is no limit to the length of a link name, a useful convention is for the first two letters to be an abbreviation of the resource type. A link for cash could be named C57, and a link for customers could be named CL/20. Links have many attributes. Some attributes control the flow of resources from the predecessor node to the successor node. Other attributes establish other relationships between these nodes. More details about links will be introduced later.

3.5 Nodes

During simulation, the resources that are part of a system are held by the various nodes of the associated network model. In particular, resources spend their time in two types of nodes: “Activities” and “Queues”. Activities are nodes in which resources spend time actively (performing a task). Resources involved in Activities are productive, sometimes in collaboration with other resources. The time resources spend in an Activity is the time required to perform the task represented by that Activity. Queues are nodes in which resources spend time passively (they are either stored there, or waiting to be used). The time resources spend in Queues is external to Queues themselves a resource stays in a Queue until it is removed because some Activity needs the resource to accomplish its task.

3.6 Queues

Figure 3.4 : Queues

Queues hold resources that are idle. Each Queue is associated with a particular resource type. That is, a Queue for tellers can only hold tellers and a Queue for cash can only hold cash. A traditional example of a Queue is the line formed by people waiting at a bank to make a withdrawal; such a Queue appears in Figure 3.1, it is named CustWaitToWithdraw, and holds resources of type Customer. Another example, a storage location, is the cash register in a bank; such a Queue appears in Figure 3.1, it is named CashRegister, and holds resources of type Cash. A third example, of servers, is the pool of tellers in the bank; such a Queue also appears in Figure 3.1, it is named TellersWait, and holds resources of type Teller. The most important fact about a Queue at any particular point in time is its contents. The manner in which the contents of a Queue is measured depends on the type of resource it holds. If the resource is bulk then its amount is expressed in some unit of measurement (e.g. dollars). If it is non-bulk (i.e., discrete) then its amount is simply a count of the number of resources in the Queue. When a discrete resource enters a Queue, the content of the Queue increases by one. When a discrete resource leaves a Queue, the content of the Queue decreases by one. The content of a Queue that holds discrete resources is never fractional. When a bulk resource enters a Queue, the content of the Queue increases by the amount of resource that enters. When a bulk resource leaves a Queue, the content of the Queue decreases by the amount of resource that leaves. The content of a Queue that holds bulk resources can be fractional.

In Queues that hold discrete, uniquely identifiable resources, only the resources that enter the Queue can leave it. For example, if John, Paul, George, and Ringo are the only customers that enter CustWaitToWilhdraw (and have not left the Queue yet), then only John, Paul, George, and Ringo can leave CustWaitToWithdraw. Although not of interest now, Queues that hold these types of resources have attributes that control the ordering of the individual resources within the Queue. In contrast. Queues that hold bulk resources make no distinction between the resources that enter the Queue and those that leave the Queue. This is because the bulk resources stored in a Queue are indistinguishable and interchangeable.

3.7 Activities

Activities are nodes that represent work or tasks to be performed using the necessary resources. In Stroboscopc there are three types of Activities. The Normal Activity and the Combi Activity will be discussed below and a third type will be discussed in chapter 10. Combi and Normal Activities differ in the way in which the tasks that they represent may start. They also differ in the manner in which they acquire the resources they need.

An Activity represents a task that can take place zero, one, or several times during simulation'. The repetitive tasks represented by an Activity can take place in series, in an overlapped fashion, or even in parallel. In the case of the Withdraw Activity (Figure 3.1), for example, several tellers can be serving several customers simultaneously. If two customers arrive at the bank at opening time, and two or more tellers are in their spots waiting for customers, then two occurrences of Activity Withdraw will start at the same time. Every occurrence of an Activity is called an instance of the Activity. Thus, during simulation several instances of Withdraw can happen concurrently. Each instance of an Activity has its own duration that represents how long it takes to do the associated work. Activity instances also hold those specific resources that were acquired in order to start it. Once created, an Activity instance exists for an amount of time equal to its duration. After this amount of time elapses during simulation, the instance of the Activity is terminated (destroyed). When this happens, the resources that were packaged inside the Activity instance are released to successor nodes through the links that leave the Activity.

3.8 Combi Activities

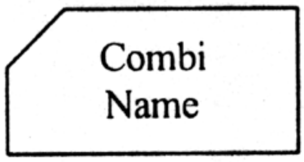

Figure 3.5 : Combi

Combi Activities represent tasks that start when certain conditions are met. For the sake of brevity, the term “Combi” will from here onwards refer to “Combi Activity”. At appropriate moments during simulation, Combis are scanned (examined one by one) to determine if the necessary conditions exist for them to start. In the majority of cases, these startup conditions relate to resource availability. For example. Withdraw is a Combi that requires three types of resources: a waiting teller, a customer who wishes to withdraw cash, and cash in the cash register. When cash, customer, and teller are all available, Withdraw can start (an instance of it can be created). Combis can acquire only resources that are inactive; they cannot interrupt (preempt) other tasks to obtain resources from them. Since inactive resources can only reside in Queues, Combis must draw resources from Queues. For this reason, all the predecessors to a Combi must be Queues (i.e., those Queues that hold the resources needed to start the Combi).

The default condition for a Combi to start is that none of its directly preceding Queues be empty**.** Thus, in order to determine whether a Combi can start it is necessary to examine the contents of its directly preceeding Queues. If the contents of each of these Queues is non-zero (not empty), then the Combi can start and an instance of it may be created. It is possible to change the default startup conditions through attributes of the Combi and/or the links that come into the Combi. A detailed explanation of how to achieve this, however, is not necessary at this point and will be postponed until later. When a Combi starts it removes resources from the Queues that precede it. By default, a Combi draws (removes) one unit of resource through each of the links that enter it. If this default behavior is not the one desired, it is possible to specify the number or quantity of resources that a Combi draws through a link by using link attributes. Furthermore, it is possible to specify the exact subset of resources that a Combi will draw from those stored in a preceding Queue (this, of course, applies only for Queues that hold a set of discrete, individually identifiable resources). For the time being, however, these attributes will not be used to control the resources drawn from Queues; the current discussion continues on the presumption that only one unit of resource is removed from each preceding Queue.

3.9 Normal Activities

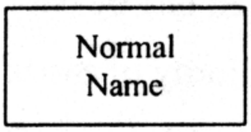

Figure 3.6 : Normal

Normal Activities represent tasks that start immediately after other tasks end. For the sake of brevity, the term “Normal” will from here onwards refer to “Normal Activity”. A Normal acquires the resources required to perform its task from the task that has just finished. Customers Leave in Figure 5 is an example of a Normal. This Activity starts immediately after an instance of Withdraw ends. In order for this to happen, there must be a link from Withdraw to Customers Leave that allows resources of type Customer to flow through, and that transmits the signal for Customers Leave to start when Withdraw ends. This is link CU13. Customers Leave receives the customer from the terminating instance of Withdraw. Notice that the terminating instance of Withdraw releases the teller through TL4 to Tellers Wait. The cash leaves with the customer and is not modeled explicitly once it is in the customer's possession. Among all nodes in a network, only Activity instances represent tasks that end and release resources. For this reason, only other Activities can be predecessors to a Normal. More than one Activity can precede a Normal. For example, Customers Leave (Figure 5) can happen not only after an instance of Withdraw ends, but also after an instance of Deposit ends. In this case, a separate instance of Customers Leave gets created every time an instance of either one of its predecessors finishes.

3.10 Networks

Nodes connected by links form a network that provides a high-level description of the operation being modeled. The network in Figure 7 shows a typical earth-moving operation. The purpose of this operation is to move soil from one place to another using loaders and haulers.

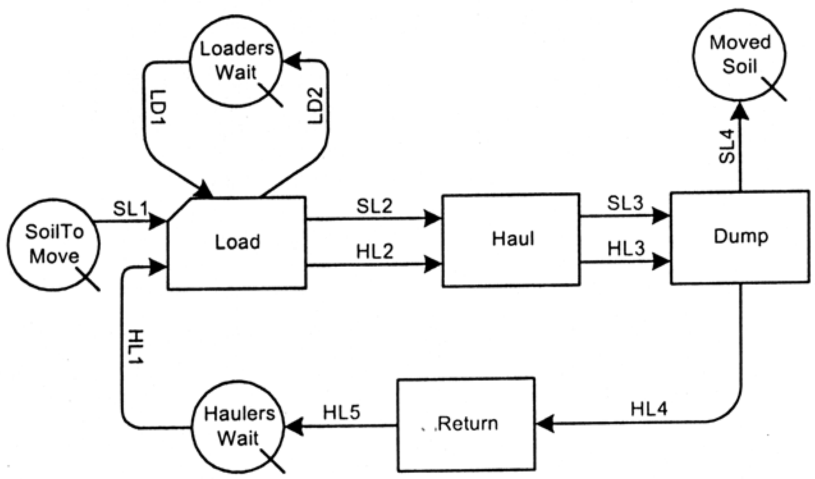

Figure 3.7 : Classic Earth-Moving Operation

This model uses resources of type Loader, Hauler, and Soil. Soil is a bulk resource type. Loader and Hauler are discrete resource types. The network contains one Combi named Load, three Normals named Haul, Dump, and Return, and four Queues named SoilToMove, LoadersWait, HaulersWait, and MovedSoil. SoilToMove and MovedSoil hold resources of type Soil; HaulersWait holds resources of type Hauler, and LoadersWait holds resources of type Loader.

At the beginning of a simulation the resources initially in the system reside in Queues. In the operation shown in Figure 7, HaulersWait contains some haulers, LoadersWait contains some loaders, and SoilToMove contains some soil. How many resource there are in each is not relevant at present. Links SL1, SL2, SL3, and SL4 indicate that soil is initially at rest in SoilToMove. It is then loaded to a hauler, hauled, and finally dumped to become part of MovedSoil. Links LD1 and LD2 indicate that loaders are withdrawn from Loaders Wait to load a hauler, and after loading a hauler with soil, they move back to wait to load again. Links HLl, HL2, HL3, HL4, and HL5 indicate that haulers are initially waiting to be loaded in HaulersWait, get loaded, haul, dump, return, and wait to get loaded again. Note that loaders and haulers follow cyclic paths. In contrast, the soil originates in one place and ends in another. All three of these resource types are involved in Load. Haulers and soil are involved in Haul and Dump. Only haulers are involved in Return.

Note that the links are named in a manner that indicates the type of the resource that flows through them. Links for soil begin with SL, links for haulers begin with HL, and links for loaders begin with LD. The naming convention adopted in this network also indicates the relative order in which the different types of resources traverse the links. Soil will first be drawn through link SL1, and then be successively released through links SL2, SL3, and SL4. The 1,2,3, and 4 appended to SL in the names of the links indicate a certain sequence. Naming for the hauler and loader links follow a similar pattern. The links are named in this example purely by convention. Link SL1 could have been named SoilIsDrawnFromPileToTruck. Although such a long link name is legal, it is not practical for two reasons. First, it is simply too long and cumbersome to write above the link itself. Second, it does not convey any information about the relative order of the link in the path followed by the resource (soil in this case).

The network shown in Figure 7 contains only one Combi Load. The conditions necessary for Load to start depend on the contents of its preceding Queues. In order for any Combi to start, the preceding Queues must contain enough resources to support the needs of the Combi. By default, any non-zero amount of a bulk resource or at least one discrete resource is considered enough. Thus, Load will start whenever there is soil in SoilToMove, at least one hauler in HaiilersWait, and at least one loader in the LoadersWait. Several loaders can be loading an equal number of haulers with soil simultaneously. Each occurrence would correspond to a different Load instance. At the beginning of the day (the start of the simulation), several Load instances could start at exactly the same time. By default, a starting Combi removes one unit of resource from each of its preceding Queues. Thus, every time Loot/starts, it will remove one unit of soil (provided one full unit is available, a unit could be a hauler-load) from SoilToMove, one hauler from HaulersWait, and one loader from Loaders Wait. The loader, hauler and soil will be packaged into an instance of Load.

This instance starts at the current simulation time and will be terminated sometime in the future.

The startup of an Activity and the creation of an instance of the Activity take no simulation time. The computer, however, needs to perform several steps sequentially in order to simulate this. During these steps, resources are removed from Queues and packaged into an instance of the Activity. For this reason, the contents of Queues before and after a Combi starts are not the same. Note that before and after, as used in the previous statement, refer to sequential moments that occur at the same simulation time. It is possible that after Stroboscope starts and instantiates Load (i.e., removes resources from the preceding Queues and creates an instance of the Combi) its startup conditions can still be met. In this case. Load will start again, removing more resources from each of the preceding Queues and creating another instance of itself. Load? will continue to start until one of the preceding Queues is empty. This will eventually happen when there are no loaders in LoadersWait, there are no haulers in HaulersWait, or there is no soil in SoilToMove. Note that all the instances of Loot/created in this scenario start at the same time and run in parallel.

For example, if there are 3 loaders, 5 haulers, and 1000 hauler-loads of soil at the start of the simulation, 3 instances of Load would be created at time 0. At that moment it would not be possible to create more instances because LoadersWait would be empty. The 2 haulers that remain in HaulersWait, and the 997 hauler-loads of soil that remain in SoilToMove, would need to wait until some loaders become available (i.e., until some loaders enter LoadersWait). When the time comes to terminate an instance of Load, this instance will release the loader, hauler and soil packaged within the instance through links LD2, HL2 and SL2, respectively. The loader will be released to LoadersWait. The hauler and soil will go to Haul. The entry of resources to Queues creates the possibility that any of the Combis that follow the Queue may be able to start. For example, assume that the last attempt to start Load was not successful because LoadersWait was empty. It is then possible that the entry of a loader to LoadersWait will enable Load to start the next time it gets scanned (this will happen sequentially later, but at the same simulation time).

Because Load is a predecessor to Haul, the termination of an instance of Load causes Haul to start. The hauler and soil received by Haul will be packaged into an instance of Haul that will in turn be terminated sometime in the future. Note that Haul starts because an instance of Load terminates. No conditions have to be checked to make it start (no Activity scanning is necessary). The termination of an instance of Haul causes Dump to start. Dump will receive the hauler and soil from Haul, and package them into an instance of Dump. This instance of Dump will in turn be terminated further into the future. The termination of an instance of Dump will release soil to MovedSoil and a hauler to Return. Return will then start and create an instance of itself. When this instance of Return terminates, the hauler is released to HaulersWait. The entry of a hauler to HaulersWait can (if LoadersWait and SoilToMove are not empty) set the conditions necessary for Load to start the next time it is scanned.

Note that, at any point in time, several instances of the different Activities in the network could be taking place. A hauler can be loaded while another hauler is dumping; several haulers could be loaded, or be dumping concurrently; etc.From the above example shows that resources spend time in Activities and in Queues. The amount of time that resources spend in an Activity depends on the duration of the articular instance of the specific Activity in which they are involved. This time is etermined when the instance is created. The amount of time resources have to wait in Queues depends on factors external to the Queues themselves. This amount of time is not known at the time a resource enters a Queue. It is only known when a resource actually leaves the Queue. Resources stay in Queues until a successor Combi removes them. This happens when the conditions necessary to start the Combi are satisfied.

CHAPTER 4

BASIC SIMULATION AND PROGRAMMING

4.1 Introduction

In the Simulation based programming, there are different types of variables and tokens for programming. The technique of general programming and simulation programming is same. There is no basic deference in coding but in user interface or compiling system, there may some deference. Graphical user interface system and command application may also differ. Generally a programmer first set variables and there values for calculation, input and output operation or other logical operation or any control operation. So selecting variable is a very important part of a simulation programming.

4.2 Variables

The example expressions used so far consist entirely of functions, operators, and numbers Stroboscope also allows the use of symbolic names to represent numbers or expressions in other expressions. This section describes a class of symbolic names called Variables. The name 'Variable' may be misleading because Stroboscope Variables are not storage locations for values (other Stroboscope elements, to be introduced later, are). Stroboscope Variables are more like functions that take no arguments or like formulas in a spreadsheet program. Some variables are defined and maintained by the system and are always available for use in expressions. Other variables are user-defined for each model with the purpose of localizing problem parameters and simplifying expressions.

4.3 Pre-Defined System-Maintained Variables

The information presented in the standard report gives us a snapshot of the state of the simulated process at the time of execution of the report. This includes information that describes the current conditions of the simulated process (e.g., the current content of a Queue, or the value of the simulation clock) as well as statistics that describe the performance of the system up to the time of the report (e.g., the average duration of instances of an Activity or average content of a Queue). Most of the information in the standard report is of a dynamic nature. Information changes while a simulation model is processed. Sometimes the information changes without a change in simulation time. For example, the current number of instances of an Activity is not the same before and after an instance of the Activity is created, even though the instants just before and just after its creation exist at the same simulated time. The system defines and maintains variables that provide comprehensive and up-to-date access to the state of the simulation. This includes all the information in the standard report, as well as other aspects of the state of the simulation. Global variables access information, such as the information contained in the standard report, that is available all the time and in any context. Instance variables access information that is valid only during the instantiation or termination of Activity instances, such as the duration of a particular instance of an Activity.

4.4 Global Variables

Global variables access information about the modeled process as a whole as well as information related to particular modeling elements. Global variables that access an aspect of the modeled process that is not related to a particular modeling element consist of the name of the variable by itself. The most commonly used variable of this class is SimTime, which returns the current value of the simulation clock. Whenever SimTime is used in an expression, Stroboscope will substitute it for the value of the simulation clock at the time of the evaluation of the expression. Another variable that is not related to a particular modeling element (at least explicitly) is the variable CurSeed, which returns the current value of the seed for the default random number generator.

Most global variables access information related to one or more modeling elements. Stroboscope creates names for these variables by using the names of the modeling elements involved and the name of the variable, separated by periods. For example, Stroboscope creates the variable Dump.Cvainst to provide access to the current number of instances of the Dump Activity. The variable Dump.CuYlnst can be used in any expression that appears after the definition of Dump. Whenever Stroboscope evaluates the expression (before, during, or after simulation), it substitutes Dywp.Curlnst for the number of instances of Dump that currently exist.

4.5 Instance Variables

In addition to global variables, Stroboscope creates and maintains instance variables. Instance variables are related to a specific instance of a specific modeling element (Activities, so far). Stroboscope provides access to instance information only when the modeling element is in context. An Activity is in context when one of its instances is being created or terminated. During the termination of an Activity, the terminating Activity and all the Normals that are successors to it are in context. During the instantiation of a Combi, only the Combi is in context. Queues are always in context. The global pre-defined system-maintained variable ActivityName.InConiext returns TRUE if Activity AcitivityName is in context.

Instance variables for Activities access information such as the duration or instance number of the instance, as well as information regarding the resources held by the instance. For an Activity named ActivityName, the variable ActivityName.Duration returns the duration of the ActivityName instance being created or terminated. Stroboscope will issue a runtime error if it has to access the ActivifyName.Dwation instance variable when ActivityName is not starting or ending (i.e., it is not in context). Similarly, for an Activity named ActivityName, the variable ActivityName. Instance returns the instance number of the instance being created or terminated. When an Activity is starting, the ActivityName. Instance variable is the same as the global variable ActivityName.Totlnst. This is not the case when an Activity instance is being terminated (unless the Activity never has overlapping instances).

4.6 User-defined Variables

It is also possible to define our own names for particular numerical values or expressions of interest by using the VARIABLE statement. In the simplest of cases a variable can be defined as a number. Variables of this type are particularly useful for the specification of problem parameters. These parameters are likely to be used in several expressions throughout a model file. The use of a Variable to hold the value allows making changes easily in only one location. All other references to the number are updated automatically. Variables are not limited to simple numbers. A Variable can be a synonym for any expression. The expression itself can reference other user-defined or system-maintained variables. Referenced Variables can themselves use other Variables. There is no limit to the level of nesting. Every time Stroboscope needs to use a Variable, it recomputes the Variables used to define it. This is done recursively. As a result, Stroboscope Variables are always up to date. This recalculation mechanism is similar to an automatically recalculated spreadsheet. Stroboscope variables resemble locked spreadsheet cells. The formula for one cell can reference a second cell. The second cell can in turn refer to a third cell, etc. When the value of the third cell changes, the value of the second cell is updated, and the value of the first cell is updated in turn. Any reference to the first cell takes into consideration the values of the second and third cells. Because the cells are locked, the formula that defines them cannot be changed (but the formula may return different values at different times).

During the simulation of a model that incorporates the above code, Stroboscope will evaluate the Duration attribute of the Erect Activity every time it creates an instance of the Activity. The Duration attribute uses the ExpErectDur and VariationCoeff variables, so these are also evaluated. ExpErectDur in turn uses the TimeForlstBeam, Erect.Totlnst, and Slope variables, so those need to be evaluated too. This procedure will theoretically go on until everything is in terms of numbers.

Given the above code, Stroboscope knows that the values of the TimeForlsfBeam and Slope variables will never change. So it doesn't actually recalculate them. Stroboscope evaluates them only once, and from then on remembers the result. This is not the case with the Erecf.Totlnst variable, since this variable attains a new value every time the Erect Activity starts. Conceptually, however, variables are always recalculated recursively. The cases mentioned above are simply optimizations and should not affect the basic concept of Stroboscope variables.

The VARIABLE statement is an element definition statement. When Stroboscope executes the statement it parses the expression and leaves it in a form that can be evaluated. The execution of the VARIABLE statement, when encountered during the processing of a simulation input file, does not actually evaluate the expression, nor does it assign any value to the variable being defined.

4.7 Display Custom Output

The output produced by the execution of the REPORT statement was shown in Figure 9. The standard report consists strictly of status and statistical information presented in a pre-defined format.

Usually, managerial decisions are made in terms of parameters that are derived from information in the standard report, or may depend on information that is not shown in the standard report. A typical example is when a process is gauged in terms of cost. It may be more meaningful, for example, to see the cost per cubic meter of soil moved, than it is to see the average waiting time of haulers at a Queue. Stroboscope has facilities that allow the display of custom output so that derived calculations can be observed directly. Furthermore, it is possible to format output in a manner that is clearer or aesthetically more pleasing, that highlights results that are otherwise lost within the sea of numbers produced in the report for a large model, or that presents values with more precision than the standard report.

The DISPLAY control statement is the simplest method of producing custom output:

Syntax: DISPLAY [String]

Expression [...];

Where *String* is text enclosed in double quotes, and Expression is any valid Stroboscope expression. The square brackets indicate that the argument is optional. The symbol ' ' indicates that either a String or Expression can be used, but not both. The ellipsis in the second set of square brackets indicates that the DISPLAY statement will accept any number of arguments in the format specified by the first set of square brackets. When more than one argument is used, each argument can be either a string or an expression independent of the other arguments.

When Stroboscope executes the DISPLAY statement, it simply echoes to the standard output device the arguments of the statement. Strings are displayed exactly as they appear in the argument list, including any embedded tabs or line breaks. Expressions are evaluated and the resulting value is displayed with up to 8 significant digits. Once all the arguments have been displayed, Stroboscope inserts a line break.

4.8 Logical Expressions, Values and Variables

Stroboscope relies heavily on logical expressions for the specification of certain element and model attributes. Stroboscope also provides system-maintained variables and operators that return logical values. The purpose of model and element attributes that return logical values is to indicate a Yes/No or TRUE/FALSE response. All expressions in Stroboscope return double precision floating point values. In logical contexts, these numbers need to be interpreted as TRUE or FALSE. Stroboscope interprets the value 0 as FALSE and any other value as TRUE. When Stroboscope applies a logical operator, function, or system-maintained variable, it returns the value 0 to indicate FALSE and the value 1 to indicate TRUE.

CHAPTER 5

ACTIVITY OF MAT FOUNDATION

5.1 Introduction

For programming of a simulation system, it is essential to make a list of work which is call activity list. In construction system it is called scope of work and in programming system it is called the activity of programming. In this chapter the list of activity for a mat foundation are prepared, and make a separate time schedule of each activity.

5.2 Scope of Works

These activities have been listed for calculation of time.

Table 1 : List of Activity in tabular form

SL	Name of Work	Details of Work
1	Site Preparation	Working yard, Site office, Site labour shade, Materials store Construction Equipments Power and water facility
2	Materials Mobilization	Stone chips, Sand, Cement MS Bar, Form Work Materials
3	Shore Protection work	Pilling work, Guide wall, Sheet Pilling
4	Earth cutting and Dumping work	Use manual cutting by labour Use Excavator and Dump Truck
5	Cement concrete work in Mat	
6	Water Proofing Work	
7	MS Bar Fabrication Work	

8	Concrete Casting work	
9	Curing Work	

5.3 Details of Activities

For a mat construction work there are some activities which are shown in figures and the details of the activities with problems are also shown in figures of all activities.

5.3.1 Site preparation work

Site preparation work is the starting step of the construction work. In this part of work all resources are collected for the start of construction work.

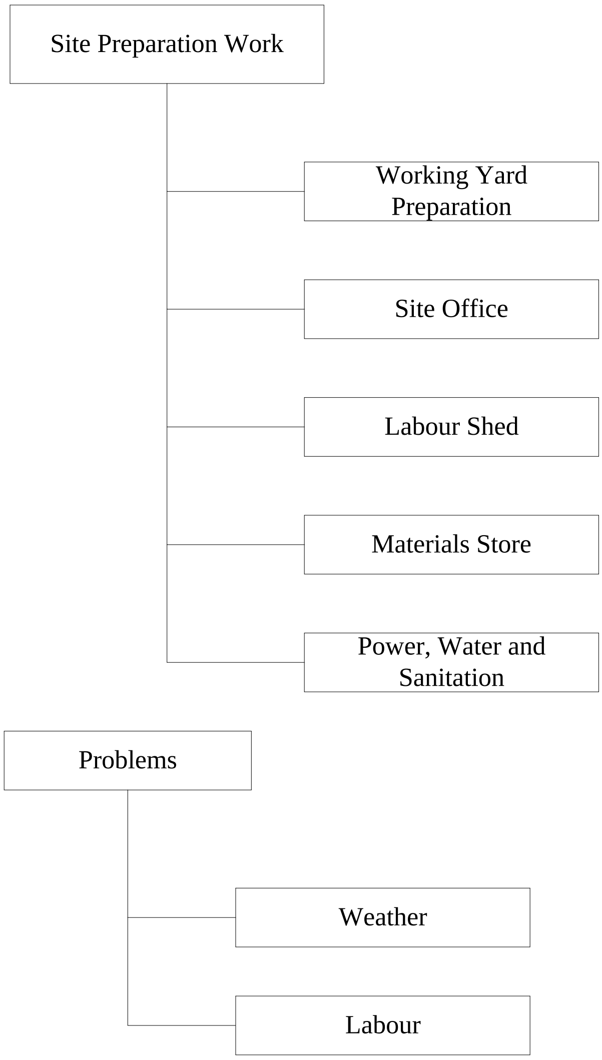

Figure 5.1: Site preparation work

In this figurer, site preparation work is divided in to blocs. These five blocks of works will start at time. So the maximum working time for any block will be the time period of the site preparation work. Also there is two problems in this activity. For the problems some extra time will be add with maximum time.

5.3.2 Materials mobilization

After completion of site preparation, the next phase is construction materials mobilization. In this part construction materials are collected for different sources. Depending on storage capacity the materials are mobilized for construction work. So there is some time to be calculated for this part of work.

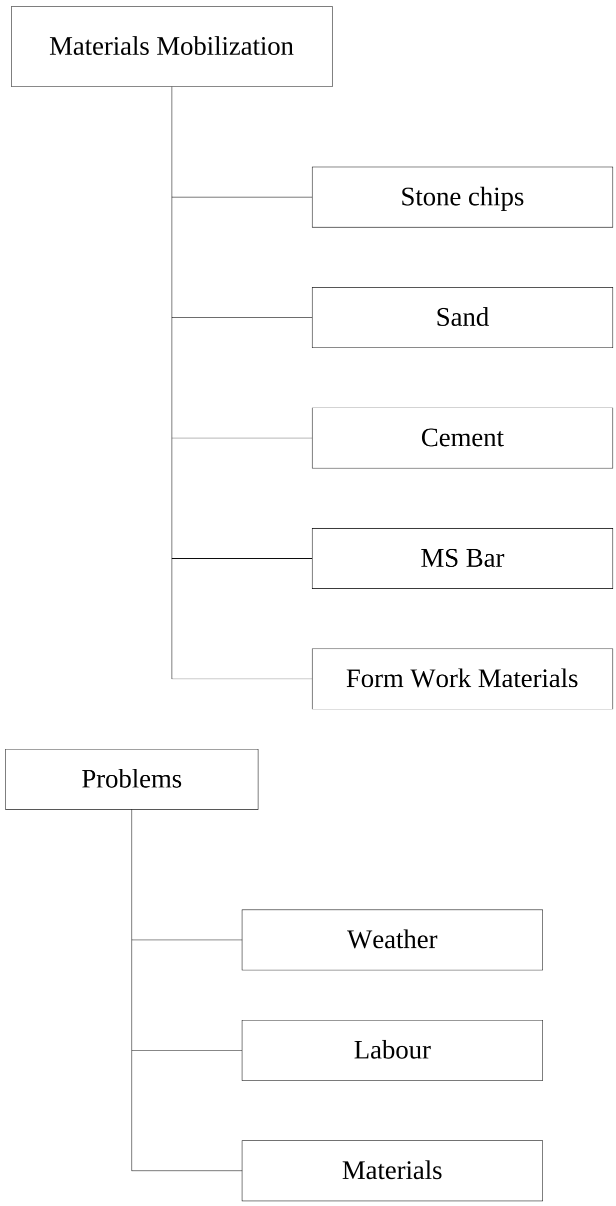

Figure 5.2: Materials mobilization

For a cast in situ construction work mainly stone chips, sand, cement is collected from different sources, formwork materials is common for all construction system. Water is collected by pumping. Power is generated form generation source.

So there is some time calculation for this work and also some problems in here. Sometime materials are shortage in market, sometime labour is not available. So considering these problems the time schedule is calculated.

5.3.3 Shore protection

For earth cutting work of mat foundation system shore protection is very important part. If the excavation is deep then shore pile is driven. Sometime sheet piles are used for shore protection work. Sometime wooden piles are used for shallow depth of mat foundation guide wall.

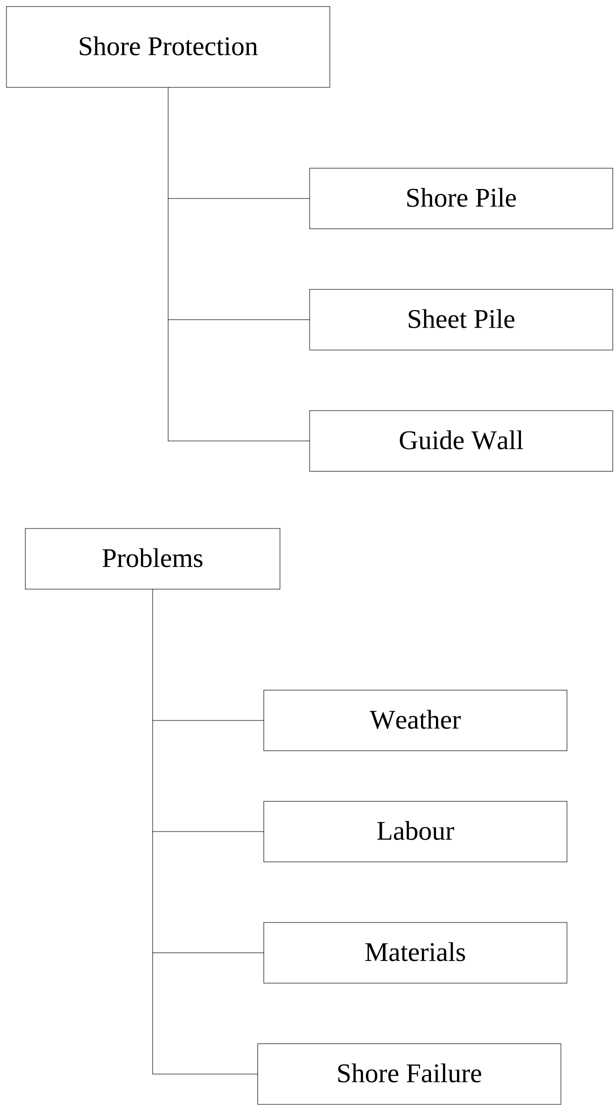

Figure 5.3: Shore protection

Using pile for a shore protection work is also an important part of Mat foundation construction. Normally piling is a heavy instrumental work and it take a scheduled time for driving the piles. Here the mechanical problem is extra problem block which create delay in works. So there is a time schedule for this part of activity.

5.3.4 Earth cutting and dumping work

After shore protection work is complete earth cutting work for a mat foundation starts. Earth cutting work could be done by manual process or by mechanical process. In manual process a team of earth cutting and carrying labour work and in mechanical process an excavator is used for cutting the earth and truck is used for carrying the earth.

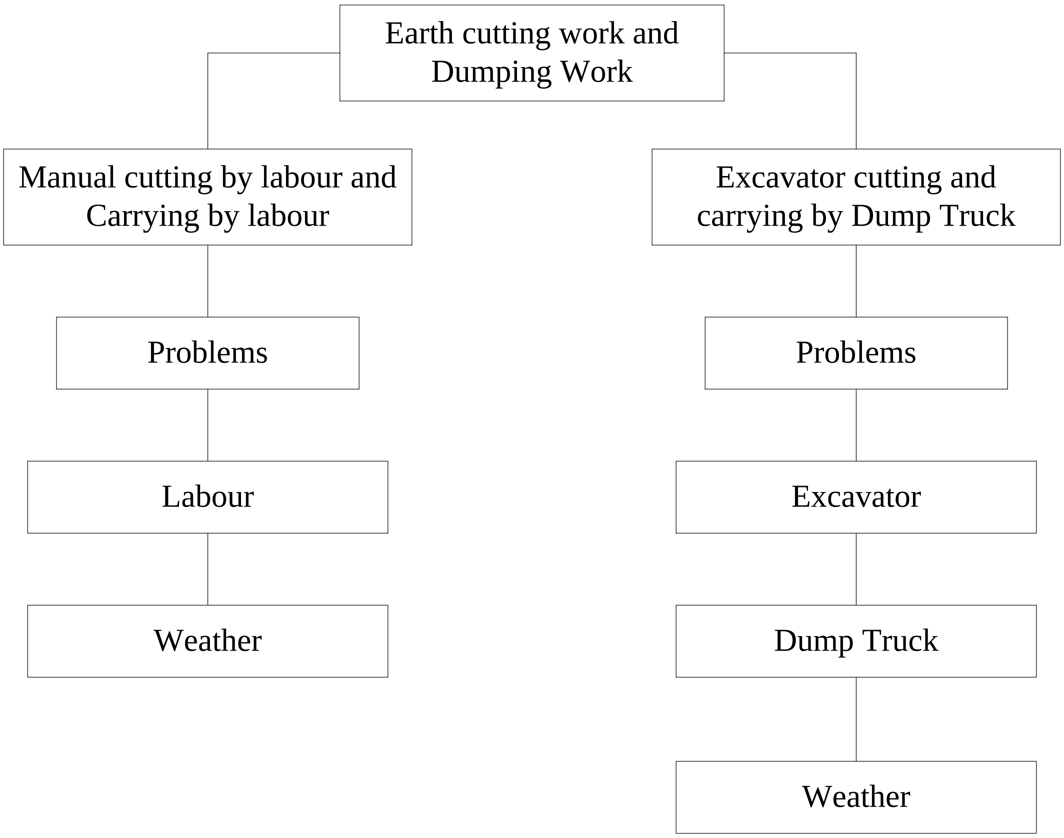

Figure 5.4: Earth cutting and dumping work

In the figurer, earth cutting work is shown in two process one is manual and the other is mechanical process. Mechanical earth cutting process is used in mat foundation work. Manual earth cutting system is a slow process for a small scale earth cutting work. Mechanical process is faster and it is used for large scale cutting work. Generally mat foundation earth cutting is a large scale earth cutting work.

5.3.5 Cement concrete work in mat

Cement concrete work is the first casting work of mat foundation. There is two way of casting. One is cast-in situ and other is ready mix use. The casting time depends on the volume of casting. Cast-in situ process is generally used for this work. Ready mix concrete is suitable for faster work.

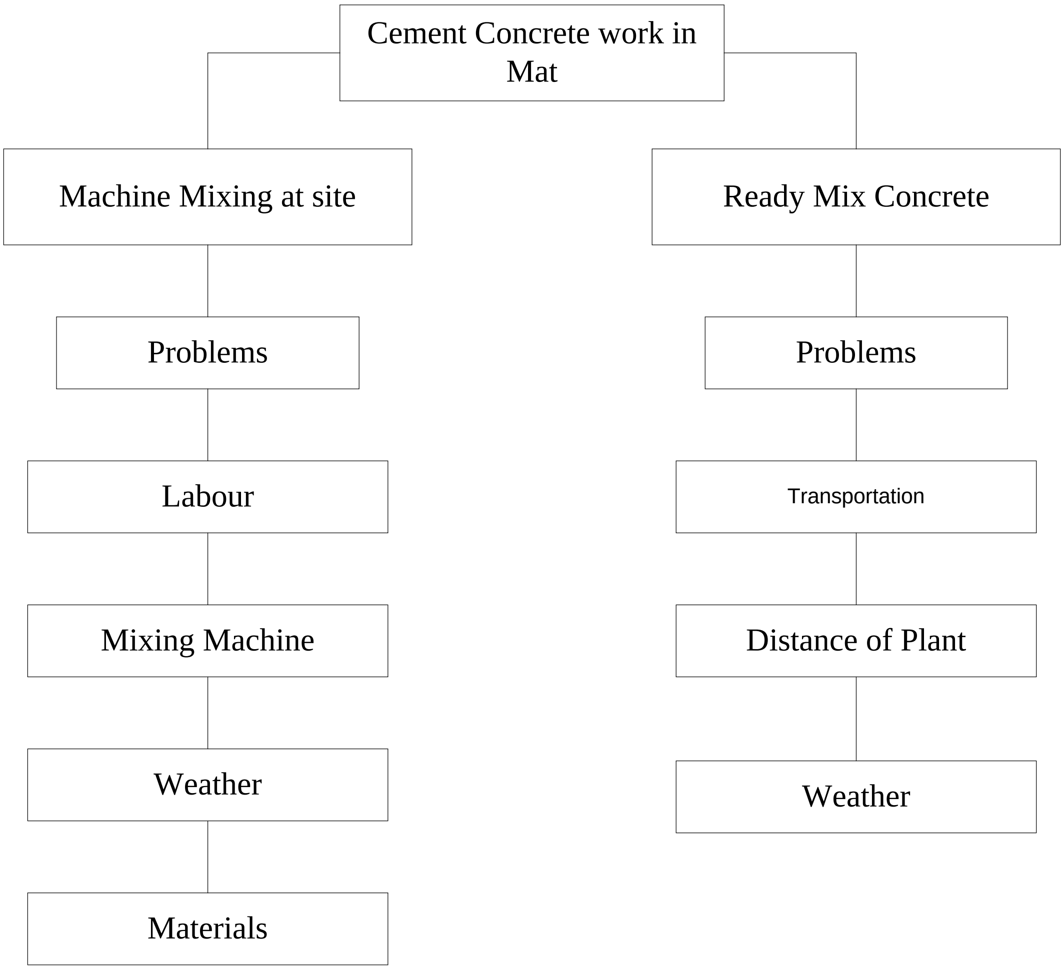

Figure 16: Cement concrete work in mat

Duration of the casting depends on the process of casting. For cast-in situ process, mixing machine disturbance affect the time of casting. Depending on past experience on execution of a similar project, the duration of casting is calculated. Also the duration of all activity are calculated in the same method.

5.3.6 Water proofing work

Water proofing work is essential when basement floor is constructed. Protecting basement floor from water penetration water proofing system is install be for mat foundation casting. There is two way of water proofing work one is using admixture in concrete and other is generating a thin water proof layer out side of the mat foundation. This thin layer may create by bitumen, bituminous asphalt or polythine etc.

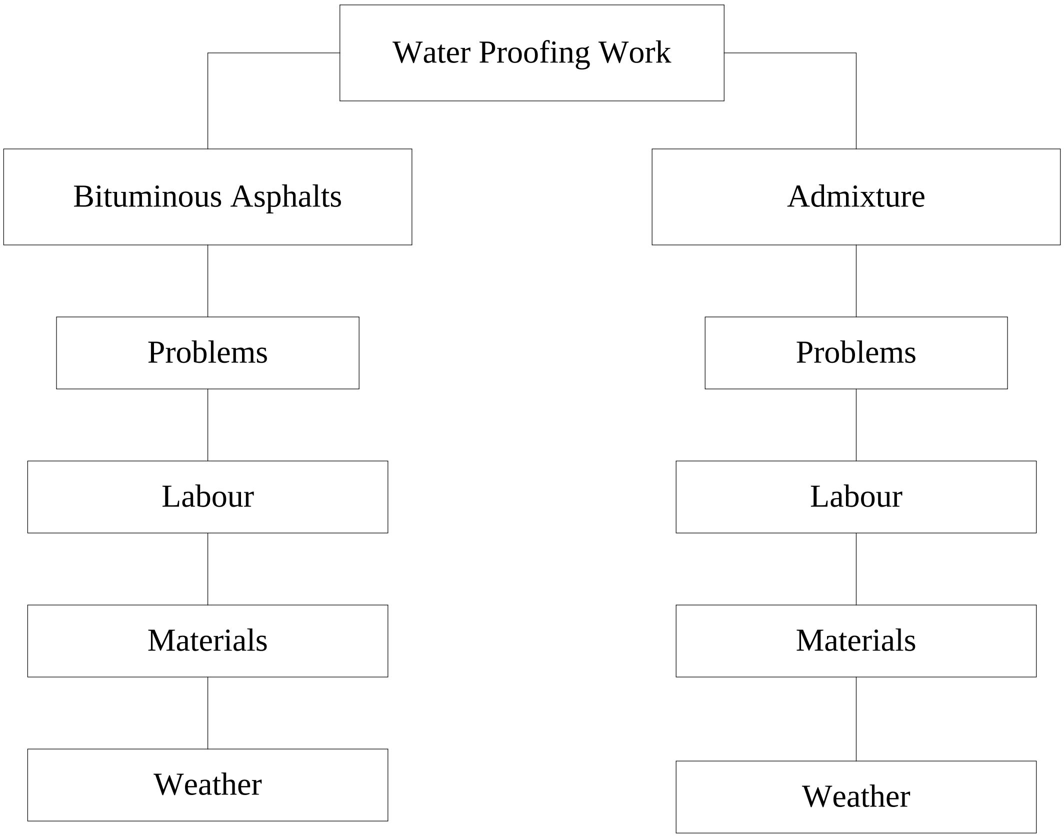

Figure 5.7: Water proofing work

figurer showing the two way of water proofing system with problem in each way. Admixture use is easier than creating a water proofing thin layer. Duration of this activity is calculation from similar project experience.

5.3.7 MS bar fabrication work on mat

After completion of cement concrete work the reinforcing bar lying is start. Before start the bar lying work it is require to shaping and sizing the bars. After sizing and shaping the bar, then those bars are lying in the mat foundation.

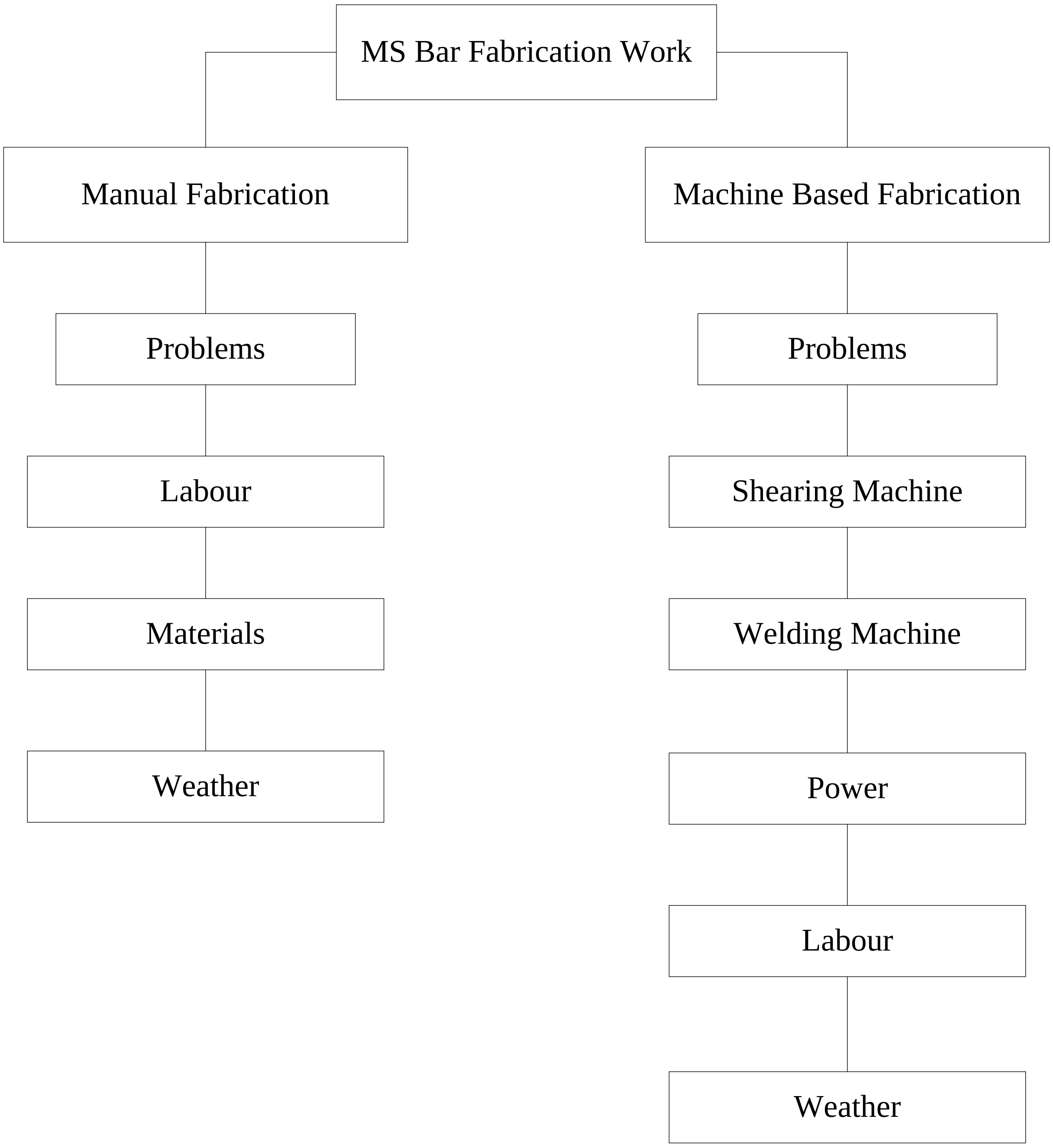

Figure 5.7: MS bar fabrication work

Duration of this activity is also calculated from past experience of similar project method. Reinforcing bar preparation work is start form completion of materials mobilization. So this activity partially runs with earth cutting time. Only bar lying time is effective time for this activity. Problems also effect on bar lying period.

5.3.8 Concrete pouring work

Final task of mat foundation is the concrete pouring work. After completion of reinforcing bar lying concrete poring work is start. There is two way of concrete pouring work. One is cast-in situ and other is ready mix use. The concrete pouring time is depending on the volume of concrete. Cast-in situ process and Ready mix concrete is use for concrete pouring process.

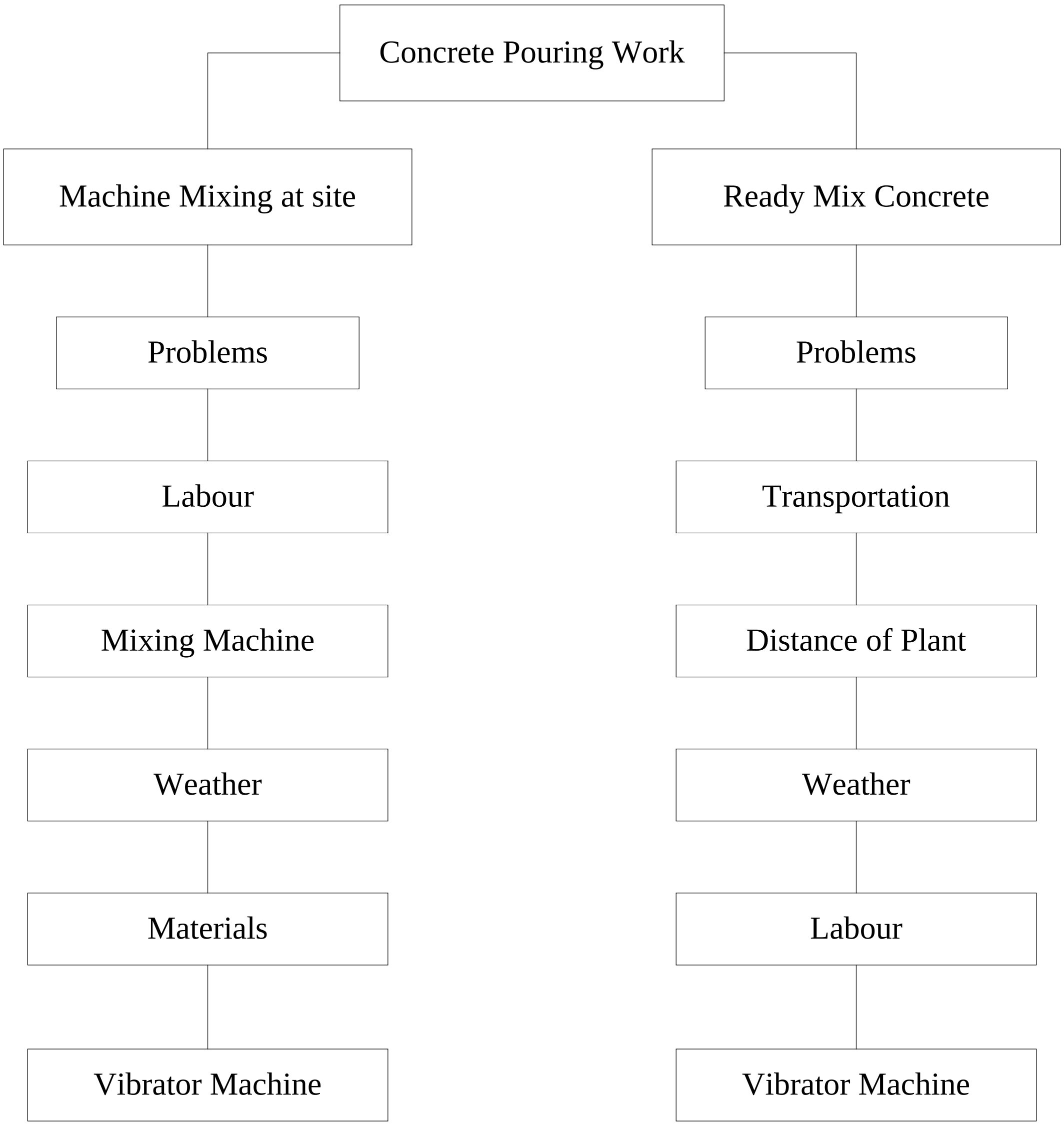

Figure 5.8: Concrete pouring work

Duration of the concrete pouring depends on the process of pouring. For cast-in situ process, mixing machine disturbance, vibrator machine disturbance, labour disturbance, are affect the time of pouring work. Depending on past experience on execution of a similar project, the duration of concrete pouring is estimated. Also the duration of all activities are calculated in the same method.

5.3.9 Mat curing

After casting of Mat foundation curing work is start. Generally the top surface of the mat foundation is watering for 28 days.

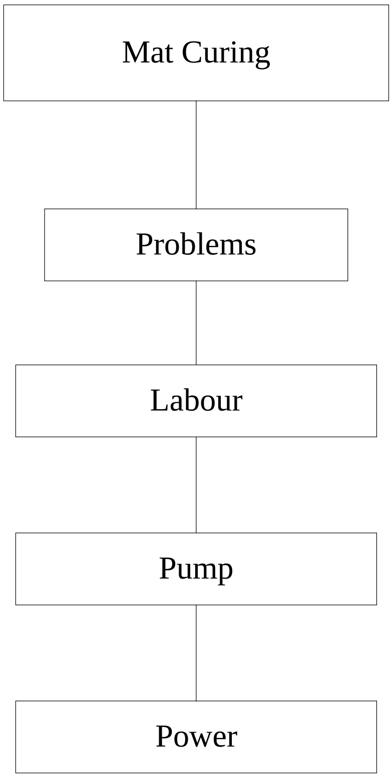

Figure 5.9: Mat curing

Curing is a simple and easy process for mat foundation. Sometime pumping problem, power problem arises in this activity. The duration of this activity is fixed as per design code.

5.4 Networks link diagrams of simulation program

In simulation programming the network and linking of the resources are shown in figure for deferent activities. This network and link has been prepared from micro soft visio software. Stroboscope connected with vision through ODBC system and creates the simulation and report.

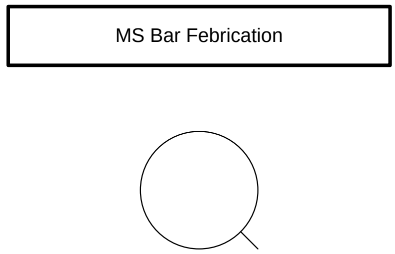

Figure – 5.10 : Network and Link diagram of bar fabrication

Figure 5.11: Network and Link diagram for earth cutting

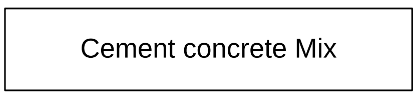

Figure 5.12: Network and Link Diagram of concrete mixing

This network diagram programming system does not require writing codes. Just drag and drop the network block and link properly. Input the data carefully in the property boxes of all networks and links then simulate the program in micro soft visio. The simulation result or report has been generated in stroboscope. Figure 5.12 shows a single mixing machine casting process. All the resources and activities are arranged according to the diagram and connect them with the connection process shown in the diagrams. Those connections are draw and release resources according to the parameter in the connection.

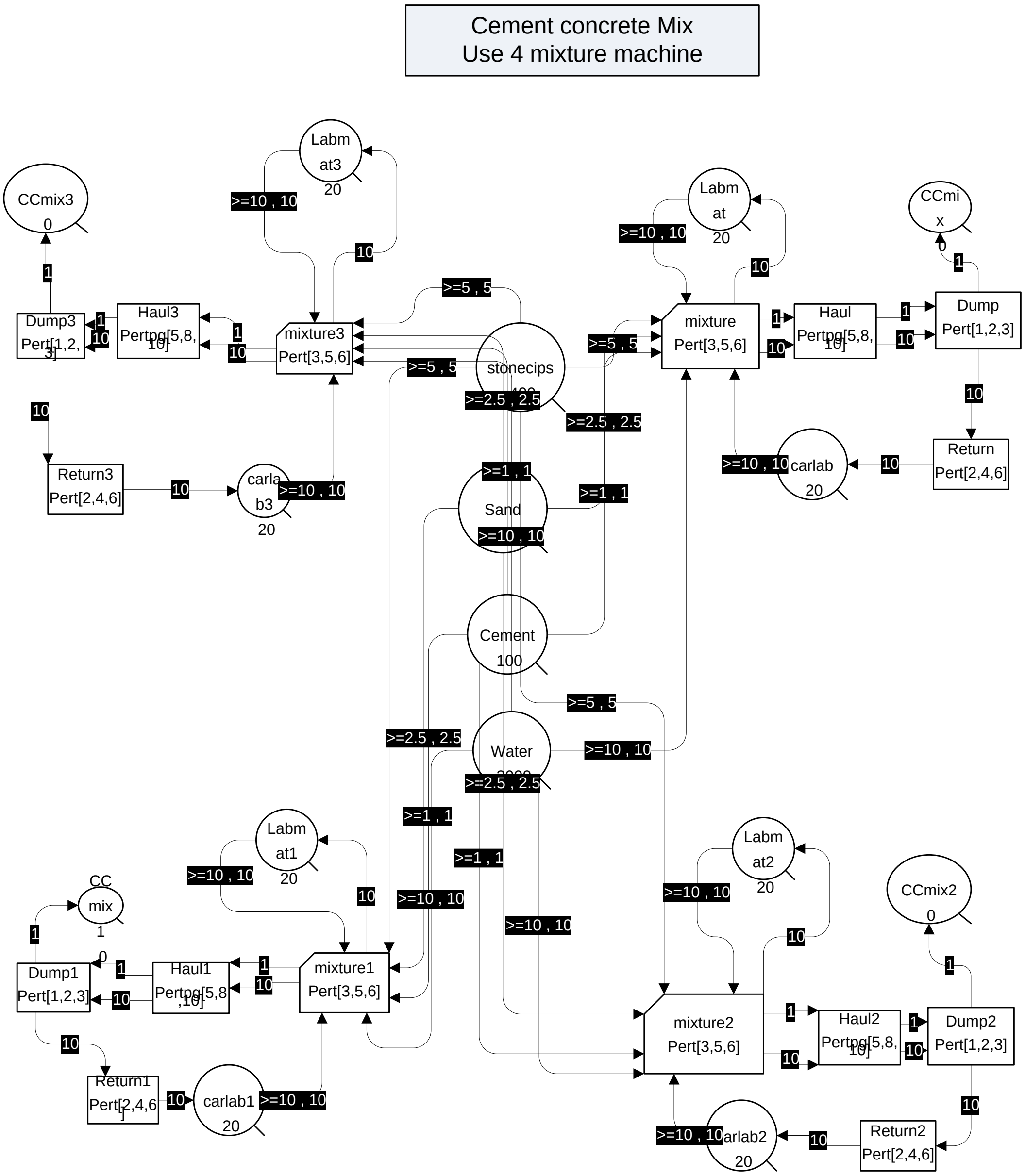

FIGURE 5.13: Network and Link Diagram of concrete mixing

CHAPTER 6

VERIFICATION

6.1 Introduction

For simulating a mat foundation it requires some specific data for the simulation work. So there is some data for a mat foundation which is use for a mat simulation. Those data are taken from a site where the mat foundation have been constructed in 69 days. But the scheduled time for the work was 62 days.

6.2 Results of Simulation Programs

For testing the simulation programs, outputs are compared for observing the results whether it is same or different, by using deferent programming method while inputting same data. The results are obtained same in all programming methods.

Table 2 : Resource Data for program Simulation

SL	Description	Amount	Unit
1	Stone chips	100	cft
2	Sand	200	cft
3	Cement	100	bag
4	Water	2000	lit
5	Caring Labour	10	no
6	Loading Labour	6	no
7	Mixture Macine	1	no

The Duration of simulation depends on the time setting of activities or duration of each activity. The time durations estimated on the basis of similar project experiences. The time duration of each activity may vary in site to site.

Table 3 : Time table for 1st test

SL	Description	Amount	Unit
1	Mixing Time	3	min
2	Haul Time	0	min
3	Dump Time	0	min
4	Return Time	0	min

.

There are three results obtain from different programs, which is found same simulation times of 75 min.(Appendix D, Result D-1, D-2, D-3). So the simulation is running error free in all programming system. It is also shows that the time of the simulation is the major factor for calculation of construction time schedule. If the programmer or user input any wrong values of time, the simulation result will be come wrong. So input the correct time that actually require for each activity, which will give the accurate result and will get correct simulation time.

For checking the simulation program, another test has been taken and the time table for the 2nd program is given in tabular form.

Table 4 : Time Table For 2nd test

SL	Description	Amount	Unit
1	Mixing Time	3	min
2	Haul Time	1	min
3	Dump Time	1	min
4	Return Time	1	min

The three results of different programs show same value of simulation time 150 min.(Appendix D, Result D-4, D-5, D-6). So the simulation is running error free in all programming system. It is also shows that the time of the simulation is the major factor for calculation of construction time schedule. If the programmer or user input any wrong value of time the simulation result will be come wrong. So input the correct time that actually require for each activity will give the accurate result and will get correct simulation time.

6.3 Simulating a Mat Foundation.

A set of data has been taken from an actual mat construction project for program simulation. Table 5 shows the detail data of the same.

Table 5 : Mat Foundation Data

SL	Activity	Amount	Unit
1	Area of Mat Foundation	16170	sft
2	Depth of Mat Foundation	3.25	ft
3	Earth Cutting Volume	161700	cft
4	Volume of cc work	4043	cft
5	Volume of Concrete pouring	52553	cft
6	Stone chips	50597	cft
7	Sand	25299	cft
8	Cement	12452	bag
9	Water	174316	lit
10	MS Bar	150	ton
11	Mixture Machine	5	no

6.4 Resource Data for Simulation

There are some resources, which is also taken from the same mat foundation project. The resources are given in the Table 6. The amount of resources draw and release are estimated from the capacity of each activity equipment and manpower.

Table 6 : Resource Data Table

SL	Name	Quantity	Release Amount	Draw Amount
1	Mixture	4	20	
2	Caring Labour	60	60	10
3	Loading Labour	40	40	10
4	Stone chips	55000	16	16
5	Sand	30000	8	8
6	Cement	13000	4	4
7	Water	200000	56	56
8	Earth volume	161700	200	200
9	Earth Cutting Excavator	1	1	250
10	Earth Caring Truck	2	2	250
11	MS Bar	92000	100	
12	Bar Fabrication Labour	15	15	

The details estimate of the data's is given in the Appendix C.

6.5 Activity Data for Simulation

The activity setup in simulation program is given in the table 07, Also the release amount and duration is given in the table.

Table 7 : Activity Table for Simulation

SL	Activity	Quantity	Release Amount	Unit	Duration in Min.

1	Mixture	1	24	Cft	3
2	Haul	1	24	Cft	3
3	Dump	1	24	Cft	1
4	Return	1	60	No	3
5	Load	1	20	Cft	3
6	Ms Bar Fabrication	1	100	Kg	180

6.6 Simulation Time :

Using the simulation program of each activity, the time in day have been obtained. The time schedule of each activity is given in Table 8.

Table 8 : Time Schedule Table

SL	Name of Activity	Days Simulate
1	Site Preparation	**4**
2	Materials Mobilization	**5**
3	Shore Protection work	**5**
4	Earth cutting Work and Dumping	**24**
5	Cement concrete work in Mat	**3**
6	Guide wall work	**5**
7	Water Proofing Work	**4**
8	MS Bar Laying	**7**
9	Concrete Casting work	**6**
10	Curing Work	**28**

All Simulation programs are given in Appendix B and outputs are given in Appendix C. Using the data from Table 8, project bar schedule have been generated through operating the stroboscope project scheduler probsched. The probsched network diagram of the simulation data is shown in Figure 6.1 and the bar schedule is shown in Figure 6.2.

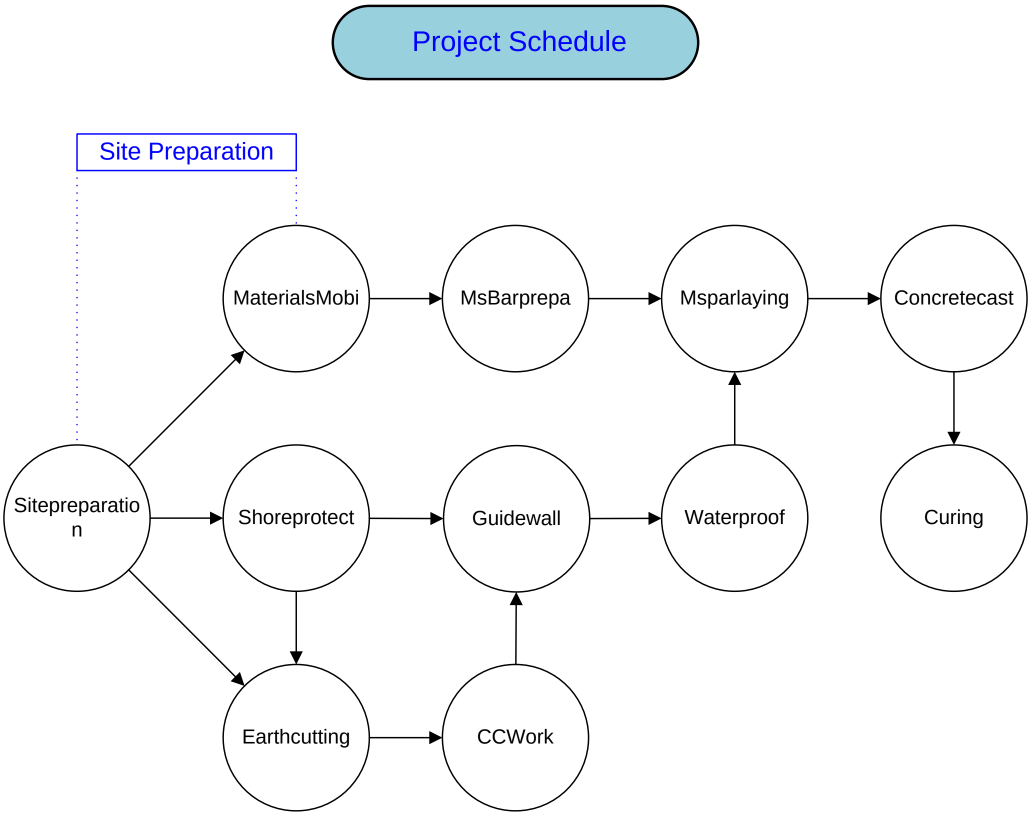

Figure 6.1 : The Network and Link diagram of Probsched

From the simulation of this Network and Link program the project final time schedule is found which is automatically generated by the software in the form of bar chard. Critical path method is used for prepare the schedule and also stroboscope use the built-in statistical calculation for result output.

6.7 Bar Schedule Generate by Stroboscope ProbSched

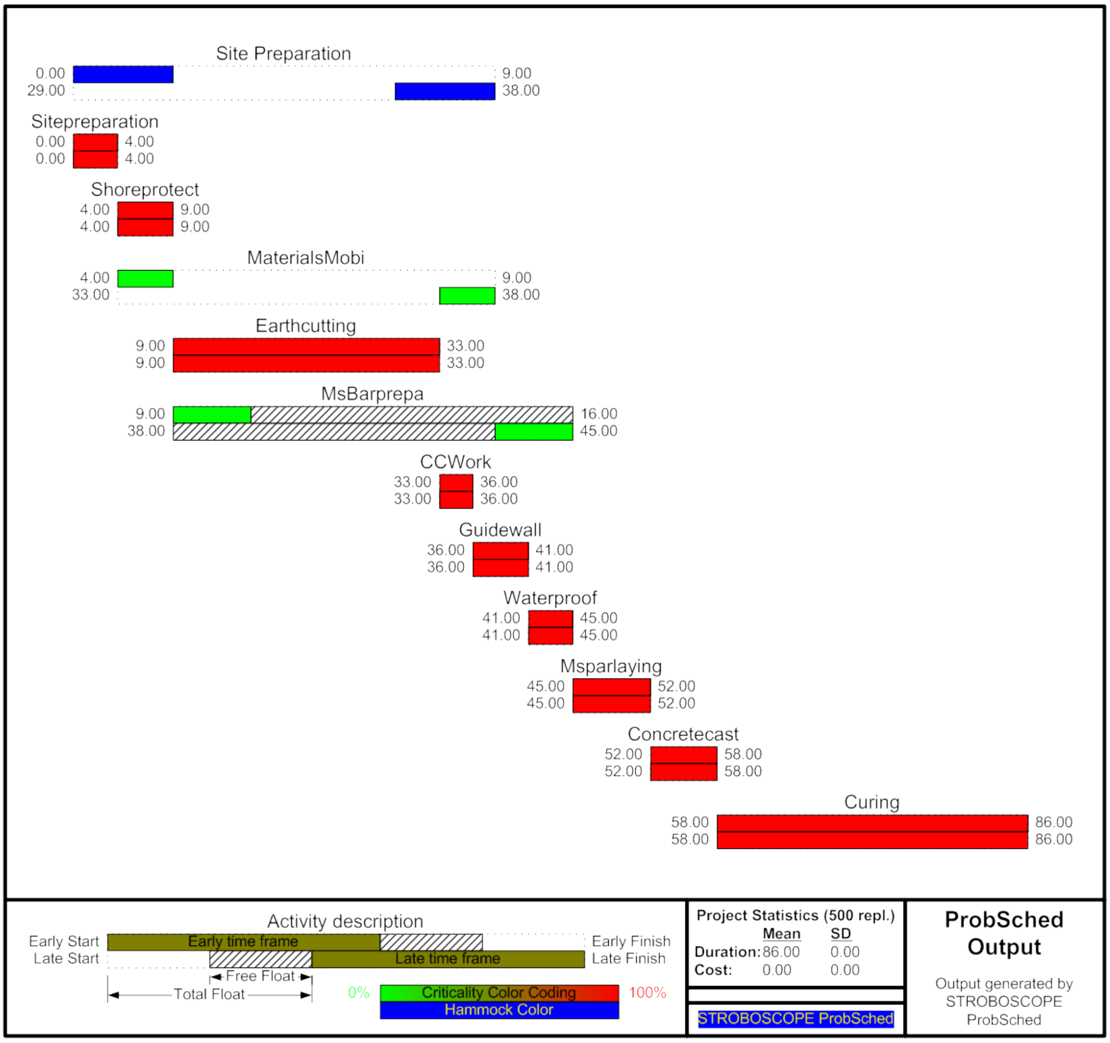

Figure 6.2 : Final Bar Schedule for the mat foundation

In this Bar schedule Figure 6.2, the completion time of the mat foundation is found 86 day including curing work, and excluding curing time the schedule time is 58 days. In the actual site work of mat foundation project, the schedule time was 62 days. The contractor completes the mat work within 69 days excluding curing work. From the simulation it is observed that the project could be finished within 58 days.

CHAPTER 7

PARAMETRIC STUDY AND OPTIMIZATION

7.1 Introduction

In this chapter few parameter of simulation has been changed and run the simulation for observed the results. It has been found that there is a change in time schedule in every activities of mat construction. It is also observed that parameter labour is critical for the mat simulation as because it has been used in all activity while other parameter is not. For example mixture machine is used only in concrete work. Changing machine parameter is effected only in casting activity time.

7.2 Parameters of site preparation work and Optimization.

In site preparation work, labour resources are considered the main factor affecting time because only labour work is the main control point of work. Other resources like mixture machine are less important. So, the changing of the parameter labour in simulation program, the different time output is obtained, more over the change of time with the change of labour is very clear.

Table 9: Site preparation time optimization

Run	Labour	Days Simulate	Comments
1	5	15	
2	10	7.5	
3	**15**	**5**	**Optimum**
4	20	3.75	
5	25	3	Resource Idle
6	30	2.5	Resource Idle
7	35	2.14	Resource Idle
8	40	1.87	Resource Idle
9	45	1.66	Resource Idle

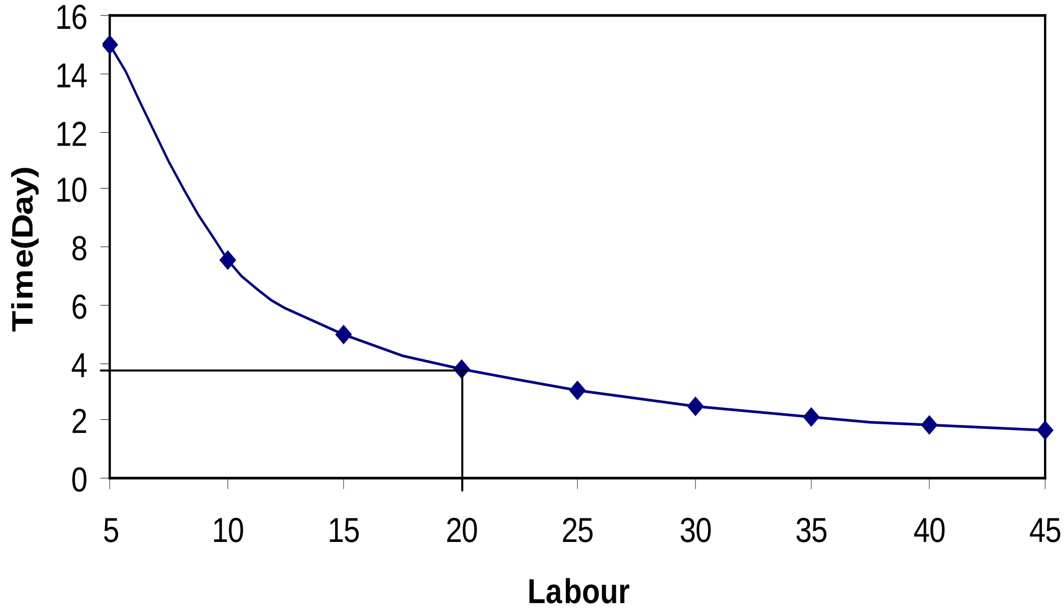

Figure 7.1 : Graphical presentation of labour and time

There fore, analyzing the obtain data's, it is seemed that the optimum number of labour is 15 and the time of site preparation is 5 day's.

7.3 Parameters of Materials Mobilization Work and Optimization.

In Materials mobilization activity, all material collection time is calculated for the project time analysis. Some time transportation problems is affect the time of materials mobilization. In this activity labour for loading, unloading and storage of materials are another main factors for time calculation, as it is a continuous process but for the starting of the project it take few days to mobilize a part of materials. The method of time calculation is same for this activity that is similar project experience method. Depending the storage capacity, Working and storage yard size, loading and unloading labour, time is estimate for the activity. In putting materials quantities and labour number the time is obtained. Changing labour parameter in simulation program the optimum time and labour is found for this activity.

7.4 Parameters of Shore Protection Work and Optimization.

Shore protection work depends on the excavation depth of foundation and site condition. If the site situated beside a highway or any busy road then its required shore piling as the foundation depth is more or basement floor is to be constructed. In the low depth excavation of foundation or basement floor work some times wooden pile is use. Some time guide wall can also protect the shore if the soil condition is good and site condition is also as good that there is a very minimum chance of shore failure. So for different types of shore protection works, different simulation program is required for time calculation. Time changes have been observed by changing of labour parameter in the simulation. So form the different run the optimum time is taken for the project time schedule.

7.5 Parameters of Earth Cutting work and Optimization.

Earth cutting work is done by manual system, using earth cutting labour team, which was around 125 labours. Changing the parameter Labour in this activity the simulation time is shown in Table 10.

Table 10: Earth cutting time optimization

Run	Labour	Days Simulate	Comments
1	50	45.4	
2	75	31.95	
3	**100**	**25.2**	**Optimum**
4	125	21.17	
5	150	18.47	Resource Idle
6	175	16.55	Resource Idle
7	200	15.1	Resource Idle
8	225	13.9	Resource Idle
9	250	13.8	Resource Idle

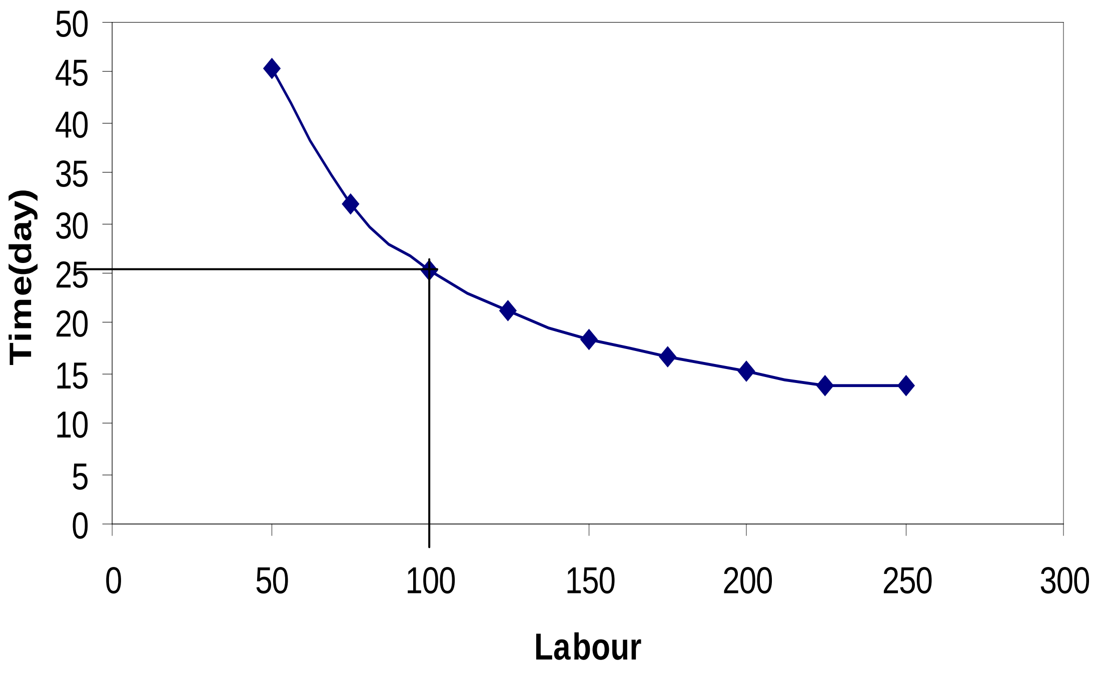

Figure 7.2 : Graphical presentation of labour and time

There fore, analyzing the obtain data's, it is seemed that the optimum number of labour is 100 and the earth cutting time is 25 day's.

7.6 Parameters of Cement Concrete work and Optimization.

Cement concrete work is depends on the number mixing machine. Here labours are included with the mixture machine. Each machine contain fixed number of labour for materials feeding and concrete caring. So changing of machine will automatic fix the labour of the corresponding machine number. Changing the machine parameter in cement concrete simulation, the result is shown in Table 11.

Table 11: Cement concrete work time for optimization

Run	Mixture Machine	Days Simulate	Comments
1	1	4.4	
2	**2**	**2.2**	**Optimum**
3	3	1.4	
4	4	1.1	Resource Idle
5	5	0.8	Resource Idle
6	6	0.7	Resource Idle

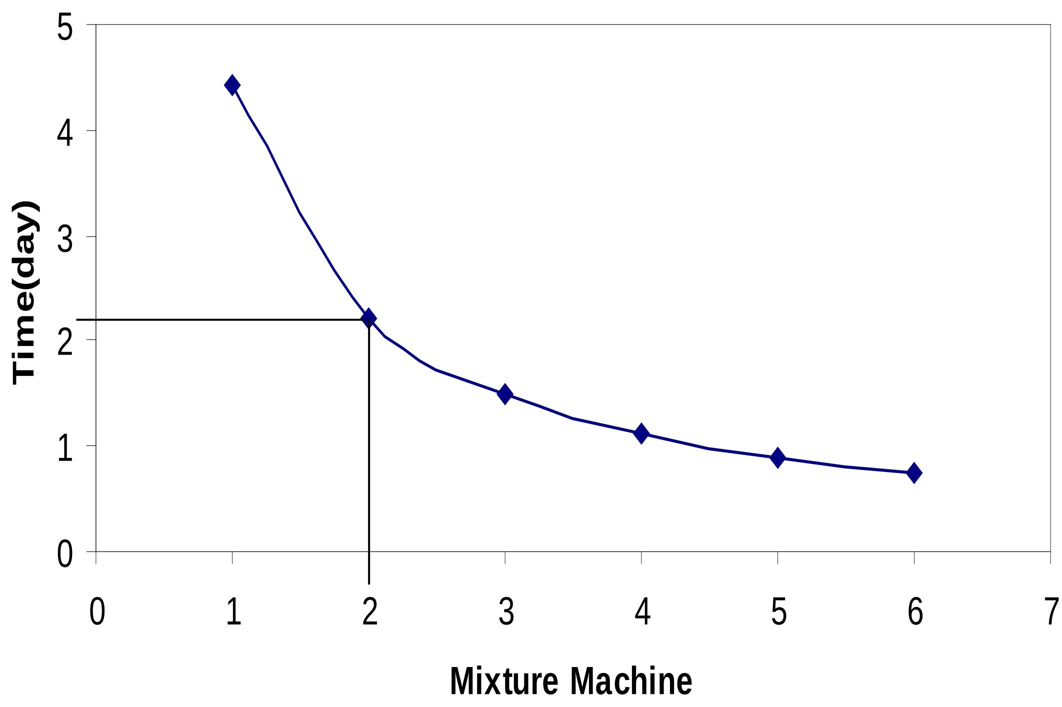

Figure 7.3 : Graphical presentation of mixture machine and time

There fore, analyzing the obtain data's, it is seemed that the optimum number of mixture machine is 2 and the cement concrete work simulation time is 2.2 day's.

7.7 Parameters of Water Proofing Work and Optimization.

Water proofing work is a special type of work that required some extra expertise worker, who are expert in water proofing system. So this a subcontract base work and the time required for this activity is depends on the type of water proofing system. There is some different water proofing systems using different water proofing materials. In general process the time is estimate for this work on the basis of area of mat. Also time is optimizing from changing of water proofing labour.

7.8 Parameters of Ms Bar Laying Work and Optimization.

Ms bar lying work is fully depends on the steel fixing labour. Preparation of bars and laying the bar in the mat is a time consuming work. The mat size and the number of working labour is important parameter for this activity. It is observed that the change of labour parameter in simulation program effect the time more.

7.9 Parameters of Concrete Pouring Work and Optimization.

Concrete pouring work is depends on the number mixing machine. Here labours are included with the mixture machine. Each machine contain fixed number of labour for materials feeding and concrete carrying. So changing of machine will fix the labour of the work and it is observed that simulation time is changes more on changing the parameter machine. From different run of simulation optimum time and machine is found.

Table 12: Concrete pouring work time for optimization

Run	Mixture Machine	Days Simulate	Comments
1	1	31.46	
2	2	15.72	
3	3	10.48	
4	**4**	**7.86**	**Optimum**
5	5	6.3	Resource Idle
6	6	5.2	Resource Idle

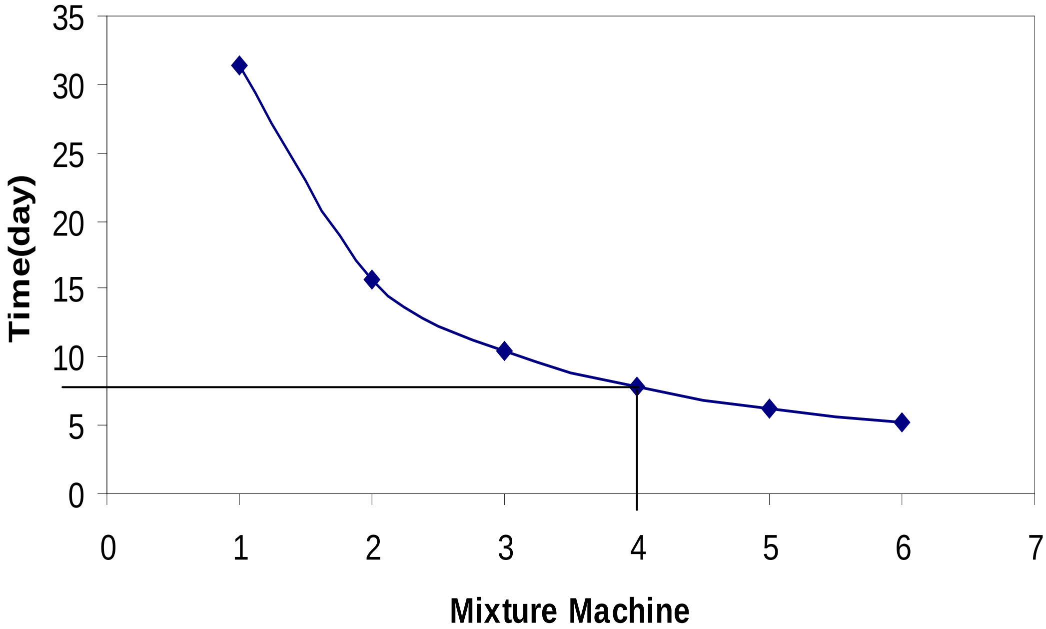

Figure 7.4 : Graphical presentation of mixture machine and time

7.10 Optimization of Time for the Mat simulation.

It has been observed that the changing of labour parameter is effect more on construction time. So the optimization of resources is very essential. It is also observed that maximum and minimum parameter setting is important for resources other wise resource will be shortfall or idle. Considering the local problems, the final optimize time is found form simulation programs.

Table 13 : Final time output of simulation

SL	Name of Activity	Days Simulate
1	Site Preparation	**5**
2	Materials Mobilization	**6**
3	Shore Protection work	**7**
4	Earth cutting Work and Dumping	**25**
5	Cement concrete work in Mat	**3**
6	Guide wall work	**7**
7	Water Proofing Work	**3**
8	MS Bar Laying	**4**
9	Concrete Casting work	**8**
10	Curing Work	**28**

Considering the local problems like labour problems, weather or transportation problems can make delay in the project works, so the local problem effect on simulation program is included. Those problems are set in the simulation with fixed time frame system, Also the problems are included through logical instruction, either it will on or off. For example consider weather problem in a activity will add one day in simulation time.

The list of problem shows that the machinery and materials is also one of them for which the delay can be occurred. From the similar project experience it has been observed that the machine fault is create delays in project works. Using spear machinery at site will optimize the project duration.

Table 14 : List of Problems included in simulation

SL	Site Problem	Set
1	Labour Problem	Yes
2	Weather Problem	Yes
3	Machine Problem	Yes
4	Materials Problem	Yes
5	Transport Problem	yes

Using all simulation program and taking the optimized time for each activities, The maximum time found 96 days including curing work. The optimum time for the mat construction work excluding curing work is 68 day. For the concreter casting process simulation work few case studies is observed for the change of working time in different weather condition.

7.11 Weather Case Study

A network based simulation is use to study some case with different weather condition like normal, moderate and rough. In all those case study the resources are control in numbers and percentages. Considering normal weather condition is an ideal condition when four mixture machine and 100% of other resources are utilized. in moderate weather condition 75% labour may be present at site as a result, 3 mixture machine could run, this weather condition also increase hauling time. For the rough weather condition 50% of labour may not be present at site, so only 2 mixture machine could run and also hauling time is increased 40%. Considering all those conditions and make different network simulation for the weather case study. The result of simulation and case conditions are given in Table 15.

Table 15 : Weather Case Study

Case	Case-1	Case-2	Case-3
Weather	Normal	Moderate	Rough
Machine	4	3	2
Labour	100%	75%	50%
Hauling time	100%	20% incr.	40% incr.
Simulation time	**1783.67(min)**	**2561.12(min)**	**4263.54(min)**

More case studies could be done with more changes in mixing time settings, caring labour settings, Change of dumping time etc. In a Simulation program parameter setting is very important for a perfect result. In this case study section the parameter labour is changed as because in construction work major parts of the works depend on labour. Other parameter hauling time is also affected very much by weather condition. So this is also come in consideration.

Simulation program diagram for Weather Case Study :

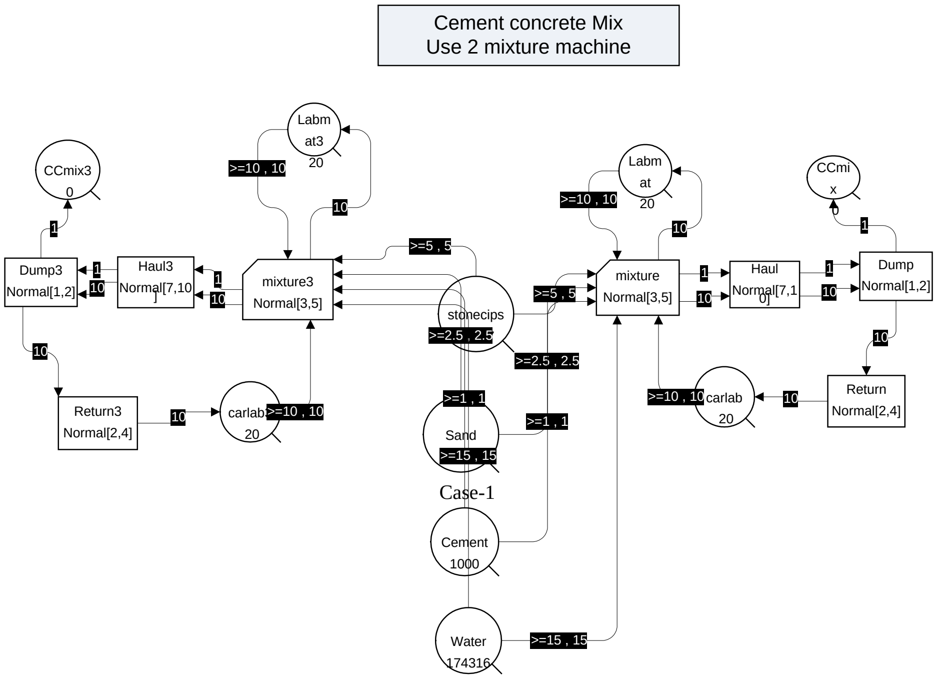

Figure 7.5 : Network Link for Rough Weather Condition. s

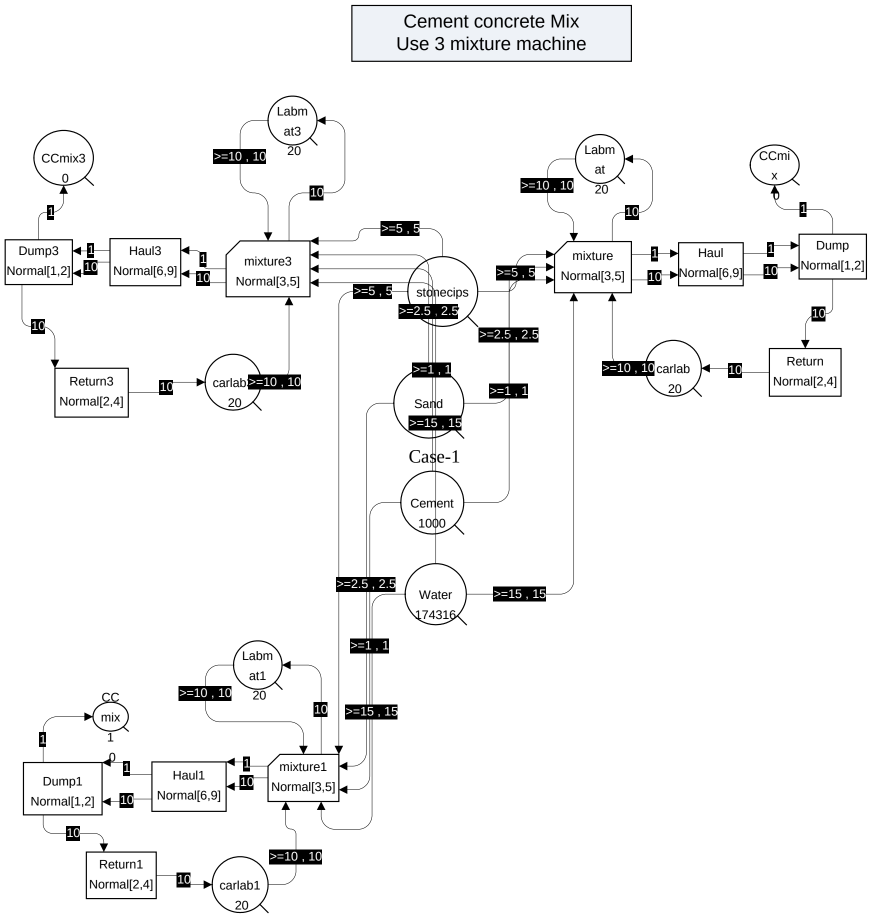

Figure 7.6 : Network Link for Moderate Weather Condition.

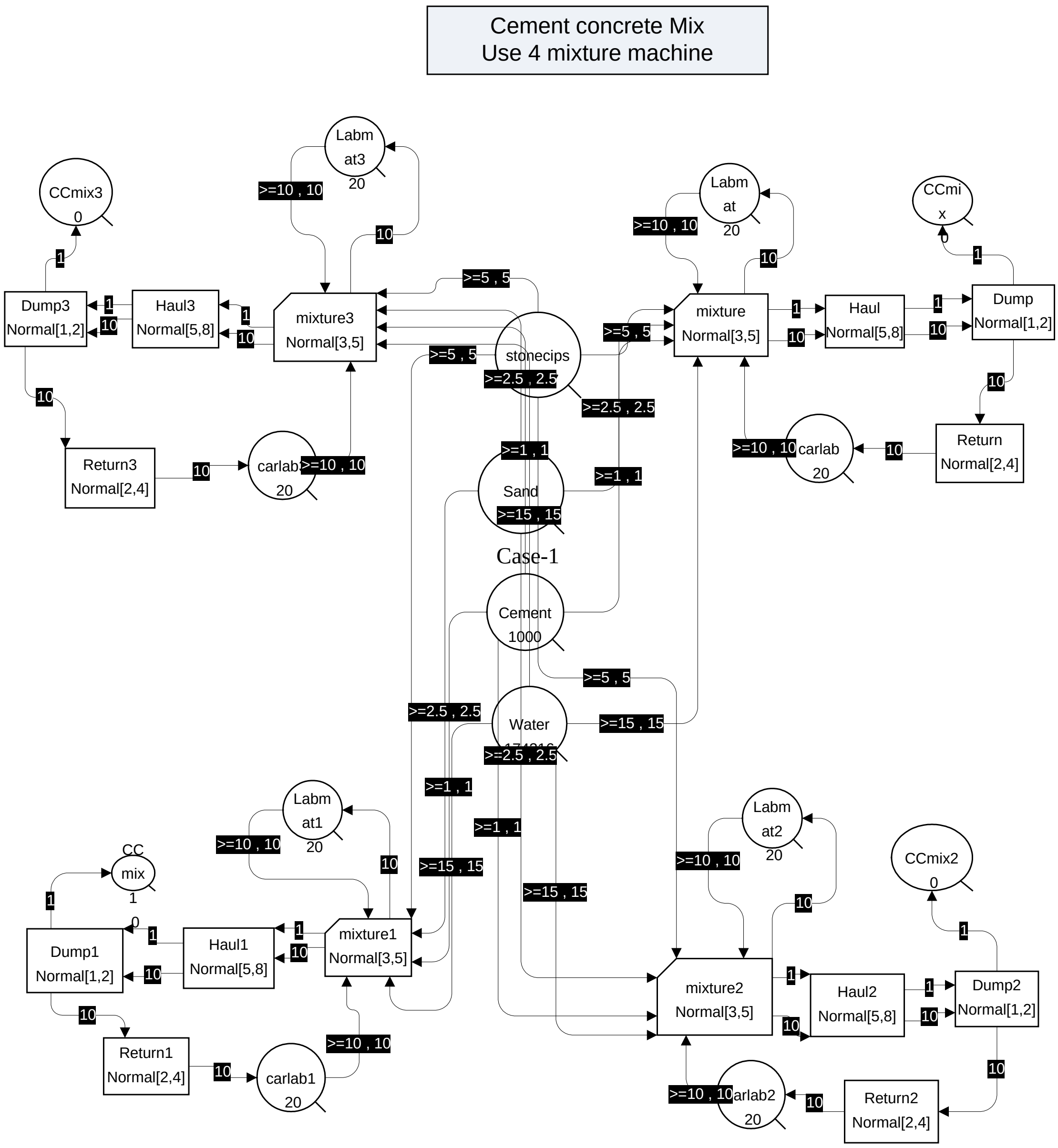

Figure 7.7 : Network Link for Normal Weather Condition.

CHAPTER 8

CONCLUSION AND RECOMANDATION

8.1 Introduction

The main purpose of this project was to make a mat foundation process simulator in a programming language. Using Stroboscope the simulation has been completed and the construction time for the Mat Foundation also simulated. Identify the Activities of Mat foundation, Separate simulation program has been created and simulate the each activity. After that, Put the simulation output in stroboscope Probsched, the bar schedule of the project have been found.

8.2 Conclusion

Mat construction process simulation result shows that labour resource variation make maximum impact on the simulation time. Simulation program also calculate the maximum and minimum durations of the project from which the optimum project time can be estimated. Optimization of resources is found form graphical method and it shows the resource conditions whether it is idle of effective.

Stroboscope is a general simulation program, use for any type of project simulation. In this project work Stroboscope used for simulating Mat construction process. In simulation programs, it is very important to find actual time frame for different activities. The time duration could be calculate in different ways. In this project the duration of mat activity is calculate from similar project experience. Using Mat casting simulation the different time for the project has been simulated, also optimum time and resources are found from the graphical analysis.

There is two Programming systems in Stroboscope. First one is to use built-in function for project simulation and second one is coding system. Built-in function has some limitations, but coding system has no limitation. Also Stroboscope has good connectivity to other specific software like Micro soft Visio, which is a another Microsoft application program. Local construction problems cannot include in built-in function programming system, So, Stroboscope coding system is used to include all local construction problems in simulation program.

Simulation programming system is now a new conception of visualization of a real world work in virtual platform where nothing exists. As a result any alternative could be added as it required. So, the tests could be performed as many as needed for observing the result. Simulation of Mat casting process gives the facility of different type of setting for project time calculation. The simulation system can run as many as it required. Changing parameters, and including problems, many simulations have been run and taken the outputs. Using graphical method the optimum time and resources also calculate from the simulation data.

The Bar schedule has been generated from the simulation result using probsched scheduler of Stroboscope. This scheduler use critical path method to build the time schedule and also link with Microsoft Visio to make bar Schedule and drawings. Using open data base connectivity Stroboscope is connecting with Microsoft Visio. In micro soft Visio there is a user friendly system to draw project networks. In this network drawing process there is no need to write any program code. Only draw project network and simulate. The output will be the same as a coded program output. So, sometime user needs not know the program codes, just studies on the network elements of the stroboscope interface and drag and drop the elements in Microsoft Visio for making any simulation program.

8.3 Recomandation

A separate simulation program could be created for the mat casting process simulation using any virtual language. Using graphical user interface more realistic simulation could be done.

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APPENDIX – A

FLOW CHART

APPENDIX - B

PROGRAMS

B-1 Site Preparation Program

```
DISPLAY"  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !    PROGRAM FOR SITE PREPARATION TIME     !";
DISPLAY"  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";

DISPLAY " ****************************************** " ;
DISPLAY " *    ACTIVITY DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ****************************************** " ;

DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE YEARD_SIZE 2000;
SAVEVALUE OFFICE_SIZE 500;
SAVEVALUE SHADE_SIZE 1000;
SAVEVALUE STORE_SIZE 750;

SAVEVALUE WORKING_LAB 10;

DISPLAY " SITE WORKING YEARD SIZE = " YEARD_SIZE " SFT";
DISPLAY " SITE OFFICE SIZE        = " OFFICE_SIZE " SFT";
DISPLAY " SITE LABOUR SHADE SIZE  = " SHADE_SIZE " SFT";
DISPLAY " SITE STORE SIZE         = " STORE_SIZE " SFT";
DISPLAY " ";

DISPLAY "  SITE PREPARATION LABOUR = " WORKING_LAB " No";

DISPLAY " ";

SAVEVALUE YEARD_PREP_TIME 0;
SAVEVALUE OFFICE_PREP_TIME 0;
SAVEVALUE SHADE_PREP_TIME 0;
SAVEVALUE STORE_PREP_TIME 0;

SAVEVALUE WEATHER_FLAG 1;
SAVEVALUE LABOUR_FLAG 0;
SAVEVALUE MATERIAL_FLAG 0;

SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE MATERIAL_LAG_TIME 0;

SAVEVALUE SITE_PREP_TIME 0;

/ <<<< TIME CALCULATION FOR EACH ACTIVITY >>>>
DISPLAY " ******** TIME CALCULATE FOR EACH ACTIVITY
********";
DISPLAY " ";
```

```
ASSIGN YEARD_PREP_TIME YEARD_SIZE/(WORKING_LAB*100);
IF YEARD_PREP_TIME<1;
ASSIGN YEARD_PREP_TIME 1;
ENDIF;

ASSIGN OFFICE_PREP_TIME OFFICE_SIZE/(WORKING_LAB*10);
IF OFFICE_PREP_TIME<1;
ASSIGN OFFICE_PREP_TIME 1;
ENDIF;

ASSIGN SHADE_PREP_TIME SHADE_SIZE/(WORKING_LAB*20);
IF SHADE_PREP_TIME<1;
ASSIGN SHADE_PREP_TIME 1;
ENDIF;

ASSIGN STORE_PREP_TIME STORE_SIZE/(WORKING_LAB*10);
IF STORE_PREP_TIME<1;
ASSIGN STORE_PREP_TIME 1;
ENDIF;

DISPLAY "WORKING YEARD PREPARATION TIME     = "
YEARD_PREP_TIME " DAY";
DISPLAY "SITE OFFICE PREPARATION TIME       = "
OFFICE_PREP_TIME " DAY";
DISPLAY "LABOUR SHADEYEARD PREPARATION TIME = "
SHADE_PREP_TIME " DAY";
DISPLAY "MATERIALS STORE PREPARATION TIME   = "
STORE_PREP_TIME " DAY";

/ <<< MAXIMUM WORKING DAY CALCULATION >>>>>>>

DISPLAY " ";

IF YEARD_PREP_TIME>OFFICE_PREP_TIME;
SAVEVALUE MAX_DAY1 0;
ASSIGN MAX_DAY1 YEARD_PREP_TIME;
ELSEIF OFFICE_PREP_TIME>YEARD_PREP_TIME;
SAVEVALUE MAX_DAY1 0;
ASSIGN MAX_DAY1 OFFICE_PREP_TIME;
ENDIF;

IF SHADE_PREP_TIME>STORE_PREP_TIME;
SAVEVALUE MAX_DAY2 0;
ASSIGN MAX_DAY2 SHADE_PREP_TIME;
ELSEIF STORE_PREP_TIME>SHADE_PREP_TIME;
SAVEVALUE MAX_DAY2 0;
ASSIGN MAX_DAY2 STORE_PREP_TIME;
ENDIF;

IF MAX_DAY1>MAX_DAY2;
SAVEVALUE MAX_DAY3 0;
```

```
ASSIGN MAX_DAY3 MAX_DAY1;
DISPLAY "MAXIMUM DAY COUNT = " MAX_DAY1 " DAY";
ELSEIF MAX_DAY2>MAX_DAY1;

SAVEVALUE MAX_DAY3 0;
ASSIGN MAX_DAY3 MAX_DAY2;
DISPLAY "MAXIMUM DAY COUNT = " MAX_DAY2 " DAY";
ENDIF;

/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>
IF WEATHER_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF MATERIAL_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;

IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF MATERIAL_FLAG==1;
ASSIGN MATERIAL_LAG_TIME 1;
DISPLAY " ";
DISPLAY " MATERIALS PROBLEM ADDING EXTRA TIME = "
MATERIAL_LAG_TIME " DAY";
ENDIF;

ASSIGN SITE_PREP_TIME
MAX_DAY3+WEATHER_LAG_TIME+LABOUR_LAG_TIME+MATERIAL_LAG_TI
ME;


DISPLAY " ";
```

```
DISPLAY "-------------------------------------------";
DISPLAY " TOTAL SITE PREPARATION TIME = " SITE_PREP_TIME
" DAY";
DISPLAY "-------------------------------------------";

ENDMODEL;
```

B-2 Materials Mobilization Program

```
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !   PROGRAM FOR MATERIALS MOBILIZATION      !";
DISPLAY "!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";
DISPLAY " ******************************************* " ;
DISPLAY " *    ACTIVITY DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ******************************************* " ;

DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE STONE_CHIPS 5000;
SAVEVALUE SAND 3000;
SAVEVALUE CEMENT 1500;
SAVEVALUE MS_BAR 50;
SAVEVALUE SHUTT_MAT 100;

SAVEVALUE MATE_MOBI_LAB 10;

DISPLAY " STONE CHIPS = " STONE_CHIPS/200 " TRUCK";
DISPLAY " SAND        = " SAND/200 " TRUCK";
DISPLAY " CEMENT      = " CEMENT/200 " BAG";
DISPLAY " SHUTTER MAT.= " SHUTT_MAT/100 " TRUCK";
DISPLAY " ";

/DISPLAY "  SITE PREPARATION LABOUR = " WORKING_LAB "
No";

DISPLAY " ";

SAVEVALUE STONE_CAR_TIME 0;
SAVEVALUE SAND_CAR_TIME 0;
SAVEVALUE CEMENT_CAR_TIME 0;
SAVEVALUE MSBAR_CAR_TIME 0;
SAVEVALUE SHUTT_CAR_TIME 0;

SAVEVALUE WEATHER_FLAG 1;
SAVEVALUE LABOUR_FLAG 1;
SAVEVALUE TRANSPORT_FLAG 1;

SAVEVALUE WEATHER_LAG_TIME 0;
```

```
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE TRANSPORT_LAG_TIME 0;

SAVEVALUE MATE_MOBI_TIME 0;

/ <<<< TIME CALCULATION FOR EACH ACTIVITY >>>>

DISPLAY " ******** TIME CALCULATE FOR EACH ACTIVITY
********";
DISPLAY " ";

ASSIGN STONE_CAR_TIME STONE_CHIPS/(200*5);
IF STONE_CAR_TIME<1;
ASSIGN STONE_CAR_TIME 1;
ENDIF;

ASSIGN SAND_CAR_TIME SAND/(200*5);
IF SAND_CAR_TIME<1;
ASSIGN SAND_CAR_TIME 1;
ENDIF;

ASSIGN CEMENT_CAR_TIME CEMENT/(200*5);
IF CEMENT_CAR_TIME<1;
ASSIGN CEMENT_CAR_TIME 1;
ENDIF;

ASSIGN MSBAR_CAR_TIME MS_BAR/(5*2);
IF MSBAR_CAR_TIME<1;
ASSIGN MSBAR_CAR_TIME 1;
ENDIF;

ASSIGN SHUTT_CAR_TIME SHUTT_MAT/(50*2);
IF SHUTT_CAR_TIME<1;
ASSIGN SHUTT_CAR_TIME 1;
ENDIF;

DISPLAY "STONE CHIPS CARING TIME     = " STONE_CAR_TIME "
DAY";
DISPLAY "SAND CARING TIME            = " SAND_CAR_TIME "
DAY";
DISPLAY "CEMENT CARING TIME          = " CEMENT_CAR_TIME
" DAY";
DISPLAY "MS BAR CARING TIME          = " MSBAR_CAR_TIME "
DAY";
DISPLAY "SHUTTER CARING TIME         = " SHUTT_CAR_TIME "
DAY";

/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>
IF WEATHER_FLAG==1;
DISPLAY " ";
```

```
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF TRANSPORT_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;

IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF TRANSPORT_FLAG==1;
ASSIGN TRANSPORT_LAG_TIME 1;
DISPLAY " ";
DISPLAY " TRANSPORT PROBLEM ADDING EXTRA TIME = "
TRANSPORT_LAG_TIME " DAY";
ENDIF;

ASSIGN MATE_MOBI_TIME
STONE_CAR_TIME+SAND_CAR_TIME+CEMENT_CAR_TIME+MSBAR_CAR_TI
ME+SHUTT_CAR_TIME+WEATHER_LAG_TIME+LABOUR_LAG_TIME+TRANSP
ORT_LAG_TIME;

DISPLAY " ";
DISPLAY "-------------------------------------------";
DISPLAY " MATERIALS MOBILIZATION TIME = " MATE_MOBI_TIME
" DAY";
DISPLAY "-------------------------------------------";
ENDMODEL;
```

B-3 Shore Protection Program

```
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !    PROGRAM FOR SHORE PROTECTION           !";
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";
DISPLAY " ****************************************** " ;
DISPLAY " *      SHORE PILING ACTIVITY DETAILS      * " ;
DISPLAY " ****************************************** " ;
DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE NO_OF_PILE 500;
SAVEVALUE NO_OF_RIG 3;

DISPLAY " NUMBER OF SHORE PILE  = " NO_OF_PILE " No";
DISPLAY " NUMBER OF MACHINE FOR PILE DRIVE   = "
NO_OF_RIG " No";

DISPLAY " ";

SAVEVALUE PILE_DRIVING_TIME 0;
SAVEVALUE MACHINE_INST_TIME 0;
SAVEVALUE MACHINE_CLOSE_TIME 0;
SAVEVALUE PILE_COM_TIME 0;
SAVEVALUE WEATHER_FLAG 1;
SAVEVALUE LABOUR_FLAG 1;
SAVEVALUE MACHINE_FLAG 1;
SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE MACHINE_LAG_TIME 0;

/ <<<< TIME CALCULATION FOR PILE DRIVING >>>>

DISPLAY " ******** TIME CALCULATE FOR PILE DRIVING
ACTIVITY ********";
DISPLAY " ";

ASSIGN PILE_DRIVING_TIME NO_OF_PILE/(2*NO_OF_RIG);
IF PILE_DRIVING_TIME<7;
ASSIGN PILE_DRIVING_TIME 7;
ENDIF;
ASSIGN MACHINE_INST_TIME 3;
ASSIGN MACHINE_CLOSE_TIME 2;
DISPLAY "MACHINE INSTALLATION TIME   = "
MACHINE_INST_TIME " DAY";
DISPLAY "PILE DRINVING TIME          = "
PILE_DRIVING_TIME " DAY";
DISPLAY "MACHINE CLOSEING TIME       = "
MACHINE_CLOSE_TIME " DAY";
```

```
/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>

IF WEATHER_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF MACHINE_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;
IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF MACHINE_FLAG==1;
ASSIGN MACHINE_LAG_TIME 2;
DISPLAY " ";
DISPLAY " MACHINE PROBLEM ADDING EXTRA TIME = "
MACHINE_LAG_TIME " DAY";
ENDIF;
ASSIGN PILE_COM_TIME
MACHINE_INST_TIME+PILE_DRIVING_TIME+MACHINE_CLOSE_TIME+WE
ATHER_LAG_TIME+LABOUR_LAG_TIME+MACHINE_LAG_TIME;

DISPLAY " ";
DISPLAY "-------------------------------------------";
DISPLAY " PILE WORK COMPLESSION TIME = " PILE_COM_TIME "
DAY";
DISPLAY "-------------------------------------------";

ENDMODEL;
```

B-4 Earth Cutting and Moving Program

```
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ! PROGRAM FOR EARTH CUTTING AND MOVING TIME !";
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";
DISPLAY " ******************************************* " ;
DISPLAY " *    ACTIVITY DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ******************************************* " ;
DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE EARTH_VOLUME 100000;
SAVEVALUE ECARING_DISTANCE 30;          / INPUT FOR SOIL
CARRING DISTANCE IN METER ( RANGE 30 TO 130 M )

SAVEVALUE ECUT_TIME_DAY 8;              / WORKING TIME
PER DAY
SAVEVALUE ECUT_PER_LAB 5;               / SOIL CUTTING BY
A LABOUR PER HOUR IN ( CFT )
SAVEVALUE ECARING_PER_LAB 4;       / SOIL CARING BY A
LABOUR PER HOUR IN ( CFT )

SAVEVALUE ECUT_LAB 150;

DISPLAY " TOTAL VOLUME OF SOIL TO CUT  = " EARTH_VOLUME "
CFT";
DISPLAY " SOIL DUMPING DISTANCE        = "
ECARING_DISTANCE " M";
DISPLAY " TOTAL LABOUR FOR THE WORK    = " ECUT_LAB "
No";

DISPLAY " ";

SAVEVALUE SOIL_CUT_TIME 0;
SAVEVALUE SOIL_CARING_TIME 0;

SAVEVALUE WEATHER_FLAG 1;               / ********** USE
FLAG FOR PROBLEM ***************
SAVEVALUE LABOUR_FLAG 1;
SAVEVALUE WATER_FLAG 1;

SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE WATER_LAG_TIME 0;
SAVEVALUE ECUT_TIME 0;

/ <<<< TIME CALCULATION FOR EACH ACTIVITY >>>>
DISPLAY " ******** TIME CALCULATE FOR EACH ACTIVITY
********";
DISPLAY " ";
```

```
ASSIGN SOIL_CUT_TIME
EARTH_VOLUME/(ECUT_LAB*0.4*ECUT_TIME_DAY*ECUT_PER_LAB); /
TIME IN DAY
IF SOIL_CUT_TIME<1;
ASSIGN SOIL_CUT_TIME 1;
ENDIF;

IF ECARING_DISTANCE<50;
ASSIGN SOIL_CARING_TIME
EARTH_VOLUME/(ECUT_LAB*0.6*ECUT_TIME_DAY*ECARING_PER_LAB)
; / TIME IN DAY
ENDIF;

IF SOIL_CARING_TIME<1;
ASSIGN SOIL_CARING_TIME 1;
ENDIF;

IF ECARING_DISTANCE>=50;
SAVEVALUE TEST_VAR 0;
SAVEVALUE TEST_FAC 0;
ASSIGN TEST_VAR ECARING_DISTANCE-50;
ASSIGN TEST_FAC (100-TEST_VAR)/100;
ASSIGN SOIL_CARING_TIME
EARTH_VOLUME/(ECUT_LAB*0.6*ECUT_TIME_DAY*ECARING_PER_LAB*
TEST_FAC); / TIME IN HOUR
ENDIF;

IF SOIL_CARING_TIME<1;
ASSIGN SOIL_CARING_TIME 1;
ENDIF;

DISPLAY "SOIL CUTTING TIME      = " SOIL_CUT_TIME " DAY";
DISPLAY "SOIL CARRING TIME      = " SOIL_CARING_TIME "
DAY";

/ <<< MAXIMUM WORKING DAY CALCULATION >>>>>>>

DISPLAY " ";
SAVEVALUE MAX_DAY1 0;

IF SOIL_CUT_TIME>SOIL_CARING_TIME;
ASSIGN MAX_DAY1 SOIL_CUT_TIME;
ELSEIF SOIL_CARING_TIME>SOIL_CUT_TIME;
ASSIGN MAX_DAY1 SOIL_CARING_TIME;
ENDIF;

/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>

IF WEATHER_FLAG==1;
DISPLAY " ";
```

```
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF WATER_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;

IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF WATER_FLAG==1;
ASSIGN WATER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WATER LOGING PROBLEM ADDING EXTRA TIME = "
WATER_LAG_TIME " DAY";
ENDIF;

ASSIGN ECUT_TIME
MAX_DAY1+WEATHER_LAG_TIME+LABOUR_LAG_TIME+WATER_LAG_TIME;

DISPLAY " ";
DISPLAY "-------------------------------------------";
DISPLAY " SOIL CUTTING TIME = " ECUT_TIME " DAY";
DISPLAY "-------------------------------------------";

ENDMODEL;
```

B-5 Concrete Casting Program

```
DISPLAY "
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !    PROGRAM FOR CONCRETE CASTING TIME
CALCULATION   !";
DISPLAY " !      program by :- Engr. AKM RUHUL AMIN
!";
DISPLAY "
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";


DISPLAY " ***************************************** " ;
DISPLAY " *    RESOURCE DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ***************************************** " ;

DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE M 1;      / ***** <INPUT FOR NO OF MIXTURE
MACHINE> *****

SAVEVALUE MIX_MACHINE 0;

SAVEVALUE MIX_CEMENT 100;
SAVEVALUE MIX_SAND_LOCAL 100;
SAVEVALUE MIX_SAND_SYLHET 100;
SAVEVALUE MIX_CHIPS 100;
SAVEVALUE MIX_WATER 2000;

/ <<<< TIME SETUP >>>>

/SAVEVALUE FID_TIME 6;
SAVEVALUE MIX_TIME 3;
SAVEVALUE CAR_TIME 0;
SAVEVALUE DUM_TIME 0;
SAVEVALUE RET_TIME 0;

/ <<<< CALCULATING LABOURS >>>>

SAVEVALUE FID_LABOUR 6*M;
SAVEVALUE CAR_LABOUR 10*M;
SAVEVALUE MACHINE_DRIVER 1*M;

/ <<<< SETING GLOBAL VARIABLES AND SOME OUTPURTS >>>>

SAVEVALUE MIX_VOLUME 5;/ MIX RATIO 1:2:4  WATER CEMENT
RATIO .4

DISPLAY " MIXTURE MACHINE NO = " M " No";
```

```
DISPLAY " ";
DISPLAY " CEMENT              = " MIX_CEMENT " bag";
DISPLAY " LOCAL SAND          = " MIX_SAND_LOCAL " cft";
DISPLAY " SYLHET SAND         = " MIX_SAND_SYLHET " cft";
DISPLAY " STONE CHIPS         = " MIX_CHIPS " cft";
DISPLAY " WATER               = " MIX_WATER " lit";
DISPLAY " FIDDING LABOUR      = " FID_LABOUR " No";
DISPLAY " CARRING LABOUR     = " CAR_LABOUR " No";
DISPLAY " MACHINE DRIVER     = " MACHINE_DRIVER " No";
DISPLAY " ";

DISPLAY " !!!   ****************** << OUT PUTS ARE >>
******************* !!! " ;

DISPLAY " ";


/ $$$$$$$  CASTING CYCLE START $$$$$$$

SAVEVALUE CAST_TIME 0;
SAVEVALUE TOTAL_VOLUME 0;

// <<<< TESTING RESOURCES IF ANY ONE IS ZERO THE CASTING
SIMULATION IS STOPED >>>>

IF MIX_CEMENT<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO CEMENT SHORTAGE
!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                    = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                   = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                   = "
MIX_CHIPS;
DISPLAY " WATER REST                         = "
MIX_WATER;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_LOCAL<=0;
```

```
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO LOCAL SAND
SHORTAGE !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                    = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                   = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                   = "
MIX_CHIPS;
DISPLAY " WATER REST                         = "
MIX_WATER;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_SYLHET<=0;
DISPLAY " ";
DISPLAY " !!!!!  SIMULATION IS STOP DUE TO SYLHET SAND
SHORTAGE   !!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = "
MIX_SAND_LOCAL;

     IF MIX_SAND_SYLHET<0;
     DISPLAY " SYLHET SAND REST              = " 0;
     ELSEIF MIX_SAND_SYLHET>=0;
     DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
     ENDIF;
DISPLAY " STONE CHIPS REST              = " MIX_CHIPS;
DISPLAY " WATER REST                    = " MIX_WATER;
DISPLAY " TOTAL CASTING            = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_CHIPS<=0;
DISPLAY " ";
DISPLAY "!!!!!!   SIMULATION IS STOP DUE TO STONE CHIPS
SHORTAGE  !!!!!";
```

```
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
     IF MIX_CHIPS<0;
     DISPLAY " STONE CHIPS REST              = " 0;
     ELSEIF MIX_CHIPS>=0;
     DISPLAY " STONE CHIPS REST              = "
MIX_CHIPS;
     ENDIF;
DISPLAY " WATER REST                    = " MIX_WATER;
DISPLAY " TOTAL CASTING            = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_WATER<=0;

DISPLAY " ";
DISPLAY "!!!!!   SIMULATION IS STOP DUE TO WATER SHORTAGE
!!!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST              = " MIX_CHIPS;
     IF MIX_WATER<0;
     DISPLAY " WATER REST                    = " 0;
     ELSEIF MIX_WATER>0;
     DISPLAY " WATER REST                    = "
MIX_WATER;
     ENDIF;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;
ENDIF;


/ <<<< SETING AMOUT OF RESOURCES FOR EACH CYCLE  >>>>

SAVEVALUE c 1*M;    / taking cememt 1 bag
SAVEVALUE sl 1*M;   / taking local sand 1 cft
SAVEVALUE ss 1*M;   / taking sylhet sand 1 cft
SAVEVALUE chi 4*M;  / taking stone chips 4 cft
```

```
SAVEVALUE w 14*M;   / taking water for mixing 11 lit

/ASSIGN CAST_TIME FID_TIME+MIX_TIME;

DISPLAY " ";
DISPLAY "  SPEAR MIXTURE MACHINE AT SITE, NO MACHINE
PORBLEM CONSIDER";
DISPLAY " ";

WHILE TOTAL_VOLUME<=2500;

/ <<<< TESTING THE RESOURCE IN EACH CYCLES OF CASTING
>>>>********************

IF MIX_CEMENT<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO CEMENT SHORTAGE
!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                    = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                   = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                   = "
MIX_CHIPS;
DISPLAY " WATER REST                         = "
MIX_WATER;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_LOCAL<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO LOCAL SAND
SHORTAGE !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
```

```
     DISPLAY " LOCAL SAND REST                    = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                    = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                    = "
MIX_CHIPS;
DISPLAY " WATER REST                          = "
MIX_WATER;
DISPLAY " TOTAL CASTING                  = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_SYLHET<=0;
DISPLAY " ";
DISPLAY " !!!!!  SIMULATION IS STOP DUE TO SYLHET SAND
SHORTAGE   !!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                    = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST                = "
MIX_SAND_LOCAL;

     IF MIX_SAND_SYLHET<0;
     DISPLAY " SYLHET SAND REST               = " 0;
     ELSEIF MIX_SAND_SYLHET>=0;
     DISPLAY " SYLHET SAND REST               = "
MIX_SAND_SYLHET;
     ENDIF;
DISPLAY " STONE CHIPS REST               = " MIX_CHIPS;
DISPLAY " WATER REST                     = " MIX_WATER;
DISPLAY " TOTAL CASTING             = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_CHIPS<=0;
DISPLAY " ";
DISPLAY "!!!!!!   SIMULATION IS STOP DUE TO STONE CHIPS
SHORTAGE  !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                    = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST                = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST               = "
MIX_SAND_SYLHET;
     IF MIX_CHIPS<0;
     DISPLAY " STONE CHIPS REST               = " 0;
     ELSEIF MIX_CHIPS>=0;
```

```
     DISPLAY " STONE CHIPS REST              = " 
MIX_CHIPS;
     ENDIF;
DISPLAY " WATER REST                   = " MIX_WATER;
DISPLAY " TOTAL CASTING           = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN " 
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_WATER<=0;

DISPLAY " ";
DISPLAY "!!!!!   SIMULATION IS STOP DUE TO WATER SHORTAGE 
!!!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = " 
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST              = " 
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST              = " MIX_CHIPS;
     IF MIX_WATER<0;
     DISPLAY " WATER REST                    = " 0;
     ELSEIF MIX_WATER>0;
     DISPLAY " WATER REST                    = " 
MIX_WATER;
     ENDIF;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME " 
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;
ENDIF;

/*********************************************************
*******************************


/ <<<< RELESIGN RESOURSCES AND CALCULATION OF TIME AND 
VOLUME >>>>

ASSIGN MIX_MACHINE MIX_MACHINE+M;
ASSIGN MIX_CEMENT MIX_CEMENT-c;
ASSIGN MIX_SAND_LOCAL MIX_SAND_LOCAL-sl;
ASSIGN MIX_SAND_SYLHET MIX_SAND_SYLHET-ss;
ASSIGN MIX_CHIPS MIX_CHIPS-chi;
ASSIGN MIX_WATER MIX_WATER-w;
ASSIGN TOTAL_VOLUME TOTAL_VOLUME+(MIX_VOLUME*M);
ASSIGN CAST_TIME 
CAST_TIME+MIX_TIME+CAR_TIME+DUM_TIME+RET_TIME;
WEND;
```

```
/ <<<< END OF CASTING LOOP AND SHOWING RESULTS >>>>

DISPLAY " NUMBER OF MIXTURE MACHINE RUNNING  = " M " NO";
DISPLAY " TOTAL MACHINE RUN                            = "
MIX_MACHINE;
DISPLAY " TOTAL CASTING                                = "
TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING                        = "
CAST_TIME " MIN " CAST_TIME/60 " HOUR";
DISPLAY " CEMENT REST                                  = "
MIX_CEMENT;
DISPLAY " LOCAL SAND REST                              = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST                             = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                             = "
MIX_CHIPS;
DISPLAY " WATER REST                                   = "
MIX_WATER;

ENDMODEL
```

B-6 Network Element Program

```
/ *  PROGRAM FOR CONCRETE_MIXING using network element *

/ STARTING MESSAGE

DISPLAY "****************************************" ;
DISPLAY "*                                      *" ;
DISPLAY "*   CASTING PROGRAM FOR A ASSIGNMENT   *" ;
DISPLAY "*                                      *" ;
DISPLAY "****************************************" ;
DISPLAY " ";

/ <<< DEFINE VARIABLES AND RESOURCES >>>

VARIABLE M 1;
SAVEVALUE MIXTURE_MACHINE 0;

VARIABLE STONETOCAST 100;
VARIABLE SANDTOCAST 200;
VARIABLE CEMENTTOCAST 100;
VARIABLE WATERTOCAST 2000;

VARIABLE STONECARLAB 6*M;
VARIABLE STONECARLABCAPA 0.5;
VARIABLE SANDCARLAB 3*M;
VARIABLE SANDCARLABCAPA 0.5;
VARIABLE CEMENTCARLAB 1*M;
```

```
VARIABLE CEMENTCARLABCAPA 1;
VARIABLE MACHINE_DRIVER 1*M;

/  << UPGRADE PART  >>>

VARIABLE STONEDRAW 4*M;
VARIABLE SANDDRAW 2*M;
VARIABLE CEMENTDRAW 1*M;
VARIABLE WATERDRAW 0.4*M;
VARIABLE FIDINGLABDRAW 6*M;
VARIABLE CARINGLABDRAW 10*M;
VARIABLE MIXINGAMOUNT
STONEDRAW+SANDDRAW+CEMENTDRAW+WATERDRAW;


///   <<<< END OF UP GRADE  >>

SAVEVALUE FIDING_LAB STONECARLAB+SANDCARLAB+CEMENTCARLAB;
SAVEVALUE CARING_LAB 10*M;

/ *****  [ PART OF UPGRADE ------ 31/12/07  ]

/ SAVEVALUE LABOUR_CAPACITY 0.5;

          // <<<< DISPLAY THE RESOURCE  >>>

ASSIGN MIXTURE_MACHINE M;

DISPLAY " MIXTURE MACHINE     = " MIXTURE_MACHINE " No";
DISPLAY " STONE  IN YARD      = " STONETOCAST " cft";
DISPLAY " SAND   IN YARD      = " SANDTOCAST  " cft";
DISPLAY " CEMETN IN YARD      = " CEMENTTOCAST " bag";
DISPLAY " WATER  IN DRUM      = " WATERTOCAST " cft";

DISPLAY " ";

DISPLAY " MATERIAL CARRING  LABOUR = " FIDING_LAB " No.";
DISPLAY " CONCRETE CARRING  LABOUR = " CARING_LAB " No.";

DISPLAY " ";

     / <<< DEFINE GENERIC RESOURCE TYPE >>>

GENTYPE stonechip;
GENTYPE sand;
GENTYPE cement;
GENTYPE water;
GENTYPE fidlab;
GENTYPE caringlab;
GENTYPE convol;
```

```
     / <<< DEFINE QUEUE >>>

QUEUE stonechips stonechip;
QUEUE sands sand;
QUEUE cements cement;
QUEUE waters water;
QUEUE fidlabs fidlab;
QUEUE caringlabs caringlab;
QUEUE convols convol;

     / <<< DEFINE ACTIVITIES >>>>

COMBI mixture;
NORMAL haul;
NORMAL dump;
NORMAL return;

     / <<< LINKING RESOURCES AND ACTIVITIES >>>

LINK LFLWM fidlabs mixture;
LINK LMWFL mixture fidlabs;
LINK LSTWM stonechips mixture;
LINK LSAWM sands mixture;
LINK LCEWM cements mixture;
LINK LWAWM waters mixture;
LINK LCRLWM caringlabs mixture;
LINK LMWH mixture haul caringlab;
LINK LHWD haul dump caringlab;
LINK LDWR dump return caringlab;
LINK LRWCARL return caringlabs;
LINK LDWCON dump convols;

     / << SETING DURATIONS >>>

DURATION mixture 3;
DURATION haul 1;
DURATION dump 1;
DURATION return 1;
DRAWDUR LSTWM 0;
DRAWDUR LFLWM 0;

     / << DARW AND RELEASE RESOURCES FOR CASTING >>

/IF fidlabs.curcount<6;
DRAWAMT LFLWM 6;
IF fidlabs.CurCount<6;
RELEASEAMT LMWFL 6;
ENDIF;
DRAWAMT LSTWM 4;
DRAWAMT LSAWM 2;
DRAWAMT LCEWM 1;
```

```
DRAWAMT LWAWM 0.4;
DRAWAMT LCRLWM 10;

RELEASEAMT LMWH 5;
RELEASEAMT LHWD 5;
RELEASEAMT LDWCON 5;
RELEASEAMT LDWR CARING_LAB;
RELEASEAMT LRWCARL CARING_LAB;

     / <<< initialization of resource  >>>
INIT stonechips STONETOCAST;
INIT sands SANDTOCAST;
INIT cements CEMENTTOCAST;
INIT waters WATERTOCAST;
INIT fidlabs  FIDING_LAB;
INIT caringlabs CARING_LAB;

SIMULATEUNTIL CEMENTTOCAST<=0;

DISPLAY "*****************************" ;
DISPLAY "*   AUTO GENERATE REPORT    *" ;
DISPLAY "*****************************" ;
DISPLAY " ";

REPORT;

DISPLAY " ";

DISPLAY "Simulation Time = " SimTime/60 " HOURE";

/DISPLAY SimTime;

DISPLAY "****************************************" ;
DISPLAY "*         USER DEFINE OUT PUT          *" ;
DISPLAY "****************************************" ;

DISPLAY " ";

DISPLAY "TOTAL CASTING             = " convols.TotCount " cft";
DISPLAY "STONE CHIPS IN YEARD      = " stonechips.CurCount " cft";
DISPLAY "SAND IN YEARD             = " sands.CurCount " cft";
DISPLAY "CEMENT IN YEARD           = " cements.CurCount " cft";
DISPLAY "WATER IN DRUM             = " waters.CurCount " cft";
ENDMODEL;
```

Appendix – C

SIMULATION RESULTS

C-1 Details of Mat Foundation

Area of Mat Foundation : 165' x 93' + 25 x 33 = 16170 sft
Depth of Mat Foundation : 48 inch
Volume of cc work (3" cc 1:2:4) = 16170 X 0.25 = **4042.5** cft
Volume of Concrete pouring = 16170 X 3.25 = **52,552.5** cft
Earth Cutting Volume = 16170 X 10 = **161700** cft
Location : Board Bazar, Gazipur.
Owner : Uni-Gears Limited.

<u>Target time of completion = 62 days</u>. (Excluding Curing Time).

Estimated Materials for the work
For CC Work :

Total Casting Volume = **4042.5** cft
Stone chips = 3638.25 cft
Sand = 2021.25 cft
Cement = 727.65 bag

For Concrete pouring Work :

Total Casting Volume = **52,552.5** cft
Stone chips = 47297.25 cft
Sand = 26276.25 cft
Cement = 11561.55 bag

For Steel Work :

Total Weight of Ms Bar :

Short Bar length	=	93 X133	= 12369 rftt
Long Bar length	=	165 X186	= 30690 rft
Short Bar length	=	25 X67	= 1675 rftt
Long Bar length	=	33 X51	= 1683 rft
		Total	= 46,417 rft

Weight = 92,834 kg

Simulation Result

C-2 Site Preparation Result

Stroboscope Model Drawing2 (1942949120)

Number of replications performed : 500

Average Project Duration : 4.00

Std. Dev. of Project Duration : 0.00

Average Project Cost : 69769.06

Std. Dev. of Project Cost : 6278.71

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
YEARDPREP	2.00	0.00	2.00	2.00	4.00	2.00	2.00	0.00%	14953.61
LABOURSHADE	3.00	0.00	1.00	3.00	4.00	1.00	1.00	0.00%	9967.19
OFFICE	4.00	0.00	0.00	4.00	4.00	0.00	0.00	100.00%	19940.30
STORE	4.00	0.00	0.00	4.00	4.00	0.00	0.00	100.00%	24907.96

C-3 Materials Mobilization Result

Stroboscope Model Drawing2 (1178370816)

Number of replications performed : 500

Average Project Duration : 5.00

Std. Dev. of Project Duration : 0.00

Average Project Cost : 1549170.29

Std. Dev. of Project Cost : 32321.98

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
CEMENT	2.00	0.00	3.00	2.00	5.00	3.00	3.00	0.00%	749872.53
SAND	2.00	0.00	3.00	2.00	5.00	3.00	3.00	0.00%	50167.28
MSBAR	5.00	0.00	0.00	5.00	5.00	0.00	0.00	100.00%	299415.99
STONECHIPS	3.00	0.00	2.00	3.00	5.00	2.00	2.00	0.00%	399327.74
WOOD	2.00	0.00	3.00	2.00	5.00	3.00	3.00	0.00%	50386.76

C-4 Earth Cutting and Moving Result

```
Stroboscope Model 09_EARTH_CUT_escavator (28355328)


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! PROGRAM FOR EARTH CUTTING AND MOVING TIME CALCULATION
!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************
 TOTAL VOLUME OF SOIL TO CUT  = 161700 CFT
 SOIL DUMPING DISTANCE        = 150 M
 NUMBER OF EXCAVATOR          = 1 No
  ******** TIME CALCULATE FOR EACH ACTIVITY ********
 SOIL CUTTING TIME      = 22.458333 DAY
  !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
  LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

-------------------------------------------
 SOIL CUTTING TIME = 23.458333 DAY
-------------------------------------------
```

C-5 Cement Concrete Work Result

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 ******************************************
 MIXTURE MACHINE NO = 2 No
 CEMENT             = 800 bag
 LOCAL SAND         = 1000 cft
 SYLHET SAND        = 1000 cft
 STONE CHIPS        = 4000 cft
 WATER              = 12000 lit
 FIDDING LABOUR     = 12 No
 CARRING LABOUR     = 20 No
 MACHINE DRIVER     = 2 No

!!  ************** << OUT PUTS ARE >> *************** !!!
 SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
 NUMBER OF MIXTURE MACHINE RUNNING = 2 NO
 TOTAL MACHINE RUN                 = 710
 TOTAL CASTING                     = 4047
 TOTAL TIME OF CASTING             = 1065 MIN 17.75 HOUR
 CEMENT REST                       = 90
 LOCAL SAND REST                   = 290
 SYLHET SAND REST                  = 290
 STONE CHIPS REST                  = 1160
 WATER REST                        = 2060
```

C-6 Concrete Pouring Result

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

*******************************************
*    RESOURCE DETAILS ARE GIVEN BELOW     *
*******************************************
MIXTURE MACHINE NO = 4 No
CEMENT             = 6000 bag
LOCAL SAND         = 10000 cft
SYLHET SAND        = 7000 cft
STONE CHIPS        = 30000 cft
WATER              = 100000 lit
FIDDING LABOUR     = 24 No
CARRING LABOUR     = 40 No
MACHINE DRIVER     = 4 No
 !!! ******** << OUT PUTS ARE >> ************** !!!
SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
NUMBER OF MIXTURE MACHINE RUNNING      = 4 NO
TOTAL MACHINE RUN                      = 5520
TOTAL CASTING                          = 48024
TOTAL TIME OF CASTING        = 3455.5 MIN 57.591667 HOUR
CEMENT REST                  = 480
LOCAL SAND REST              = 1720
SYLHET SAND REST             = 1480
STONE CHIPS REST             = 2400
WATER REST                   = 17200
```

C-7 Mat Casting Result

Stroboscope Model Drawing2 (1617951744)

Number of replications performed : 500

<u>Average Project Duration : 86.00</u>

Std. Dev. of Project Duration : 0.00

Average Project Cost : 0.00

Std. Dev. of Project Cost : 0.00

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
Curing	28.00	58.00	58.00	86.00	86.00	0.00	0.00	100.00%	0.00
CCWork	3.00	33.00	33.00	36.00	36.00	0.00	0.00	100.00%	0.00
MsBarprepa	7.00	9.00	38.00	16.00	45.00	29.00	29.00	0.00%	0.00
Msparlaying	7.00	45.00	45.00	52.00	52.00	0.00	0.00	100.00%	0.00
MaterialsMobi	5.00	4.00	33.00	9.00	38.00	0.00	29.00	0.00%	0.00
Guidewall	5.00	36.00	36.00	41.00	41.00	0.00	0.00	100.00%	0.00
Waterproof	4.00	41.00	41.00	45.00	45.00	0.00	0.00	100.00%	0.00
Shoreprotect	5.00	4.00	4.00	9.00	9.00	0.00	0.00	100.00%	0.00
Sitepreparation	4.00	0.00	0.00	4.00	4.00	0.00	0.00	100.00%	0.00
Concretecast	6.00	52.00	52.00	58.00	58.00	0.00	0.00	100.00%	0.00
Earthcutting	24.00	9.00	9.00	33.00	33.00	0.00	0.00	100.00%	0.00

Appendix – D

SIMULATION OUT PUTS

D-1 Program Out Put – 1

User Define Programming

```
Stroboscope Model 05_CON_MIX_CAL_02 (412749952)
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 *******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 *******************************************
 MIXTURE MACHINE NO = 1 No
 CEMENT             = 100 bag
 LOCAL SAND         = 100 cft
 SYLHET SAND        = 100 cft
 STONE CHIPS        = 100 cft
 WATER              = 2000 lit
 Material LABOUR    = 6 No
 CARRING LABOUR     = 10 No
 MACHINE DRIVER     = 1 No
  /******* << OUT PUTS ARE >> *************
SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
!!! SIMULATION IS STOP DUE TO STONE CHIPS SHORTAGE  !!!!!
 NO OF MIXTURE MACHINE RUN    = 25
 CEMENT REST                  = 75
 LOCAL SAND REST              = 75
 SYLHET SAND REST             = 75
 STONE CHIPS REST             = 0
 WATER REST                   = 1650
 TOTAL CASTING                = 125
 TOTAL TIME OF CASTING   = 75 MIN 1.25 HOUR
```

D-2 Program Out Put – 2

Using Built-in Functions in Programming

```
Stroboscope Model CONCRETE_MIX_upgrade (1474211968)
****************************************
*   CASTING PROGRAM FOR A ASSIGNMENT   *
****************************************
 MIXTURE MACHINE    = 1 No
 STONE  IN YARD     = 100 cft
 SAND   IN YARD     = 200 cft
 CEMETN IN YARD     = 100 bag
 WATER  IN DRUM     = 2000 cft
 MATERIAL CARRING  LABOUR = 6 No.
 CONCRETE CARRING  LABOUR = 10 No.
*****************************
*   AUTO GENERATE REPORT    *
*****************************
```

Statistics report at simulation time 75

```
Queue          Res             Cur       Tot   AvWait
AvCont    SDCont MinCont   MaxCont
=========================================================
==
caringlabs     caringlab      10.00    260.00    0.00
0.00      0.00    0.00     10.00
cements        cement         75.00    100.00   65.25
87.00      7.21   75.00    100.00
convols        convol        125.00    125.00   36.00
60.00     36.06    0.00    125.00
fidlabs        fidlab         10.00    160.00    1.88
4.00      0.00    4.00     10.00
sands          sand          150.00    200.00   65.25
174.00     14.42  150.00    200.00
stonechips     stonechip       0.00    100.00   36.00
48.00     28.84    0.00    100.00
```

```
waters          water         1990.00   2000.00   74.80
1994.80       2.88 1990.00   2000.00
Activity          Cur      Tot      1stSt      LstSt    AvDur
SDDur   MinD     MaxD   AvInt  SDInt     MinI     MaxI
=========================================================
==
dump               0       25       3.00      75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
haul               0       25       3.00      75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
mixture            0       25       0.00      72.00    3.00
0.00   3.00    3.00    3.00   0.00    3.00    3.00
return             0       25       3.00      75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
```

The Future Events List is empty at simulation time 75.00

```
Total Number of Named Objects : 38
Total Number of Variables : 61
Total Number of Statements : 112
```

Simulation Time = 1.25 HOURE

```
****************************************
*         USER DEFINE OUT PUT          *
****************************************
TOTAL CASTING             = 125 cft
STONE CHIPS IN YEARD      = 0 cft
SAND IN YEARD             = 150 cft
CEMENT IN YEARD           = 75 cft
WATER IN DRUM                  = 1990 cft
```

D-3 Program Out Put – 3

Using Visio Block Networks in Programming

```
Stroboscope Model concretmix.vsd (997558400)
```

<u>Statistics report at simulation time 75</u>

```
Queue     Res              Cur       Tot   AvWait
AvCont    SDCont MinCont   MaxCont
=========================================================
==
CCmix    ezs           125.00    125.00   36.00     60.00
36.06    0.00    125.00
Cement     ezs            75.00    100.00   65.25
87.00      7.21   75.00    100.00
Labmat     ezs             6.00    156.00    0.00
0.00      0.00    0.00      6.00
Sand      ezs            50.00    100.00   55.50
74.00     14.42   50.00    100.00
Water     ezs          1625.00   2000.00   67.69
1805.00    108.17 1625.00   2000.00
carlab    ezs            20.00    270.00    2.78
10.00      0.00   10.00     20.00
stonecips ezs             0.00    100.00   36.00
48.00     28.84    0.00    100.00
Activity        Cur     Tot      1stSt     LstSt   AvDur
SDDur   MinD    MaxD   AvInt  SDInt    MinI    MaxI
=========================================================
==
Dump     0      25      3.00     75.00    0.00   0.00
0.00    0.00    3.00   0.00    3.00    3.00
Haul              0      25      3.00     75.00     0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
Return            0      25      3.00     75.00     0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
mixture           0      25      0.00     72.00     3.00
0.00   3.00    3.00    3.00   0.00    3.00    3.00
```

The Future Events List is empty at simulation time 75.00

Total Number of Named Objects : 36

Total Number of Variables : 63

Total Number of Statements : 16

D-4 Program Out Put – 4

User Define Programming

```
Stroboscope Model 05_CON_MIX_CAL_02 (1843159168)
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 *******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 *******************************************
 MIXTURE MACHINE NO = 1 No
 CEMENT             = 100 bag
 LOCAL SAND         = 100 cft
 SYLHET SAND        = 100 cft
 STONE CHIPS        = 100 cft
 WATER              = 2000 lit
 FIDDING LABOUR     = 6 No
 CARRING LABOUR     = 10 No
 MACHINE DRIVER     = 1 No
!! ************ << OUT PUTS ARE >> *******************
!!!
SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
!!!   SIMULATION IS STOP DUE TO STONE CHIPS SHORTAGE
!!!!!
 NO OF MIXTURE MACHINE RUN    = 25
 CEMENT REST                  = 75
 LOCAL SAND REST              = 75
 SYLHET SAND REST             = 75
```

```
 STONE CHIPS REST             = 0
 WATER REST                   = 1650
 TOTAL CASTING                = 125
```

TOTAL TIME OF CASTING   = 150 MIN 2.5 HOUR

D-5 Program Out Put – 5

Using Built-in Function in Programming

```
Stroboscope Model CONCRETE_MIX_upgrade (630943872)
****************************************
*   CASTING PROGRAM FOR A ASSIGNMENT   *
****************************************
 MIXTURE MACHINE    = 1 No
 STONE  IN YARD     = 100 cft
 SAND   IN YARD     = 200 cft
 CEMETN IN YARD     = 100 bag
 WATER  IN DRUM     = 2000 cft
 MATERIAL CARRING  LABOUR = 6 No.
 CONCRETE CARRING  LABOUR = 10 No.
*****************************
*   AUTO GENERATE REPORT    *
*****************************
```

Statistics report at simulation time 150

```
Queue           Res              Cur       Tot   AvWait
AvCont     SDCont MinCont   MaxCont
=========================================================
==
caringlabs     caringlab       10.00    260.00     0.00
0.00       0.00    0.00     10.00
cements         cement         75.00    100.00   130.50
87.00       7.21   75.00    100.00
convols         convol        125.00    125.00    73.00
60.83      36.10    0.00    125.00
```

```
fidlabs        fidlab         10.00    160.00    6.56
7.00      3.00    4.00     10.00
sands          sand          150.00    200.00  130.50
174.00     14.42  150.00    200.00
stonechips     stonechip       0.00    100.00   72.00
48.00     28.84    0.00    100.00
waters         water        1990.00   2000.00  149.61
1994.80      2.88 1990.00   2000.00
Activity        Cur      Tot      1stSt     LstSt   AvDur
SDDur   MinD    MaxD   AvInt  SDInt    MinI    MaxI
=========================================================
==
dump              0       25       4.00    148.00    1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
haul              0       25       3.00    147.00    1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
mixture           0       25       0.00    144.00    3.00
0.00   3.00    3.00    6.00   0.00    6.00    6.00
return            0       25       5.00    149.00    1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
```

The Future Events List is empty at simulation time 150.00

```
Total Number of Named Objects : 38
Total Number of Variables : 61
Total Number of Statements : 112
```

Simulation Time = 2.5 HOURE

```
****************************************
*         USER DEFINE OUT PUT          *
****************************************
TOTAL CASTING            = 125 cft
STONE CHIPS IN YEARD     = 0 cft
SAND IN YEARD            = 150 cft
CEMENT IN YEARD          = 75 cft
WATER IN DRUM            = 1990 cft
```

D-6 Program Out Put – 6

Using Visio Block Network Programming

```
Stroboscope Model concretmix.vsd (1804417152)
```

Statistics report at simulation time 150

```
Queue          Res              Cur       Tot  AvWait
AvCont    SDCont MinCont   MaxCont
=========================================================
==
CCmix          ezs           125.00    125.00   73.00
60.83     36.10    0.00    125.00
Cement         ezs            75.00    100.00  130.50
87.00      7.21   75.00    100.00
Labmat         ezs             6.00    156.00    2.88
3.00      3.00    0.00      6.00
Sand           ezs            50.00    100.00  111.00
74.00     14.42   50.00    100.00
Water          ezs          1625.00   2000.00  135.38
1805.00    108.17 1625.00   2000.00
carlab         ezs            10.00    260.00    0.00
0.00      0.00    0.00     10.00
stonecips      ezs             0.00    100.00   72.00
48.00     28.84    0.00    100.00
Activity         Cur      Tot      1stSt      LstSt    AvDur
SDDur   MinD     MaxD    AvInt  SDInt    MinI     MaxI
=========================================================
==
Dump               0       25       4.00     148.00     1.00
0.00   1.00     1.00    6.00   0.00     6.00     6.00
Haul               0       25       3.00     147.00     1.00
0.00   1.00     1.00    6.00   0.00     6.00     6.00
Return             0       25       5.00     149.00     1.00
0.00   1.00     1.00    6.00   0.00     6.00     6.00
```

```
mixture           0      25      0.00    144.00    3.00
0.00   3.00    3.00    6.00   0.00    6.00    6.00
```

<u>The Future Events List is empty at simulation time 150.00</u>

Total Number of Named Objects : 36

Total Number of Variables : 63

Total Number of Statements : 16

Appendix – E

PARAMETRIC STUDY OUT PUTS

E-1 Parametric Study – 1

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 *******************************************

 MIXTURE MACHINE NO = 3 No

 CEMENT             = 800 bag
 LOCAL SAND         = 1000 cft
 SYLHET SAND        = 1000 cft
 STONE CHIPS        = 4000 cft
 WATER              = 12000 lit
 FIDDING LABOUR     = 18 No
 CARRING LABOUR     = 30 No
 MACHINE DRIVER     = 3 No

!!!   ****************** << OUT PUTS ARE >>********** !!!

 SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER

 NUMBER OF MIXTURE MACHINE RUNNING = 3 NO
 TOTAL MACHINE RUN                 = 711
 TOTAL CASTING                     = 4052.7
 TOTAL TIME OF CASTING             = 711 MIN 11.85 HOUR
 CEMENT REST                       = 89
 LOCAL SAND REST                   = 289
 SYLHET SAND REST                  = 289
 STONE CHIPS REST                  = 1156
 WATER REST                        = 2046

-------------------------------------
Execution    Time = 0.125 seconds


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 *******************************************

 MIXTURE MACHINE NO = 3 No
```

```
 CEMENT              = 6000 bag
 LOCAL SAND          = 10000 cft
 SYLHET SAND         = 7000 cft
 STONE CHIPS         = 30000 cft
 WATER               = 100000 lit
 FIDDING LABOUR      = 18 No
 CARRING LABOUR      = 30 No
 MACHINE DRIVER      = 3 No

!!!   ****************** << OUT PUTS ARE >> **********
!!!


SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER

 NUMBER OF MIXTURE MACHINE RUNNING = 3 NO
 TOTAL MACHINE RUN                 = 5523
 TOTAL CASTING                     = 48050.1
```
TOTAL TIME OF CASTING = 4602.5 MIN 76.708333

```
 HOUR
 CEMENT REST                       = 477
 LOCAL SAND REST                   = 4477
 SYLHET SAND REST                  = 1477
 STONE CHIPS REST                  = 7908
 WATER REST                        = 22678

-------------------------------------
Execution    Time = 0.515 seconds
```

E-2 Parametric Study – 2

```
Stroboscope Model 01_Site_preparation (1756636928)

 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR SITE PREPARATION TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************

 SITE WORKING YEARD SIZE = 2000 SFT
 SITE OFFICE SIZE        = 500 SFT
 SITE LABOUR SHADE SIZE  = 1000 SFT
 SITE STORE SIZE         = 750 SFT

  SITE PREPARATION LABOUR = 15 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********
```

```
WORKING YEARD PREPARATION TIME     = 1.3333333 DAY
SITE OFFICE PREPARATION TIME       = 3.3333333 DAY
LABOUR SHADEYEARD PREPARATION TIME = 3.3333333 DAY
MATERIALS STORE PREPARATION TIME   = 5 DAY

MAXIMUM DAY COUNT = 5 DAY

-------------------------------------------
 TOTAL SITE PREPARATION TIME = 5 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.062 seconds

Stroboscope Model Drawing2 (1505480832)

Number of replications performed : 500
Average Project Duration         : 5.98
Std. Dev. of Project Duration    : 0.96
Average Project Cost             : 1550368.02
Std. Dev. of Project Cost        : 35659.13


CPM Activity     Time    ESD    LSD    EFD    LFD     FF
TF %Critic   Cost
=========================================================
=====================
CEMENT           2.92   0.00   3.06   2.92   5.98   3.06
3.06   2.20% 751496.79
SAND             1.98   0.00   4.01   1.98   5.98   4.01
4.01   0.20% 49703.24
MSBAR            3.00   0.00   2.99   3.00   5.98   2.99
2.99   1.40% 299492.42
STONECHIPS       5.95   0.00   0.03   5.95   5.98   0.03
0.03  93.60% 399956.37
WOOD             3.01   0.00   2.97   3.01   5.98   2.97
2.97   2.60% 49719.19

-------------------------------------
Execution    Time = 3.344 seconds


Stroboscope Model 09_EARTH_CUT_escavator (1763087360)


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! PROGRAM FOR EARTH CUTTING AND MOVING TIME CALCULATION
!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************

 TOTAL VOLUME OF SOIL TO CUT  = 161700 CFT
 SOIL DUMPING DISTANCE        = 150 M
 NUMBER OF EXCAVATOR          = 1 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********

SOIL CUTTING TIME      = 22.458333 DAY

 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 LABOUR PROBLEM ADDING EXTRA TIME = 3 DAY

-------------------------------------------
```

SOIL CUTTING TIME = 25.458333 DAY

```
-------------------------------------------

-------------------------------------
Execution    Time = 0.063 seconds
```

E-3 Parametric Study – 3

Stroboscope Model 01_Site_preparation (1419852800)

```
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR SITE PREPARATION TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************

 SITE WORKING YEARD SIZE = 2000 SFT
 SITE OFFICE SIZE        = 500 SFT
 SITE LABOUR SHADE SIZE  = 1000 SFT
 SITE STORE SIZE         = 750 SFT

  SITE PREPARATION LABOUR = 20 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********

WORKING YEARD PREPARATION TIME     = 1 DAY
SITE OFFICE PREPARATION TIME       = 2.5 DAY
LABOUR SHADEYEARD PREPARATION TIME = 2.5 DAY
MATERIALS STORE PREPARATION TIME   = 3.75 DAY

MAXIMUM DAY COUNT = 3.75 DAY
```

```
 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 WEATHER PROBLEM ADDING EXTRA TIME = 2 DAY

 LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

 MATERIALS PROBLEM ADDING EXTRA TIME = 1 DAY

-------------------------------------------
 TOTAL SITE PREPARATION TIME = 7.75 DAY
-------------------------------------------

-------------------------------------

 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !      PROGRAM FOR MATERIALS MOBILIZATION           !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************

 STONE CHIPS = 25 TRUCK
 SAND        = 15 TRUCK
 CEMENT      = 7.5 BAG
 SHUTTER MAT.= 1 TRUCK


 ******** TIME CALCULATE FOR EACH ACTIVITY ********

STONE CHIPS CARING TIME     = 5 DAY
SAND CARING TIME            = 3 DAY
CEMENT CARING TIME          = 1.5 DAY
MS BAR CARING TIME          = 5 DAY
SHUTTER CARING TIME         = 1 DAY

 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 WEATHER PROBLEM ADDING EXTRA TIME = 2 DAY

 LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

 TRANSPORT PROBLEM ADDING EXTRA TIME = 1 DAY

-------------------------------------------
 MATERIALS MOBILIZATION TIME = 9 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.062 seconds
```

```
Stroboscope Model 09_EARTH_CUT_escavator (630008320)


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! PROGRAM FOR EARTH CUTTING AND MOVING TIME CALCULATION
!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 ******************************************

 TOTAL VOLUME OF SOIL TO CUT  = 161700 CFT
 SOIL DUMPING DISTANCE        = 150 M
 NUMBER OF EXCAVATOR          = 1 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********

SOIL CUTTING TIME      = 22.458333 DAY

 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 WEATHER PROBLEM ADDING EXTRA TIME = 2 DAY

 LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

 WATER LOGING PROBLEM ADDING EXTRA TIME = 2 DAY

-------------------------------------------
 SOIL CUTTING TIME = 27.458333 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.062 seconds
```

Stroboscope Model Drawing1 (1719242752)

Number of replications performed : 500
Average Project Duration : 85.59
Std. Dev. of Project Duration : 9.01
Average Project Cost : 0.00
Std. Dev. of Project Cost : 0.00

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
Curing	14.24	71.35	71.35	85.59	85.59	0.00	-0.00	100.00%	0.00
CCWork	6.00	43.00	43.00	49.00	49.00	0.00	-0.00	100.00%	0.00
MsBarprepa	5.00	17.00	51.34	22.00	56.34	34.34	34.34	0.00%	0.00
Msparlaying	5.01	56.34	56.34	61.35	61.35	0.00	-0.00	100.00%	0.00
MaterialsMobi	9.00	8.00	42.34	17.00	51.34	0.00	34.34	0.00%	0.00
Guidewall	3.84	49.00	49.00	52.84	52.84	-0.00	-0.00	100.00%	0.00
Waterproof	3.50	52.84	52.84	56.34	56.34	0.00	-0.00	100.00%	0.00
Shoreprotect	7.00	8.00	8.00	15.00	15.00	0.00	-0.00	100.00%	0.00
Sitepreparation	8.00	0.00	-0.00	8.00	8.00	0.00	-0.00	100.00%	0.00
Concretecast	10.00	61.35	61.35	71.35	71.35	-0.00	-0.00	100.00%	0.00
Earthcutting	28.00	15.00	15.00	43.00	43.00	0.00	-0.00	100.00%	0.00

Execution Time = 0.844

Case study Outputs:

Stroboscope Model **4machine_case_study.vsd** (129735872)

Statistics report at simulation time **1805.42**

Queue	Res	Cur	Tot	AvWait	AvCont	SDCont	MinCont	MaxCont
CCmix	ezs	265.00	265.00	875.82	128.55	76.54	0.00	265.00
CCmix1	ezs	249.00	249.00	911.74	125.74	73.10	0.00	249.00
CCmix2	ezs	251.00	251.00	906.72	126.06	74.05	0.00	251.00
CCmix3	ezs	235.00	235.00	894.14	116.38	68.37	0.00	235.00
Cement	ezs	0.00	1000.00	897.15	496.92	291.84	0.00	1000.00
Labmat	ezs	20.00	2670.00	9.95	14.72	6.15	0.00	20.00
Labmat1	ezs	20.00	2510.00	10.58	14.71	6.29	0.00	20.00
Labmat2	ezs	20.00	2530.00	10.27	14.39	6.43	0.00	20.00
Labmat3	ezs	20.00	2370.00	11.14	14.62	6.50	0.00	20.00
Sand	ezs	22799.00	25299.00	1715.67	24041.30	729.60	22799.00	25299.00
Water	ezs	159316.00	174316.00	1727.26	166769.78	4377.59	159316.00	174316.00
carlab	ezs	20.00	2670.00	0.11	0.16	1.70	0.00	20.00
carlab1	ezs	20.00	2510.00	0.07	0.10	1.01	0.00	20.00
carlab2	ezs	20.00	2530.00	0.18	0.25	2.21	0.00	20.00
carlab3	ezs	20.00	2370.00	0.03	0.04	0.77	0.00	20.00
stonecips	ezs	45597.00	50597.00	1715.67	48081.59	1459.20	45597.00	50597.00

Activity	Cur	Tot	1stSt	LstSt	AvDur	SDDur	MinD	MaxD	AvInt	SDInt	MinI	MaxI
Dump	0	265	10.22	1789.41	1.50	1.54	0.00	7.11	6.74	5.30	0.00	32.20
Dump1	0	249	0.02	1797.97	1.51	1.57	0.00	8.47	7.25	4.92	0.00	22.02
Dump2	0	251	9.18	1781.74	1.43	1.62	0.00	6.86	7.09	5.28	0.04	25.25
Dump3	0	235	9.69	1795.21	1.41	1.44	0.00	7.92	7.63	5.47	0.00	26.04
Haul	0	265	4.94	1786.21	5.44	5.82	0.00	26.25	6.75	5.16	0.02	25.04
Haul1	0	249	0.00	1796.34	6.19	5.79	0.00	26.33	7.24	5.12	0.00	26.16

Haul2 0 251 7.46 1779.68 5.82 6.23 0.00 30.49 7.09 5.47
0.00 25.52
Haul3 0 235 2.98 1787.73 7.04 6.58 0.00 30.59 7.63 5.31
0.00 25.73
Return 0 265 11.93 1789.41 2.98 3.10 0.00 13.44 6.73 5.36
0.00 30.18
Return1 0 249 1.77 1797.97 2.90 3.15 0.00 12.38 7.24 5.13
0.00 21.67
Return2 0 251 9.62 1782.62 2.92 3.14 0.00 11.72 7.09 5.04
0.01 23.18
Return3 0 235 12.24 1796.09 2.75 2.95 0.00 12.58 7.62 5.36
0.00 25.46
mixture 0 265 0.00 1778.29 3.60 3.58 0.00 14.63 6.74 5.37
0.00 31.46
mixture1 0 249 0.00 1780.56 3.84 4.28 0.00 16.53 7.18 5.48
0.00 27.13
mixture2 0 251 0.00 1774.49 4.04 4.27 0.00 26.12 7.10 5.26
0.00 27.16
mixture3 0 235 0.00 1779.29 4.13 4.00 0.00 17.39 7.60 5.40
0.00 23.28

The Future Events List is empty at simulation time **1805.42**

Total Number of Named Objects : 99
Total Number of Variables : 171
Total Number of Statements : 25

Integral Stat Ave. Wait
=========================

Execution Time = 490.95 seconds

Stroboscope Model **3machine_case_study.vsd** (1038334336)

Statistics report at simulation time **2561.12**

Queue Res Cur Tot AvWait AvCont SDCont MinCont
MaxCont
===
==============================

CCmix	ezs	331.00	331.00	1255.33	162.24	96.48	0.00	331.00
CCmix1	ezs	342.00	342.00	1275.63	170.34	98.33	0.00	342.00
CCmix3	ezs	327.00	327.00	1288.32	164.49	94.13	0.00	327.00
Cement	ezs	0.00	1000.00	1275.55	498.04	288.74	0.00	1000.00
Labmat	ezs	20.00	3330.00	11.47	14.92	6.05	0.00	20.00
Labmat1	ezs	20.00	3440.00	11.35	15.24	5.98	0.00	20.00
Labmat3	ezs	20.00	3290.00	12.17	15.63	5.85	0.00	20.00
Sand	ezs	22799.00	25299.00	2434.08	24044.11	721.85	22799.00	25299.00
Water	ezs	159316.00	174316.00	2450.49	166786.66	4331.08	159316.00	174316.00
carlab	ezs	20.00	3330.00	0.05	0.06	0.77	0.00	20.00
carlab1	ezs	20.00	3440.00	0.11	0.15	1.63	0.00	20.00
carlab3	ezs	20.00	3290.00	0.06	0.07	0.99	0.00	20.00
stonecips	ezs	45597.00	50597.00	2434.08	48087.22	1443.69	45597.00	50597.00

Activity	Cur	Tot	1stSt	LstSt	AvDur	SDDur	MinD	MaxD	AvInt	SDInt	MinI	MaxI
Dump	0	331	20.44	2555.59	1.41	1.47	0.00	6.84	7.68	5.69	0.00	27.20
Dump1	0	342	4.92	2545.19	1.45	1.58	0.00	7.29	7.45	5.49	0.00	25.74
Dump3	0	327	5.06	2546.46	1.41	1.46	0.00	6.50	7.80	5.56	0.02	28.44
Haul	0	331	0.00	2545.16	7.32	7.25	0.00	38.24	7.71	5.77	0.00	31.38
Haul1	0	342	4.92	2541.16	7.33	7.07	0.00	35.37	7.44	5.53	0.00	27.36
Haul3	0	327	0.00	2542.07	7.70	7.03	0.00	31.99	7.80	5.54	0.00	27.61
Return	0	331	21.89	2555.88	2.77	2.89	0.00	13.30	7.68	5.69	0.00	34.04
Return1	0	342	9.11	2545.25	2.53	2.87	0.00	11.67	7.44	5.66	0.00	26.62
Return3	0	327	5.39	2548.57	3.08	3.18	0.00	14.17	7.80	5.59	0.00	27.19
mixture	0	331	0.00	2534.42	3.93	3.93	0.00	17.73	7.68	5.74	0.00	25.71
mixture1	0	342	0.00	2539.41	3.56	3.80	0.00	16.54	7.45	5.49	0.00	26.39
mixture3	0	327	0.00	2536.80	3.42	3.96	0.00	21.07	7.78	5.76	0.00	29.63

The Future Events List is empty at simulation time **2561.12**

Total Number of Named Objects : 78
Total Number of Variables : 135
Total Number of Statements : 22

Integral Stat   Ave. Wait

========================

Execution   Time = 533.11 seconds

Stroboscope Model **2machine_case_study.vsd** (1260219904)

Statistics report at simulation time **4263.54**

Queue	Res	Cur	Tot	AvWait	AvCont	SDCont	MinCont	MaxCont
CCmix	ezs	491.00	491.00	2111.68	243.19	142.72	0.00	491.00
CCmix3	ezs	509.00	509.00	2164.60	258.42	149.70	0.00	509.00
Cement	ezs	0.00	1000.00	2110.79	495.08	292.37	0.00	1000.00
Labmat	ezs	20.00	4930.00	13.28	15.35	5.95	0.00	20.00
Labmat3	ezs	20.00	5110.00	13.01	15.59	5.85	0.00	20.00
Sand	ezs	22799.00	25299.00	4050.81	24036.70	730.92	22799.00	25299.00
Water	ezs	159316.00	174316.00	4078.30	166742.19	4385.52	159316.00	174316.00
carlab	ezs	20.00	4930.00	0.03	0.04	0.62	0.00	20.00
carlab3	ezs	20.00	5110.00	0.10	0.12	1.55	0.00	20.00
stonecips	ezs	45597.00	50597.00	4050.81	48072.40	1461.84	45597.00	50597.00

Activity	Cur	Tot	1stSt	LstSt	AvDur	SDDur	MinD	MaxD	AvInt	SDInt	MinI	MaxI
Dump	0	491	6.19	4261.72	1.32	1.42	0.00	6.89	8.68	6.26	0.00	34.78
Dump3	0	509	4.35	4237.83	1.45	1.54	0.00	7.80	8.33	6.29	0.00	31.26
Haul	0	491	1.62	4242.47	9.10	8.06	0.00	39.16	8.65	6.09	0.00	27.73
Haul3	0	509	0.00	4235.85	8.69	8.05	0.00	35.55	8.34	6.20	0.00	31.88

Return 0 491 8.63 4261.72 2.88 3.15 0.00 13.62 8.68 6.40
0.00 34.34
Return3 0 509 5.49 4237.83 2.83 3.14 0.00 14.42 8.33 6.32
0.00 32.26
mixture 0 491 0.00 4233.99 4.04 3.84 0.00 17.44 8.64 6.44
0.00 30.33
mixture3 0 509 0.00 4225.71 3.69 3.73 0.00 16.60 8.32 6.27
0.00 33.86

The Future Events List is empty at simulation time **4263.54**

Total Number of Named Objects : 57
Total Number of Variables : 99
Total Number of Statements : 19

Integral Stat Ave. Wait
========================

Execution Time = 529.70 seconds

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APPENDIX – A

FLOW CHART

APPENDIX - B

PROGRAMS

B-1 Site Preparation Program

```
DISPLAY"  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !    PROGRAM FOR SITE PREPARATION TIME     !";
DISPLAY"  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";

DISPLAY " ******************************************* " ;
DISPLAY " *    ACTIVITY DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ******************************************* " ;

DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE YEARD_SIZE 2000;
SAVEVALUE OFFICE_SIZE 500;
SAVEVALUE SHADE_SIZE 1000;
SAVEVALUE STORE_SIZE 750;

SAVEVALUE WORKING_LAB 10;

DISPLAY " SITE WORKING YEARD SIZE = " YEARD_SIZE " SFT";
DISPLAY " SITE OFFICE SIZE        = " OFFICE_SIZE " SFT";
DISPLAY " SITE LABOUR SHADE SIZE  = " SHADE_SIZE " SFT";
DISPLAY " SITE STORE SIZE         = " STORE_SIZE " SFT";
DISPLAY " ";

DISPLAY "  SITE PREPARATION LABOUR = " WORKING_LAB " No";

DISPLAY " ";

SAVEVALUE YEARD_PREP_TIME 0;
SAVEVALUE OFFICE_PREP_TIME 0;
SAVEVALUE SHADE_PREP_TIME 0;
SAVEVALUE STORE_PREP_TIME 0;

SAVEVALUE WEATHER_FLAG 1;
SAVEVALUE LABOUR_FLAG 0;
SAVEVALUE MATERIAL_FLAG 0;

SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE MATERIAL_LAG_TIME 0;

SAVEVALUE SITE_PREP_TIME 0;

/ <<<< TIME CALCULATION FOR EACH ACTIVITY >>>>
DISPLAY " ******** TIME CALCULATE FOR EACH ACTIVITY
********";
DISPLAY " ";
```

```
ASSIGN YEARD_PREP_TIME YEARD_SIZE/(WORKING_LAB*100);
IF YEARD_PREP_TIME<1;
ASSIGN YEARD_PREP_TIME 1;
ENDIF;

ASSIGN OFFICE_PREP_TIME OFFICE_SIZE/(WORKING_LAB*10);
IF OFFICE_PREP_TIME<1;
ASSIGN OFFICE_PREP_TIME 1;
ENDIF;

ASSIGN SHADE_PREP_TIME SHADE_SIZE/(WORKING_LAB*20);
IF SHADE_PREP_TIME<1;
ASSIGN SHADE_PREP_TIME 1;
ENDIF;

ASSIGN STORE_PREP_TIME STORE_SIZE/(WORKING_LAB*10);
IF STORE_PREP_TIME<1;
ASSIGN STORE_PREP_TIME 1;
ENDIF;

DISPLAY "WORKING YEARD PREPARATION TIME     = "
YEARD_PREP_TIME " DAY";
DISPLAY "SITE OFFICE PREPARATION TIME       = "
OFFICE_PREP_TIME " DAY";
DISPLAY "LABOUR SHADEYEARD PREPARATION TIME = "
SHADE_PREP_TIME " DAY";
DISPLAY "MATERIALS STORE PREPARATION TIME   = "
STORE_PREP_TIME " DAY";

/ <<< MAXIMUM WORKING DAY CALCULATION >>>>>>>

DISPLAY " ";

IF YEARD_PREP_TIME>OFFICE_PREP_TIME;
SAVEVALUE MAX_DAY1 0;
ASSIGN MAX_DAY1 YEARD_PREP_TIME;
ELSEIF OFFICE_PREP_TIME>YEARD_PREP_TIME;
SAVEVALUE MAX_DAY1 0;
ASSIGN MAX_DAY1 OFFICE_PREP_TIME;
ENDIF;

IF SHADE_PREP_TIME>STORE_PREP_TIME;
SAVEVALUE MAX_DAY2 0;
ASSIGN MAX_DAY2 SHADE_PREP_TIME;
ELSEIF STORE_PREP_TIME>SHADE_PREP_TIME;
SAVEVALUE MAX_DAY2 0;
ASSIGN MAX_DAY2 STORE_PREP_TIME;
ENDIF;

IF MAX_DAY1>MAX_DAY2;
SAVEVALUE MAX_DAY3 0;
```

```
ASSIGN MAX_DAY3 MAX_DAY1;
DISPLAY "MAXIMUM DAY COUNT = " MAX_DAY1 " DAY";
ELSEIF MAX_DAY2>MAX_DAY1;

SAVEVALUE MAX_DAY3 0;
ASSIGN MAX_DAY3 MAX_DAY2;
DISPLAY "MAXIMUM DAY COUNT = " MAX_DAY2 " DAY";
ENDIF;

/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>
IF WEATHER_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF MATERIAL_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;

IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF MATERIAL_FLAG==1;
ASSIGN MATERIAL_LAG_TIME 1;
DISPLAY " ";
DISPLAY " MATERIALS PROBLEM ADDING EXTRA TIME = "
MATERIAL_LAG_TIME " DAY";
ENDIF;

ASSIGN SITE_PREP_TIME
MAX_DAY3+WEATHER_LAG_TIME+LABOUR_LAG_TIME+MATERIAL_LAG_TI
ME;


DISPLAY " ";
```

```
DISPLAY "-------------------------------------------";
DISPLAY " TOTAL SITE PREPARATION TIME = " SITE_PREP_TIME
" DAY";
DISPLAY "-------------------------------------------";

ENDMODEL;
```

B-2 Materials Mobilization Program

```
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !   PROGRAM FOR MATERIALS MOBILIZATION      !";
DISPLAY "!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";
DISPLAY " ****************************************** " ;
DISPLAY " *    ACTIVITY DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ****************************************** " ;

DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE STONE_CHIPS 5000;
SAVEVALUE SAND 3000;
SAVEVALUE CEMENT 1500;
SAVEVALUE MS_BAR 50;
SAVEVALUE SHUTT_MAT 100;

SAVEVALUE MATE_MOBI_LAB 10;

DISPLAY " STONE CHIPS = " STONE_CHIPS/200 " TRUCK";
DISPLAY " SAND        = " SAND/200 " TRUCK";
DISPLAY " CEMENT      = " CEMENT/200 " BAG";
DISPLAY " SHUTTER MAT.= " SHUTT_MAT/100 " TRUCK";
DISPLAY " ";

/DISPLAY "  SITE PREPARATION LABOUR = " WORKING_LAB "
No";

DISPLAY " ";

SAVEVALUE STONE_CAR_TIME 0;
SAVEVALUE SAND_CAR_TIME 0;
SAVEVALUE CEMENT_CAR_TIME 0;
SAVEVALUE MSBAR_CAR_TIME 0;
SAVEVALUE SHUTT_CAR_TIME 0;

SAVEVALUE WEATHER_FLAG 1;
SAVEVALUE LABOUR_FLAG 1;
SAVEVALUE TRANSPORT_FLAG 1;
```

```
SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE TRANSPORT_LAG_TIME 0;

SAVEVALUE MATE_MOBI_TIME 0;

/ <<<< TIME CALCULATION FOR EACH ACTIVITY >>>>

DISPLAY " ******** TIME CALCULATE FOR EACH ACTIVITY
********";
DISPLAY " ";

ASSIGN STONE_CAR_TIME STONE_CHIPS/(200*5);
IF STONE_CAR_TIME<1;
ASSIGN STONE_CAR_TIME 1;
ENDIF;

ASSIGN SAND_CAR_TIME SAND/(200*5);
IF SAND_CAR_TIME<1;
ASSIGN SAND_CAR_TIME 1;
ENDIF;

ASSIGN CEMENT_CAR_TIME CEMENT/(200*5);
IF CEMENT_CAR_TIME<1;
ASSIGN CEMENT_CAR_TIME 1;
ENDIF;

ASSIGN MSBAR_CAR_TIME MS_BAR/(5*2);
IF MSBAR_CAR_TIME<1;
ASSIGN MSBAR_CAR_TIME 1;
ENDIF;

ASSIGN SHUTT_CAR_TIME SHUTT_MAT/(50*2);
IF SHUTT_CAR_TIME<1;
ASSIGN SHUTT_CAR_TIME 1;
ENDIF;

DISPLAY "STONE CHIPS CARING TIME     = " STONE_CAR_TIME "
DAY";
DISPLAY "SAND CARING TIME            = " SAND_CAR_TIME "
DAY";
DISPLAY "CEMENT CARING TIME          = " CEMENT_CAR_TIME
" DAY";
DISPLAY "MS BAR CARING TIME          = " MSBAR_CAR_TIME "
DAY";
DISPLAY "SHUTTER CARING TIME         = " SHUTT_CAR_TIME "
DAY";

/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>
IF WEATHER_FLAG==1;
DISPLAY " ";
```

```
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF TRANSPORT_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;

IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF TRANSPORT_FLAG==1;
ASSIGN TRANSPORT_LAG_TIME 1;
DISPLAY " ";
DISPLAY " TRANSPORT PROBLEM ADDING EXTRA TIME = "
TRANSPORT_LAG_TIME " DAY";
ENDIF;

ASSIGN MATE_MOBI_TIME
STONE_CAR_TIME+SAND_CAR_TIME+CEMENT_CAR_TIME+MSBAR_CAR_TI
ME+SHUTT_CAR_TIME+WEATHER_LAG_TIME+LABOUR_LAG_TIME+TRANSP
ORT_LAG_TIME;

DISPLAY " ";
DISPLAY "-------------------------------------------";
DISPLAY " MATERIALS MOBILIZATION TIME = " MATE_MOBI_TIME
" DAY";
DISPLAY "-------------------------------------------";
ENDMODEL;
```

B-3 Shore Protection Program

```
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !    PROGRAM FOR SHORE PROTECTION           !";
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";
DISPLAY " ****************************************** " ;
DISPLAY " *      SHORE PILING ACTIVITY DETAILS      * " ;
DISPLAY " ****************************************** " ;
DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE NO_OF_PILE 500;
SAVEVALUE NO_OF_RIG 3;

DISPLAY " NUMBER OF SHORE PILE  = " NO_OF_PILE " No";
DISPLAY " NUMBER OF MACHINE FOR PILE DRIVE   = "
NO_OF_RIG " No";

DISPLAY " ";

SAVEVALUE PILE_DRIVING_TIME 0;
SAVEVALUE MACHINE_INST_TIME 0;
SAVEVALUE MACHINE_CLOSE_TIME 0;
SAVEVALUE PILE_COM_TIME 0;
SAVEVALUE WEATHER_FLAG 1;
SAVEVALUE LABOUR_FLAG 1;
SAVEVALUE MACHINE_FLAG 1;
SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE MACHINE_LAG_TIME 0;

/ <<<< TIME CALCULATION FOR PILE DRIVING >>>>

DISPLAY " ******** TIME CALCULATE FOR PILE DRIVING
ACTIVITY ********";
DISPLAY " ";

ASSIGN PILE_DRIVING_TIME NO_OF_PILE/(2*NO_OF_RIG);
IF PILE_DRIVING_TIME<7;
ASSIGN PILE_DRIVING_TIME 7;
ENDIF;
ASSIGN MACHINE_INST_TIME 3;
ASSIGN MACHINE_CLOSE_TIME 2;
DISPLAY "MACHINE INSTALLATION TIME   = "
MACHINE_INST_TIME " DAY";
DISPLAY "PILE DRINVING TIME          = "
PILE_DRIVING_TIME " DAY";
DISPLAY "MACHINE CLOSEING TIME       = "
MACHINE_CLOSE_TIME " DAY";
```

```
/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>

IF WEATHER_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF MACHINE_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;
IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF MACHINE_FLAG==1;
ASSIGN MACHINE_LAG_TIME 2;
DISPLAY " ";
DISPLAY " MACHINE PROBLEM ADDING EXTRA TIME = "
MACHINE_LAG_TIME " DAY";
ENDIF;
ASSIGN PILE_COM_TIME
MACHINE_INST_TIME+PILE_DRIVING_TIME+MACHINE_CLOSE_TIME+WE
ATHER_LAG_TIME+LABOUR_LAG_TIME+MACHINE_LAG_TIME;

DISPLAY " ";
DISPLAY "-------------------------------------------";
DISPLAY " PILE WORK COMPLESSION TIME = " PILE_COM_TIME "
DAY";
DISPLAY "-------------------------------------------";

ENDMODEL;
```

B-4 Earth Cutting and Moving Program

```
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ! PROGRAM FOR EARTH CUTTING AND MOVING TIME !";
DISPLAY " !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";
DISPLAY " ***************************************** " ;
DISPLAY " *    ACTIVITY DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ***************************************** " ;
DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE EARTH_VOLUME 100000;
SAVEVALUE ECARING_DISTANCE 30;          / INPUT FOR SOIL
CARRING DISTANCE IN METER ( RANGE 30 TO 130 M )

SAVEVALUE ECUT_TIME_DAY 8;              / WORKING TIME
PER DAY
SAVEVALUE ECUT_PER_LAB 5;               / SOIL CUTTING BY
A LABOUR PER HOUR IN ( CFT )
SAVEVALUE ECARING_PER_LAB 4;       / SOIL CARING BY A
LABOUR PER HOUR IN ( CFT )

SAVEVALUE ECUT_LAB 150;

DISPLAY " TOTAL VOLUME OF SOIL TO CUT  = " EARTH_VOLUME "
CFT";
DISPLAY " SOIL DUMPING DISTANCE        = "
ECARING_DISTANCE " M";
DISPLAY " TOTAL LABOUR FOR THE WORK    = " ECUT_LAB "
No";

DISPLAY " ";

SAVEVALUE SOIL_CUT_TIME 0;
SAVEVALUE SOIL_CARING_TIME 0;

SAVEVALUE WEATHER_FLAG 1;               / ********** USE
FLAG FOR PROBLEM ***************
SAVEVALUE LABOUR_FLAG 1;
SAVEVALUE WATER_FLAG 1;

SAVEVALUE WEATHER_LAG_TIME 0;
SAVEVALUE LABOUR_LAG_TIME 0;
SAVEVALUE WATER_LAG_TIME 0;
SAVEVALUE ECUT_TIME 0;

/ <<<< TIME CALCULATION FOR EACH ACTIVITY >>>>
DISPLAY " ******** TIME CALCULATE FOR EACH ACTIVITY
********";
```

```
DISPLAY " ";
ASSIGN SOIL_CUT_TIME
EARTH_VOLUME/(ECUT_LAB*0.4*ECUT_TIME_DAY*ECUT_PER_LAB); /
TIME IN DAY
IF SOIL_CUT_TIME<1;
ASSIGN SOIL_CUT_TIME 1;
ENDIF;

IF ECARING_DISTANCE<50;
ASSIGN SOIL_CARING_TIME
EARTH_VOLUME/(ECUT_LAB*0.6*ECUT_TIME_DAY*ECARING_PER_LAB)
; / TIME IN DAY
ENDIF;

IF SOIL_CARING_TIME<1;
ASSIGN SOIL_CARING_TIME 1;
ENDIF;

IF ECARING_DISTANCE>=50;
SAVEVALUE TEST_VAR 0;
SAVEVALUE TEST_FAC 0;
ASSIGN TEST_VAR ECARING_DISTANCE-50;
ASSIGN TEST_FAC (100-TEST_VAR)/100;
ASSIGN SOIL_CARING_TIME
EARTH_VOLUME/(ECUT_LAB*0.6*ECUT_TIME_DAY*ECARING_PER_LAB*
TEST_FAC); / TIME IN HOUR
ENDIF;

IF SOIL_CARING_TIME<1;
ASSIGN SOIL_CARING_TIME 1;
ENDIF;

DISPLAY "SOIL CUTTING TIME      = " SOIL_CUT_TIME " DAY";
DISPLAY "SOIL CARRING TIME      = " SOIL_CARING_TIME "
DAY";

/ <<< MAXIMUM WORKING DAY CALCULATION >>>>>>>

DISPLAY " ";
SAVEVALUE MAX_DAY1 0;

IF SOIL_CUT_TIME>SOIL_CARING_TIME;
ASSIGN MAX_DAY1 SOIL_CUT_TIME;
ELSEIF SOIL_CARING_TIME>SOIL_CUT_TIME;
ASSIGN MAX_DAY1 SOIL_CARING_TIME;
ENDIF;

/ <<<< ADDIGN PROBLEMS IN THE ACTIVITY >>>>>

IF WEATHER_FLAG==1;
DISPLAY " ";
```

```
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF LABOUR_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ELSEIF WATER_FLAG==1;
DISPLAY " ";
DISPLAY " !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
";
ENDIF;

IF WEATHER_FLAG==1;
ASSIGN WEATHER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WEATHER PROBLEM ADDING EXTRA TIME = "
WEATHER_LAG_TIME " DAY";
ENDIF;

IF LABOUR_FLAG==1;
ASSIGN LABOUR_LAG_TIME 1;
DISPLAY " ";
DISPLAY " LABOUR PROBLEM ADDING EXTRA TIME = "
LABOUR_LAG_TIME " DAY";
ENDIF;

IF WATER_FLAG==1;
ASSIGN WATER_LAG_TIME 2;
DISPLAY " ";
DISPLAY " WATER LOGING PROBLEM ADDING EXTRA TIME = "
WATER_LAG_TIME " DAY";
ENDIF;

ASSIGN ECUT_TIME
MAX_DAY1+WEATHER_LAG_TIME+LABOUR_LAG_TIME+WATER_LAG_TIME;

DISPLAY " ";
DISPLAY "-------------------------------------------";
DISPLAY " SOIL CUTTING TIME = " ECUT_TIME " DAY";
DISPLAY "-------------------------------------------";

ENDMODEL;
```

B-5 Concrete Casting Program

```
DISPLAY "
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " !    PROGRAM FOR CONCRETE CASTING TIME
CALCULATION   !";
DISPLAY " !      program by :- Engr. AKM RUHUL AMIN
!";
DISPLAY "
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!";
DISPLAY " ";


DISPLAY " ****************************************** " ;
DISPLAY " *    RESOURCE DETAILS ARE GIVEN BELOW     * " ;
DISPLAY " ****************************************** " ;

DISPLAY " ";

/ <<< RESOURCE SETUP >>>>

SAVEVALUE M 1;      / ***** <INPUT FOR NO OF MIXTURE
MACHINE> *****

SAVEVALUE MIX_MACHINE 0;

SAVEVALUE MIX_CEMENT 100;
SAVEVALUE MIX_SAND_LOCAL 100;
SAVEVALUE MIX_SAND_SYLHET 100;
SAVEVALUE MIX_CHIPS 100;
SAVEVALUE MIX_WATER 2000;

/ <<<< TIME SETUP >>>>

/SAVEVALUE FID_TIME 6;
SAVEVALUE MIX_TIME 3;
SAVEVALUE CAR_TIME 0;
SAVEVALUE DUM_TIME 0;
SAVEVALUE RET_TIME 0;

/ <<<< CALCULATING LABOURS >>>>

SAVEVALUE FID_LABOUR 6*M;
SAVEVALUE CAR_LABOUR 10*M;
SAVEVALUE MACHINE_DRIVER 1*M;

/ <<<< SETING GLOBAL VARIABLES AND SOME OUTPURTS >>>>

SAVEVALUE MIX_VOLUME 5;/ MIX RATIO 1:2:4  WATER CEMENT
RATIO .4
```

```
DISPLAY " MIXTURE MACHINE NO = " M " No";
DISPLAY " ";
DISPLAY " CEMENT              = " MIX_CEMENT " bag";
DISPLAY " LOCAL SAND          = " MIX_SAND_LOCAL " cft";
DISPLAY " SYLHET SAND         = " MIX_SAND_SYLHET " cft";
DISPLAY " STONE CHIPS         = " MIX_CHIPS " cft";
DISPLAY " WATER               = " MIX_WATER " lit";
DISPLAY " FIDDING LABOUR      = " FID_LABOUR " No";
DISPLAY " CARRING LABOUR     = " CAR_LABOUR " No";
DISPLAY " MACHINE DRIVER     = " MACHINE_DRIVER " No";
DISPLAY " ";

DISPLAY " !!!   ****************** << OUT PUTS ARE >>
****************** !!! " ;

DISPLAY " ";


/ $$$$$$$  CASTING CYCLE START $$$$$$$

SAVEVALUE CAST_TIME 0;
SAVEVALUE TOTAL_VOLUME 0;

// <<<< TESTING RESOURCES IF ANY ONE IS ZERO THE CASTING
SIMULATION IS STOPED >>>>

IF MIX_CEMENT<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO CEMENT SHORTAGE
!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                    = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                   = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                   = "
MIX_CHIPS;
DISPLAY " WATER REST                         = "
MIX_WATER;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;
```

```
ELSEIF MIX_SAND_LOCAL<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO LOCAL SAND
SHORTAGE !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                           = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                      = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                      = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                      = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                      = "
MIX_CHIPS;
DISPLAY " WATER REST                            = "
MIX_WATER;
DISPLAY " TOTAL CASTING                    = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING            = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_SYLHET<=0;
DISPLAY " ";
DISPLAY " !!!!!  SIMULATION IS STOP DUE TO SYLHET SAND
SHORTAGE   !!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                      = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST                  = "
MIX_SAND_LOCAL;

     IF MIX_SAND_SYLHET<0;
     DISPLAY " SYLHET SAND REST              = " 0;
     ELSEIF MIX_SAND_SYLHET>=0;
     DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
     ENDIF;
DISPLAY " STONE CHIPS REST                 = " MIX_CHIPS;
DISPLAY " WATER REST                       = " MIX_WATER;
DISPLAY " TOTAL CASTING               = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING       = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_CHIPS<=0;
DISPLAY " ";
```

```
DISPLAY "!!!!!!   SIMULATION IS STOP DUE TO STONE CHIPS
SHORTAGE  !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
     IF MIX_CHIPS<0;
     DISPLAY " STONE CHIPS REST              = " 0;
     ELSEIF MIX_CHIPS>=0;
     DISPLAY " STONE CHIPS REST              = "
MIX_CHIPS;
     ENDIF;
DISPLAY " WATER REST                    = " MIX_WATER;
DISPLAY " TOTAL CASTING            = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_WATER<=0;

DISPLAY " ";
DISPLAY "!!!!!   SIMULATION IS STOP DUE TO WATER SHORTAGE
!!!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST              = " MIX_CHIPS;
     IF MIX_WATER<0;
     DISPLAY " WATER REST                     = " 0;
     ELSEIF MIX_WATER>0;
     DISPLAY " WATER REST                     = "
MIX_WATER;
     ENDIF;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;
ENDIF;


/ <<<< SETING AMOUT OF RESOURCES FOR EACH CYCLE  >>>>

SAVEVALUE c 1*M;    / taking cememt 1 bag
SAVEVALUE sl 1*M;   / taking local sand 1 cft
```

```
SAVEVALUE ss 1*M;   / taking sylhet sand 1 cft
SAVEVALUE chi 4*M;  / taking stone chips 4 cft
SAVEVALUE w 14*M;   / taking water for mixing 11 lit

/ASSIGN CAST_TIME FID_TIME+MIX_TIME;

DISPLAY " ";
DISPLAY "  SPEAR MIXTURE MACHINE AT SITE, NO MACHINE
PORBLEM CONSIDER";
DISPLAY " ";

WHILE TOTAL_VOLUME<=2500;

/ <<<< TESTING THE RESOURCE IN EACH CYCLES OF CASTING
>>>>*******************

IF MIX_CEMENT<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO CEMENT SHORTAGE
!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                    = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                   = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                   = "
MIX_CHIPS;
DISPLAY " WATER REST                         = "
MIX_WATER;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_LOCAL<=0;
DISPLAY " ";
DISPLAY " !!!!! SIMULATION IS STOP DUE TO LOCAL SAND
SHORTAGE !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN     = " MIX_MACHINE;
DISPLAY " CEMENT REST                        = "
MIX_CEMENT;
     IF MIX_SAND_LOCAL<0;
     DISPLAY " LOCAL SAND REST                    = " 0;
```

```
     ELSEIF MIX_SAND_LOCAL>=0;
     DISPLAY " LOCAL SAND REST                   = "
MIX_SAND_LOCAL;
     ENDIF;
DISPLAY " SYLHET SAND REST                  = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                  = "
MIX_CHIPS;
DISPLAY " WATER REST                        = "
MIX_WATER;
DISPLAY " TOTAL CASTING                = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING        = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_SAND_SYLHET<=0;
DISPLAY " ";
DISPLAY " !!!!!  SIMULATION IS STOP DUE TO SYLHET SAND
SHORTAGE   !!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                  = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST              = "
MIX_SAND_LOCAL;

     IF MIX_SAND_SYLHET<0;
     DISPLAY " SYLHET SAND REST              = " 0;
     ELSEIF MIX_SAND_SYLHET>=0;
     DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
     ENDIF;
DISPLAY " STONE CHIPS REST             = " MIX_CHIPS;
DISPLAY " WATER REST                   = " MIX_WATER;
DISPLAY " TOTAL CASTING            = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_CHIPS<=0;
DISPLAY " ";
DISPLAY "!!!!!!   SIMULATION IS STOP DUE TO STONE CHIPS
SHORTAGE  !!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                  = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST              = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST             = "
MIX_SAND_SYLHET;
     IF MIX_CHIPS<0;
     DISPLAY " STONE CHIPS REST              = " 0;
```

```
     ELSEIF MIX_CHIPS>=0;
     DISPLAY " STONE CHIPS REST              = "
MIX_CHIPS;
     ENDIF;
DISPLAY " WATER REST                    = " MIX_WATER;
DISPLAY " TOTAL CASTING            = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING    = " CAST_TIME " MIN "
CAST_TIME/60 " HOUR";
ENDMODEL;

ELSEIF MIX_WATER<=0;

DISPLAY " ";
DISPLAY "!!!!!   SIMULATION IS STOP DUE TO WATER SHORTAGE
!!!!!!!";
DISPLAY " ";
DISPLAY " NO OF MIXTURE MACHINE RUN = " MIX_MACHINE;
DISPLAY " CEMENT REST                   = " MIX_CEMENT;
DISPLAY " LOCAL SAND REST               = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST              = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST              = " MIX_CHIPS;
     IF MIX_WATER<0;
     DISPLAY " WATER REST                    = " 0;
     ELSEIF MIX_WATER>0;
     DISPLAY " WATER REST                    = "
MIX_WATER;
     ENDIF;
DISPLAY " TOTAL CASTING                 = " TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING         = " CAST_TIME "
MIN " CAST_TIME/60 " HOUR";
ENDMODEL;
ENDIF;

/*********************************************************
*******************************


/ <<<< RELESIGN RESOURSCES AND CALCULATION OF TIME AND
VOLUME >>>>

ASSIGN MIX_MACHINE MIX_MACHINE+M;
ASSIGN MIX_CEMENT MIX_CEMENT-c;
ASSIGN MIX_SAND_LOCAL MIX_SAND_LOCAL-sl;
ASSIGN MIX_SAND_SYLHET MIX_SAND_SYLHET-ss;
ASSIGN MIX_CHIPS MIX_CHIPS-chi;
ASSIGN MIX_WATER MIX_WATER-w;
ASSIGN TOTAL_VOLUME TOTAL_VOLUME+(MIX_VOLUME*M);
ASSIGN CAST_TIME
CAST_TIME+MIX_TIME+CAR_TIME+DUM_TIME+RET_TIME;
```

```
WEND;

/ <<<< END OF CASTING LOOP AND SHOWING RESULTS >>>>

DISPLAY " NUMBER OF MIXTURE MACHINE RUNNING  = " M " NO";
DISPLAY " TOTAL MACHINE RUN                                  = "
MIX_MACHINE;
DISPLAY " TOTAL CASTING                                      = "
TOTAL_VOLUME;
DISPLAY " TOTAL TIME OF CASTING                              = "
CAST_TIME " MIN " CAST_TIME/60 " HOUR";
DISPLAY " CEMENT REST                                        = "
MIX_CEMENT;
DISPLAY " LOCAL SAND REST                                    = "
MIX_SAND_LOCAL;
DISPLAY " SYLHET SAND REST                                   = "
MIX_SAND_SYLHET;
DISPLAY " STONE CHIPS REST                                   = "
MIX_CHIPS;
DISPLAY " WATER REST                                         = "
MIX_WATER;

ENDMODEL
```

B-6 Network Element Program

```
/ *  PROGRAM FOR CONCRETE_MIXING using network element *

/ STARTING MESSAGE

DISPLAY "****************************************" ;
DISPLAY "*                                      *" ;
DISPLAY "*   CASTING PROGRAM FOR A ASSIGNMENT   *" ;
DISPLAY "*                                      *" ;
DISPLAY "****************************************" ;
DISPLAY " ";

/ <<< DEFINE VARIABLES AND RESOURCES >>>

VARIABLE M 1;
SAVEVALUE MIXTURE_MACHINE 0;

VARIABLE STONETOCAST 100;
VARIABLE SANDTOCAST 200;
VARIABLE CEMENTTOCAST 100;
VARIABLE WATERTOCAST 2000;

VARIABLE STONECARLAB 6*M;
VARIABLE STONECARLABCAPA 0.5;
VARIABLE SANDCARLAB 3*M;
```

```
VARIABLE SANDCARLABCAPA 0.5;
VARIABLE CEMENTCARLAB 1*M;
VARIABLE CEMENTCARLABCAPA 1;
VARIABLE MACHINE_DRIVER 1*M;

/  << UPGRADE PART  >>>

VARIABLE STONEDRAW 4*M;
VARIABLE SANDDRAW 2*M;
VARIABLE CEMENTDRAW 1*M;
VARIABLE WATERDRAW 0.4*M;
VARIABLE FIDINGLABDRAW 6*M;
VARIABLE CARINGLABDRAW 10*M;
VARIABLE MIXINGAMOUNT
STONEDRAW+SANDDRAW+CEMENTDRAW+WATERDRAW;


///   <<<< END OF UP GRADE  >>

SAVEVALUE FIDING_LAB STONECARLAB+SANDCARLAB+CEMENTCARLAB;
SAVEVALUE CARING_LAB 10*M;

/ *****  [ PART OF UPGRADE ------ 31/12/07  ]

/ SAVEVALUE LABOUR_CAPACITY 0.5;

          // <<<< DISPLAY THE RESOURCE  >>>

ASSIGN MIXTURE_MACHINE M;

DISPLAY " MIXTURE MACHINE     = " MIXTURE_MACHINE " No";
DISPLAY " STONE  IN YARD      = " STONETOCAST " cft";
DISPLAY " SAND   IN YARD      = " SANDTOCAST  " cft";
DISPLAY " CEMETN IN YARD      = " CEMENTTOCAST " bag";
DISPLAY " WATER  IN DRUM      = " WATERTOCAST " cft";

DISPLAY " ";

DISPLAY " MATERIAL CARRING  LABOUR = " FIDING_LAB " No.";
DISPLAY " CONCRETE CARRING  LABOUR = " CARING_LAB " No.";

DISPLAY " ";

     / <<< DEFINE GENERIC RESOURCE TYPE >>>

GENTYPE stonechip;
GENTYPE sand;
GENTYPE cement;
GENTYPE water;
GENTYPE fidlab;
GENTYPE caringlab;
```

```
GENTYPE convol;

     / <<< DEFINE QUEUE >>>

QUEUE stonechips stonechip;
QUEUE sands sand;
QUEUE cements cement;
QUEUE waters water;
QUEUE fidlabs fidlab;
QUEUE caringlabs caringlab;
QUEUE convols convol;

     / <<< DEFINE ACTIVITIES >>>>

COMBI mixture;
NORMAL haul;
NORMAL dump;
NORMAL return;

     / <<< LINKING RESOURCES AND ACTIVITIES >>>

LINK LFLWM fidlabs mixture;
LINK LMWFL mixture fidlabs;
LINK LSTWM stonechips mixture;
LINK LSAWM sands mixture;
LINK LCEWM cements mixture;
LINK LWAWM waters mixture;
LINK LCRLWM caringlabs mixture;
LINK LMWH mixture haul caringlab;
LINK LHWD haul dump caringlab;
LINK LDWR dump return caringlab;
LINK LRWCARL return caringlabs;
LINK LDWCON dump convols;

     / << SETING DURATIONS >>>

DURATION mixture 3;
DURATION haul 1;
DURATION dump 1;
DURATION return 1;
DRAWDUR LSTWM 0;
DRAWDUR LFLWM 0;

     / << DARW AND RELEASE RESOURCES FOR CASTING >>

/IF fidlabs.curcount<6;
DRAWAMT LFLWM 6;
IF fidlabs.CurCount<6;
RELEASEAMT LMWFL 6;
ENDIF;
DRAWAMT LSTWM 4;
```

```
DRAWAMT LSAWM 2;
DRAWAMT LCEWM 1;
DRAWAMT LWAWM 0.4;
DRAWAMT LCRLWM 10;

RELEASEAMT LMWH 5;
RELEASEAMT LHWD 5;
RELEASEAMT LDWCON 5;
RELEASEAMT LDWR CARING_LAB;
RELEASEAMT LRWCARL CARING_LAB;

     / <<< initialization of resource  >>>
INIT stonechips STONETOCAST;
INIT sands SANDTOCAST;
INIT cements CEMENTTOCAST;
INIT waters WATERTOCAST;
INIT fidlabs  FIDING_LAB;
INIT caringlabs CARING_LAB;

SIMULATEUNTIL CEMENTTOCAST<=0;

DISPLAY "******************************" ;
DISPLAY "*   AUTO GENERATE REPORT    *" ;
DISPLAY "******************************" ;
DISPLAY " ";

REPORT;

DISPLAY " ";

DISPLAY "Simulation Time = " SimTime/60 " HOURE";

/DISPLAY SimTime;

DISPLAY "****************************************" ;
DISPLAY "*          USER DEFINE OUT PUT          *" ;
DISPLAY "****************************************" ;

DISPLAY " ";

DISPLAY "TOTAL CASTING             = " convols.TotCount "
cft";
DISPLAY "STONE CHIPS IN YEARD      = "
stonechips.CurCount " cft";
DISPLAY "SAND IN YEARD             = " sands.CurCount "
cft";
DISPLAY "CEMENT IN YEARD           = " cements.CurCount "
cft";
DISPLAY "WATER IN DRUM             = " waters.CurCount "
cft";
ENDMODEL;
```

Appendix – C

SIMULATION RESULTS

C-1 Details of Mat Foundation

Area of Mat Foundation : 165’ x 93’ + 25 x 33 = 16170 sft
Depth of Mat Foundation : 48 inch
Volume of cc work (3” cc 1:2:4) = 16170 X 0.25 = **4042.5** cft
Volume of Concrete pouring = 16170 X 3.25 = **52,552.5** cft
Earth Cutting Volume = 16170 X 10 = **161700** cft
Location : Board Bazar, Gazipur.
Owner : Uni-Gears Limited.

Target time of completion = 62 days. (Excluding Curing Time).

Estimated Materials for the work
For CC Work :

Total Casting Volume = **4042.5** cft
Stone chips = 3638.25 cft
Sand = 2021.25 cft
Cement = 727.65 bag

For Concrete pouring Work :

Total Casting Volume = **52,552.5** cft
Stone chips = 47297.25 cft
Sand = 26276.25 cft
Cement = 11561.55 bag

For Steel Work :

Total Weight of Ms Bar :

Short Bar length	=	93 X133	=	12369 rftt
Long Bar length	=	165 X186	=	30690 rft
Short Bar length	=	25 X67	=	1675 rftt
Long Bar length	=	33 X51	=	1683 rft
		Total	=	46,417 rft

Weight = 92,834 kg

Simulation Result

C-2 Site Preparation Result

Stroboscope Model Drawing2 (1942949120)

Number of replications performed : 500

Average Project Duration : 4.00

Std. Dev. of Project Duration : 0.00

Average Project Cost : 69769.06

Std. Dev. of Project Cost : 6278.71

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
YEARDPREP	2.00	0.00	2.00	2.00	4.00	2.00	2.00	0.00%	14953.61
LABOURSHADE	3.00	0.00	1.00	3.00	4.00	1.00	1.00	0.00%	9967.19
OFFICE	4.00	0.00	0.00	4.00	4.00	0.00	0.00	100.00%	19940.30
STORE	4.00	0.00	0.00	4.00	4.00	0.00	0.00	100.00%	24907.96

C-3 Materials Mobilization Result

Stroboscope Model Drawing2 (1178370816)

Number of replications performed : 500

Average Project Duration : 5.00

Std. Dev. of Project Duration : 0.00

Average Project Cost : 1549170.29

Std. Dev. of Project Cost : 32321.98

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
CEMENT	2.00	0.00	3.00	2.00	5.00	3.00	3.00	0.00%	749872.53
SAND	2.00	0.00	3.00	2.00	5.00	3.00	3.00	0.00%	50167.28
MSBAR	5.00	0.00	0.00	5.00	5.00	0.00	0.00	100.00%	299415.99
STONECHIPS	3.00	0.00	2.00	3.00	5.00	2.00	2.00	0.00%	399327.74
WOOD	2.00	0.00	3.00	2.00	5.00	3.00	3.00	0.00%	50386.76

C-4 Earth Cutting and Moving Result

```
Stroboscope Model 09_EARTH_CUT_escavator (28355328)


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! PROGRAM FOR EARTH CUTTING AND MOVING TIME CALCULATION
!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************
 TOTAL VOLUME OF SOIL TO CUT  = 161700 CFT
 SOIL DUMPING DISTANCE        = 150 M
 NUMBER OF EXCAVATOR          = 1 No
  ******** TIME CALCULATE FOR EACH ACTIVITY ********
 SOIL CUTTING TIME      = 22.458333 DAY
  !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!
  LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

-------------------------------------------
```

SOIL CUTTING TIME = 23.458333 DAY

```
-------------------------------------------
```

C-5 Cement Concrete Work Result

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 ******************************************
 MIXTURE MACHINE NO = 2 No
 CEMENT             = 800 bag
 LOCAL SAND         = 1000 cft
 SYLHET SAND        = 1000 cft
 STONE CHIPS        = 4000 cft
 WATER              = 12000 lit
 FIDDING LABOUR     = 12 No
 CARRING LABOUR     = 20 No
 MACHINE DRIVER     = 2 No

!!  ************** << OUT PUTS ARE >> ************** !!!
 SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
 NUMBER OF MIXTURE MACHINE RUNNING = 2 NO
 TOTAL MACHINE RUN                 = 710
 TOTAL CASTING                     = 4047
 TOTAL TIME OF CASTING             = 1065 MIN 17.75 HOUR
 CEMENT REST                       = 90
 LOCAL SAND REST                   = 290
 SYLHET SAND REST                  = 290
 STONE CHIPS REST                  = 1160
 WATER REST                        = 2060
```

C-6 Concrete Pouring Result

!!!

! PROGRAM FOR CONCRETE CASTING TIME CALCULATION !

!!!

****

* RESOURCE DETAILS ARE GIVEN BELOW *

****

MIXTURE MACHINE NO = 4 No

CEMENT = 6000 bag

LOCAL SAND = 10000 cft

SYLHET SAND = 7000 cft

STONE CHIPS = 30000 cft

WATER = 100000 lit

FIDDING LABOUR = 24 No

CARRING LABOUR = 40 No

MACHINE DRIVER = 4 No

!!! ******** << OUT PUTS ARE >> ************** !!!

SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM CONSIDER

NUMBER OF MIXTURE MACHINE RUNNING = 4 NO

TOTAL MACHINE RUN = 5520

TOTAL CASTING = 48024

TOTAL TIME OF CASTING = 3455.5 MIN 57.591667 HOUR

CEMENT REST = 480

LOCAL SAND REST = 1720

SYLHET SAND REST = 1480

STONE CHIPS REST = 2400

WATER REST = 17200

C-7 Mat Casting Result

```
Stroboscope Model Drawing2 (1617951744)
Number of replications performed : 500
```

<u>Average Project Duration : 86.00</u>

```
Std. Dev. of Project Duration    : 0.00
Average Project Cost             : 0.00
Std. Dev. of Project Cost        : 0.00
CPM Activity     Time    ESD    LSD    EFD    LFD     FF
TF %Critic   Cost
=========================================================
==
Curing          28.00  58.00  58.00  86.00  86.00   0.00
0.00 100.00%   0.00
CCWork           3.00  33.00  33.00  36.00  36.00   0.00
0.00 100.00%   0.00
MsBarprepa       7.00   9.00  38.00  16.00  45.00  29.00
29.00   0.00%   0.00
Msparlaying      7.00  45.00  45.00  52.00  52.00   0.00
0.00 100.00%   0.00
MaterialsMobi    5.00   4.00  33.00   9.00  38.00   0.00
29.00   0.00%   0.00
Guidewall        5.00  36.00  36.00  41.00  41.00   0.00
0.00 100.00%   0.00
Waterproof       4.00  41.00  41.00  45.00  45.00   0.00
0.00 100.00%   0.00
Shoreprotect     5.00   4.00   4.00   9.00   9.00   0.00
0.00 100.00%   0.00
Sitepreparation   4.00   0.00   0.00   4.00   4.00   0.00
0.00 100.00%   0.00
Concretecast     6.00  52.00  52.00  58.00  58.00   0.00
0.00 100.00%   0.00
Earthcutting    24.00   9.00   9.00  33.00  33.00   0.00
0.00 100.00%   0.00
```

Appendix – D

SIMULATION OUT PUTS

D-1 Program Out Put – 1

User Define Programming

```
Stroboscope Model 05_CON_MIX_CAL_02 (412749952)
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 *******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 *******************************************
 MIXTURE MACHINE NO = 1 No
 CEMENT             = 100 bag
 LOCAL SAND         = 100 cft
 SYLHET SAND        = 100 cft
 STONE CHIPS        = 100 cft
 WATER              = 2000 lit
 Material LABOUR    = 6 No
 CARRING LABOUR     = 10 No
 MACHINE DRIVER     = 1 No
  /******* << OUT PUTS ARE >> *************
SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
!!! SIMULATION IS STOP DUE TO STONE CHIPS SHORTAGE  !!!!!
 NO OF MIXTURE MACHINE RUN    = 25
 CEMENT REST                  = 75
 LOCAL SAND REST              = 75
 SYLHET SAND REST             = 75
 STONE CHIPS REST             = 0
 WATER REST                   = 1650
 TOTAL CASTING                = 125
 TOTAL TIME OF CASTING   = 75 MIN 1.25 HOUR
```

D-2 Program Out Put – 2

Using Built-in Functions in Programming

```
Stroboscope Model CONCRETE_MIX_upgrade (1474211968)
****************************************
*   CASTING PROGRAM FOR A ASSIGNMENT   *
****************************************
 MIXTURE MACHINE    = 1 No
 STONE  IN YARD     = 100 cft
 SAND   IN YARD     = 200 cft
 CEMETN IN YARD     = 100 bag
 WATER  IN DRUM     = 2000 cft
 MATERIAL CARRING  LABOUR = 6 No.
 CONCRETE CARRING  LABOUR = 10 No.
*****************************
*   AUTO GENERATE REPORT    *
*****************************
```

Statistics report at simulation time 75

```
Queue           Res               Cur       Tot   AvWait
AvCont    SDCont MinCont   MaxCont
=========================================================
==
caringlabs     caringlab      10.00    260.00    0.00
0.00      0.00    0.00     10.00
cements        cement         75.00    100.00   65.25
87.00      7.21   75.00    100.00
convols        convol        125.00    125.00   36.00
60.00     36.06    0.00    125.00
fidlabs        fidlab         10.00    160.00    1.88
4.00      0.00    4.00     10.00
sands          sand          150.00    200.00   65.25
174.00     14.42  150.00    200.00
stonechips     stonechip       0.00    100.00   36.00
48.00     28.84    0.00    100.00
```

```
waters         water        1990.00   2000.00   74.80
1994.80      2.88 1990.00   2000.00
Activity         Cur     Tot      1stSt     LstSt    AvDur
SDDur   MinD    MaxD   AvInt  SDInt    MinI    MaxI
=========================================================
==
dump              0       25       3.00      75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
haul              0       25       3.00      75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
mixture           0       25       0.00      72.00    3.00
0.00   3.00    3.00    3.00   0.00    3.00    3.00
return            0       25       3.00      75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
```

The Future Events List is empty at simulation time 75.00

```
Total Number of Named Objects : 38
Total Number of Variables : 61
Total Number of Statements : 112
```

Simulation Time = 1.25 HOURE

```
****************************************
*         USER DEFINE OUT PUT          *
****************************************
TOTAL CASTING            = 125 cft
STONE CHIPS IN YEARD     = 0 cft
SAND IN YEARD            = 150 cft
CEMENT IN YEARD          = 75 cft
WATER IN DRUM                 = 1990 cft
```

D-3 Program Out Put – 3

Using Visio Block Networks in Programming

Stroboscope Model concretmix.vsd (997558400)

Statistics report at simulation time 75

```
Queue     Res              Cur       Tot   AvWait
AvCont    SDCont MinCont   MaxCont
==========================================================
==
CCmix    ezs          125.00    125.00   36.00     60.00
36.06    0.00    125.00
Cement     ezs           75.00    100.00   65.25
87.00      7.21   75.00    100.00
Labmat     ezs            6.00    156.00    0.00
0.00      0.00    0.00      6.00
Sand      ezs            50.00    100.00   55.50
74.00     14.42   50.00    100.00
Water     ezs          1625.00   2000.00   67.69
1805.00    108.17 1625.00   2000.00
carlab    ezs            20.00    270.00    2.78
10.00      0.00   10.00     20.00
stonecips ezs             0.00    100.00   36.00
48.00     28.84    0.00    100.00
Activity       Cur     Tot     1stSt     LstSt   AvDur
SDDur   MinD    MaxD   AvInt  SDInt    MinI    MaxI
==========================================================
==
Dump     0      25      3.00     75.00    0.00   0.00
0.00    0.00    3.00   0.00    3.00    3.00
Haul              0      25      3.00     75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
Return            0      25      3.00     75.00    0.00
0.00   0.00    0.00    3.00   0.00    3.00    3.00
mixture           0      25      0.00     72.00    3.00
0.00   3.00    3.00    3.00   0.00    3.00    3.00
```

The Future Events List is empty at simulation time 75.00

```
Total Number of Named Objects : 36
Total Number of Variables : 63
Total Number of Statements : 16
```

D-4 Program Out Put – 4

User Define Programming

```
Stroboscope Model 05_CON_MIX_CAL_02 (1843159168)
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 *******************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 *******************************************
 MIXTURE MACHINE NO = 1 No
 CEMENT             = 100 bag
 LOCAL SAND         = 100 cft
 SYLHET SAND        = 100 cft
 STONE CHIPS        = 100 cft
 WATER              = 2000 lit
 FIDDING LABOUR     = 6 No
 CARRING LABOUR     = 10 No
 MACHINE DRIVER     = 1 No
!! ************ << OUT PUTS ARE >> *******************
!!!
SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER
!!!   SIMULATION IS STOP DUE TO STONE CHIPS SHORTAGE
!!!!!
 NO OF MIXTURE MACHINE RUN    = 25
 CEMENT REST                  = 75
 LOCAL SAND REST              = 75
 SYLHET SAND REST             = 75
```

```
 STONE CHIPS REST              = 0
 WATER REST                    = 1650
 TOTAL CASTING                 = 125
```

TOTAL TIME OF CASTING   = 150 MIN 2.5 HOUR

D-5 Program Out Put – 5

Using Built-in Function in Programming

```
Stroboscope Model CONCRETE_MIX_upgrade (630943872)
****************************************
*   CASTING PROGRAM FOR A ASSIGNMENT   *
****************************************
 MIXTURE MACHINE    = 1 No
 STONE  IN YARD     = 100 cft
 SAND   IN YARD     = 200 cft
 CEMETN IN YARD     = 100 bag
 WATER  IN DRUM     = 2000 cft
 MATERIAL CARRING  LABOUR = 6 No.
 CONCRETE CARRING  LABOUR = 10 No.
*****************************
*   AUTO GENERATE REPORT    *
*****************************
```

Statistics report at simulation time 150

```
Queue            Res               Cur       Tot   AvWait
AvCont    SDCont MinCont   MaxCont
=========================================================
==
caringlabs     caringlab      10.00    260.00    0.00
0.00      0.00    0.00     10.00
cements        cement         75.00    100.00  130.50
87.00      7.21   75.00    100.00
convols        convol        125.00    125.00   73.00
60.83     36.10    0.00    125.00
```

```
fidlabs        fidlab         10.00    160.00    6.56
7.00      3.00    4.00     10.00
sands          sand          150.00    200.00  130.50
174.00     14.42  150.00    200.00
stonechips     stonechip       0.00    100.00   72.00
48.00     28.84    0.00    100.00
waters         water        1990.00   2000.00  149.61
1994.80      2.88 1990.00   2000.00
Activity        Cur     Tot     1stSt     LstSt   AvDur
SDDur   MinD    MaxD   AvInt  SDInt    MinI    MaxI
=========================================================
==
dump               0       25      4.00    148.00    1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
haul               0       25      3.00    147.00    1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
mixture            0       25      0.00    144.00    3.00
0.00   3.00    3.00    6.00   0.00    6.00    6.00
return             0       25      5.00    149.00    1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
```

The Future Events List is empty at simulation time 150.00

```
Total Number of Named Objects : 38
Total Number of Variables : 61
Total Number of Statements : 112
```

Simulation Time = 2.5 HOURE

```
****************************************
*         USER DEFINE OUT PUT          *
****************************************
TOTAL CASTING            = 125 cft
STONE CHIPS IN YEARD     = 0 cft
SAND IN YEARD            = 150 cft
CEMENT IN YEARD          = 75 cft
WATER IN DRUM            = 1990 cft
```

D-6 Program Out Put – 6

Using Visio Block Network Programming

```
Stroboscope Model concretmix.vsd (1804417152)
Statistics report at simulation time 150
Queue          Res              Cur       Tot  AvWait
AvCont    SDCont MinCont   MaxCont
=========================================================
==
CCmix          ezs            125.00    125.00   73.00
60.83     36.10    0.00    125.00
Cement         ezs             75.00    100.00  130.50
87.00      7.21   75.00    100.00
Labmat         ezs              6.00    156.00    2.88
3.00      3.00    0.00      6.00
Sand           ezs             50.00    100.00  111.00
74.00     14.42   50.00    100.00
Water          ezs           1625.00   2000.00  135.38
1805.00    108.17 1625.00   2000.00
carlab         ezs             10.00    260.00    0.00
0.00      0.00    0.00     10.00
stonecips      ezs              0.00    100.00   72.00
48.00     28.84    0.00    100.00
Activity        Cur      Tot      1stSt      LstSt    AvDur
SDDur   MinD    MaxD   AvInt  SDInt    MinI    MaxI
=========================================================
==
Dump               0       25       4.00     148.00     1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
Haul               0       25       3.00     147.00     1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
Return             0       25       5.00     149.00     1.00
0.00   1.00    1.00    6.00   0.00    6.00    6.00
```

```
mixture           0      25      0.00    144.00    3.00
0.00   3.00    3.00    6.00   0.00    6.00    6.00
```

The Future Events List is empty at simulation time 150.00

```
Total Number of Named Objects : 36
Total Number of Variables : 63
Total Number of Statements : 16
```

Appendix – E

PARAMETRIC STUDY OUT PUTS

E-1 Parametric Study – 1

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ********************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 ********************************************

 MIXTURE MACHINE NO = 3 No

 CEMENT              = 800 bag
 LOCAL SAND          = 1000 cft
 SYLHET SAND         = 1000 cft
 STONE CHIPS         = 4000 cft
 WATER               = 12000 lit
 FIDDING LABOUR      = 18 No
 CARRING LABOUR      = 30 No
 MACHINE DRIVER      = 3 No

!!!   ****************** << OUT PUTS ARE >>********** !!!

 SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER

 NUMBER OF MIXTURE MACHINE RUNNING = 3 NO
 TOTAL MACHINE RUN                 = 711
 TOTAL CASTING                     = 4052.7
 TOTAL TIME OF CASTING             = 711 MIN 11.85 HOUR
 CEMENT REST                       = 89
 LOCAL SAND REST                   = 289
 SYLHET SAND REST                  = 289
 STONE CHIPS REST                  = 1156
 WATER REST                        = 2046

-------------------------------------
Execution    Time = 0.125 seconds


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!    PROGRAM FOR CONCRETE CASTING TIME CALCULATION   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ********************************************
 *    RESOURCE DETAILS ARE GIVEN BELOW     *
 ********************************************

 MIXTURE MACHINE NO = 3 No
```

```
 CEMENT              = 6000 bag
 LOCAL SAND          = 10000 cft
 SYLHET SAND         = 7000 cft
 STONE CHIPS         = 30000 cft
 WATER               = 100000 lit
 FIDDING LABOUR      = 18 No
 CARRING LABOUR      = 30 No
 MACHINE DRIVER      = 3 No

!!!   ****************** << OUT PUTS ARE >> **********
!!!


SPEAR MIXTURE MACHINE AT SITE, NO MACHINE PORBLEM
CONSIDER

 NUMBER OF MIXTURE MACHINE RUNNING = 3 NO
 TOTAL MACHINE RUN                 = 5523
 TOTAL CASTING                     = 48050.1
```

TOTAL TIME OF CASTING = 4602.5 MIN 76.708333

```
 HOUR
 CEMENT REST                       = 477
 LOCAL SAND REST                   = 4477
 SYLHET SAND REST                  = 1477
 STONE CHIPS REST                  = 7908
 WATER REST                        = 22678

-------------------------------------
Execution    Time = 0.515 seconds
```

E-2 Parametric Study – 2

```
Stroboscope Model 01_Site_preparation (1756636928)

 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR SITE PREPARATION TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 ******************************************

 SITE WORKING YEARD SIZE = 2000 SFT
 SITE OFFICE SIZE        = 500 SFT
 SITE LABOUR SHADE SIZE  = 1000 SFT
 SITE STORE SIZE         = 750 SFT

  SITE PREPARATION LABOUR = 15 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********
```

```
WORKING YEARD PREPARATION TIME     = 1.3333333 DAY
SITE OFFICE PREPARATION TIME       = 3.3333333 DAY
LABOUR SHADEYEARD PREPARATION TIME = 3.3333333 DAY
MATERIALS STORE PREPARATION TIME   = 5 DAY

MAXIMUM DAY COUNT = 5 DAY

-------------------------------------------
 TOTAL SITE PREPARATION TIME = 5 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.062 seconds

Stroboscope Model Drawing2 (1505480832)

Number of replications performed : 500
Average Project Duration         : 5.98
Std. Dev. of Project Duration    : 0.96
Average Project Cost             : 1550368.02
Std. Dev. of Project Cost        : 35659.13


CPM Activity     Time    ESD    LSD    EFD    LFD     FF
TF %Critic   Cost
=========================================================
=====================
CEMENT           2.92   0.00   3.06   2.92   5.98   3.06
3.06   2.20% 751496.79
SAND             1.98   0.00   4.01   1.98   5.98   4.01
4.01   0.20% 49703.24
MSBAR            3.00   0.00   2.99   3.00   5.98   2.99
2.99   1.40% 299492.42
STONECHIPS       5.95   0.00   0.03   5.95   5.98   0.03
0.03  93.60% 399956.37
WOOD             3.01   0.00   2.97   3.01   5.98   2.97
2.97   2.60% 49719.19

-------------------------------------
Execution    Time = 3.344 seconds


Stroboscope Model 09_EARTH_CUT_escavator (1763087360)


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! PROGRAM FOR EARTH CUTTING AND MOVING TIME CALCULATION
!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
 ******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 ******************************************

 TOTAL VOLUME OF SOIL TO CUT  = 161700 CFT
 SOIL DUMPING DISTANCE        = 150 M
 NUMBER OF EXCAVATOR          = 1 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********

SOIL CUTTING TIME      = 22.458333 DAY

 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 LABOUR PROBLEM ADDING EXTRA TIME = 3 DAY

-------------------------------------------
 SOIL CUTTING TIME = 25.458333 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.063 seconds
```

E-3 Parametric Study – 3

Stroboscope Model 01_Site_preparation (1419852800)

```
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !    PROGRAM FOR SITE PREPARATION TIME CALCULATION   !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 ******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 ******************************************

 SITE WORKING YEARD SIZE = 2000 SFT
 SITE OFFICE SIZE        = 500 SFT
 SITE LABOUR SHADE SIZE  = 1000 SFT
 SITE STORE SIZE         = 750 SFT

  SITE PREPARATION LABOUR = 20 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********

WORKING YEARD PREPARATION TIME     = 1 DAY
SITE OFFICE PREPARATION TIME       = 2.5 DAY
LABOUR SHADEYEARD PREPARATION TIME = 2.5 DAY
MATERIALS STORE PREPARATION TIME   = 3.75 DAY

MAXIMUM DAY COUNT = 3.75 DAY
```

```
 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 WEATHER PROBLEM ADDING EXTRA TIME = 2 DAY

 LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

 MATERIALS PROBLEM ADDING EXTRA TIME = 1 DAY

-------------------------------------------
 TOTAL SITE PREPARATION TIME = 7.75 DAY
-------------------------------------------

-------------------------------------

 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 !      PROGRAM FOR MATERIALS MOBILIZATION            !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************

 STONE CHIPS = 25 TRUCK
 SAND        = 15 TRUCK
 CEMENT      = 7.5 BAG
 SHUTTER MAT.= 1 TRUCK


 ******** TIME CALCULATE FOR EACH ACTIVITY ********

STONE CHIPS CARING TIME     = 5 DAY
SAND CARING TIME            = 3 DAY
CEMENT CARING TIME          = 1.5 DAY
MS BAR CARING TIME          = 5 DAY
SHUTTER CARING TIME         = 1 DAY

 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 WEATHER PROBLEM ADDING EXTRA TIME = 2 DAY

 LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

 TRANSPORT PROBLEM ADDING EXTRA TIME = 1 DAY

-------------------------------------------
 MATERIALS MOBILIZATION TIME = 9 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.062 seconds
```

```
Stroboscope Model 09_EARTH_CUT_escavator (630008320)

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! PROGRAM FOR EARTH CUTTING AND MOVING TIME CALCULATION
!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 *******************************************
 *    ACTIVITY DETAILS ARE GIVEN BELOW     *
 *******************************************

 TOTAL VOLUME OF SOIL TO CUT  = 161700 CFT
 SOIL DUMPING DISTANCE        = 150 M
 NUMBER OF EXCAVATOR          = 1 No

 ******** TIME CALCULATE FOR EACH ACTIVITY ********

SOIL CUTTING TIME      = 22.458333 DAY

 !!!!!  INCLUDIGN EXTRA TIME FOR PROBLEM  !!!!!

 WEATHER PROBLEM ADDING EXTRA TIME = 2 DAY

 LABOUR PROBLEM ADDING EXTRA TIME = 1 DAY

 WATER LOGING PROBLEM ADDING EXTRA TIME = 2 DAY

-------------------------------------------
 SOIL CUTTING TIME = 27.458333 DAY
-------------------------------------------

-------------------------------------
Execution    Time = 0.062 seconds
```

Stroboscope Model Drawing1 (1719242752)

Number of replications performed : 500
Average Project Duration : 85.59
Std. Dev. of Project Duration : 9.01
Average Project Cost : 0.00
Std. Dev. of Project Cost : 0.00

CPM Activity	Time	ESD	LSD	EFD	LFD	FF	TF	%Critic	Cost
Curing	14.24	71.35	71.35	85.59	85.59	0.00	-0.00	100.00%	0.00
CCWork	6.00	43.00	43.00	49.00	49.00	0.00	-0.00	100.00%	0.00
MsBarprepa	5.00	17.00	51.34	22.00	56.34	34.34	34.34	0.00%	0.00
Msparlaying	5.01	56.34	56.34	61.35	61.35	0.00	-0.00	100.00%	0.00
MaterialsMobi	9.00	8.00	42.34	17.00	51.34	0.00	34.34	0.00%	0.00
Guidewall	3.84	49.00	49.00	52.84	52.84	-0.00	-0.00	100.00%	0.00
Waterproof	3.50	52.84	52.84	56.34	56.34	0.00	-0.00	100.00%	0.00
Shoreprotect	7.00	8.00	8.00	15.00	15.00	0.00	-0.00	100.00%	0.00
Sitepreparation	8.00	0.00	-0.00	8.00	8.00	0.00	-0.00	100.00%	0.00
Concretecast	10.00	61.35	61.35	71.35	71.35	-0.00	-0.00	100.00%	0.00
Earthcutting	28.00	15.00	15.00	43.00	43.00	0.00	-0.00	100.00%	0.00

Execution Time = 0.844

Case study Outputs:

Stroboscope Model **4machine_case_study.vsd** (129735872)

Statistics report at simulation time **1805.42**

Queue	Res	Cur	Tot	AvWait	AvCont	SDCont	MinCont	MaxCont
CCmix	ezs	265.00	265.00	875.82	128.55	76.54	0.00	265.00
CCmix1	ezs	249.00	249.00	911.74	125.74	73.10	0.00	249.00
CCmix2	ezs	251.00	251.00	906.72	126.06	74.05	0.00	251.00
CCmix3	ezs	235.00	235.00	894.14	116.38	68.37	0.00	235.00
Cement	ezs	0.00	1000.00	897.15	496.92	291.84	0.00	1000.00
Labmat	ezs	20.00	2670.00	9.95	14.72	6.15	0.00	20.00
Labmat1	ezs	20.00	2510.00	10.58	14.71	6.29	0.00	20.00
Labmat2	ezs	20.00	2530.00	10.27	14.39	6.43	0.00	20.00
Labmat3	ezs	20.00	2370.00	11.14	14.62	6.50	0.00	20.00
Sand	ezs	22799.00	25299.00	1715.67	24041.30	729.60	22799.00	25299.00
Water	ezs	159316.00	174316.00	1727.26	166769.78	4377.59	159316.00	174316.00
carlab	ezs	20.00	2670.00	0.11	0.16	1.70	0.00	20.00
carlab1	ezs	20.00	2510.00	0.07	0.10	1.01	0.00	20.00
carlab2	ezs	20.00	2530.00	0.18	0.25	2.21	0.00	20.00
carlab3	ezs	20.00	2370.00	0.03	0.04	0.77	0.00	20.00
stonecips	ezs	45597.00	50597.00	1715.67	48081.59	1459.20	45597.00	50597.00

Activity	Cur	Tot	1stSt	LstSt	AvDur	SDDur	MinD	MaxD	AvInt	SDInt	MinI	MaxI
Dump	0	265	10.22	1789.41	1.50	1.54	0.00	7.11	6.74	5.30	0.00	32.20
Dump1	0	249	0.02	1797.97	1.51	1.57	0.00	8.47	7.25	4.92	0.00	22.02
Dump2	0	251	9.18	1781.74	1.43	1.62	0.00	6.86	7.09	5.28	0.04	25.25
Dump3	0	235	9.69	1795.21	1.41	1.44	0.00	7.92	7.63	5.47	0.00	26.04
Haul	0	265	4.94	1786.21	5.44	5.82	0.00	26.25	6.75	5.16	0.02	25.04
Haul1	0	249	0.00	1796.34	6.19	5.79	0.00	26.33	7.24	5.12	0.00	26.16

Haul2	0	251	7.46	1779.68	5.82	6.23	0.00	30.49	7.09	5.47	0.00	25.52
Haul3	0	235	2.98	1787.73	7.04	6.58	0.00	30.59	7.63	5.31	0.00	25.73
Return	0	265	11.93	1789.41	2.98	3.10	0.00	13.44	6.73	5.36	0.00	30.18
Return1	0	249	1.77	1797.97	2.90	3.15	0.00	12.38	7.24	5.13	0.00	21.67
Return2	0	251	9.62	1782.62	2.92	3.14	0.00	11.72	7.09	5.04	0.01	23.18
Return3	0	235	12.24	1796.09	2.75	2.95	0.00	12.58	7.62	5.36	0.00	25.46
mixture	0	265	0.00	1778.29	3.60	3.58	0.00	14.63	6.74	5.37	0.00	31.46
mixture1	0	249	0.00	1780.56	3.84	4.28	0.00	16.53	7.18	5.48	0.00	27.13
mixture2	0	251	0.00	1774.49	4.04	4.27	0.00	26.12	7.10	5.26	0.00	27.16
mixture3	0	235	0.00	1779.29	4.13	4.00	0.00	17.39	7.60	5.40	0.00	23.28

The Future Events List is empty at simulation time **1805.42**

Total Number of Named Objects : 99
Total Number of Variables : 171
Total Number of Statements : 25

Integral Stat   Ave. Wait
=========================

Execution   Time = 490.95 seconds

Stroboscope Model **3machine_case_study.vsd** (1038334336)

Statistics report at simulation time **2561.12**

Queue   Res   Cur   Tot   AvWait   AvCont   SDCont   MinCont   MaxCont
==

CCmix	ezs	331.00	331.00	1255.33	162.24	96.48	0.00	331.00
CCmix1	ezs	342.00	342.00	1275.63	170.34	98.33	0.00	342.00
CCmix3	ezs	327.00	327.00	1288.32	164.49	94.13	0.00	327.00
Cement	ezs	0.00	1000.00	1275.55	498.04	288.74	0.00	1000.00
Labmat	ezs	20.00	3330.00	11.47	14.92	6.05	0.00	20.00
Labmat1	ezs	20.00	3440.00	11.35	15.24	5.98	0.00	20.00
Labmat3	ezs	20.00	3290.00	12.17	15.63	5.85	0.00	20.00
Sand	ezs	22799.00	25299.00	2434.08	24044.11	721.85	22799.00	25299.00
Water	ezs	159316.00	174316.00	2450.49	166786.66	4331.08	159316.00	174316.00
carlab	ezs	20.00	3330.00	0.05	0.06	0.77	0.00	20.00
carlab1	ezs	20.00	3440.00	0.11	0.15	1.63	0.00	20.00
carlab3	ezs	20.00	3290.00	0.06	0.07	0.99	0.00	20.00
stonecips	ezs	45597.00	50597.00	2434.08	48087.22	1443.69	45597.00	50597.00

Activity	Cur	Tot	1stSt	LstSt	AvDur	SDDur	MinD	MaxD	AvInt	SDInt	MinI	MaxI
Dump	0	331	20.44	2555.59	1.41	1.47	0.00	6.84	7.68	5.69	0.00	27.20
Dump1	0	342	4.92	2545.19	1.45	1.58	0.00	7.29	7.45	5.49	0.00	25.74
Dump3	0	327	5.06	2546.46	1.41	1.46	0.00	6.50	7.80	5.56	0.02	28.44
Haul	0	331	0.00	2545.16	7.32	7.25	0.00	38.24	7.71	5.77	0.00	31.38
Haul1	0	342	4.92	2541.16	7.33	7.07	0.00	35.37	7.44	5.53	0.00	27.36
Haul3	0	327	0.00	2542.07	7.70	7.03	0.00	31.99	7.80	5.54	0.00	27.61
Return	0	331	21.89	2555.88	2.77	2.89	0.00	13.30	7.68	5.69	0.00	34.04
Return1	0	342	9.11	2545.25	2.53	2.87	0.00	11.67	7.44	5.66	0.00	26.62
Return3	0	327	5.39	2548.57	3.08	3.18	0.00	14.17	7.80	5.59	0.00	27.19
mixture	0	331	0.00	2534.42	3.93	3.93	0.00	17.73	7.68	5.74	0.00	25.71
mixture1	0	342	0.00	2539.41	3.56	3.80	0.00	16.54	7.45	5.49	0.00	26.39
mixture3	0	327	0.00	2536.80	3.42	3.96	0.00	21.07	7.78	5.76	0.00	29.63

The Future Events List is empty at simulation time **2561.12**

Total Number of Named Objects : 78
Total Number of Variables : 135
Total Number of Statements : 22

Integral Stat   Ave. Wait
========================

Execution   Time = 533.11 seconds

Stroboscope Model **2machine_case_study.vsd** (1260219904)

Statistics report at simulation time **4263.54**

Queue	Res	Cur	Tot	AvWait	AvCont	SDCont	MinCont	MaxCont
CCmix	ezs	491.00	491.00	2111.68	243.19	142.72	0.00	491.00
CCmix3	ezs	509.00	509.00	2164.60	258.42	149.70	0.00	509.00
Cement	ezs	0.00	1000.00	2110.79	495.08	292.37	0.00	1000.00
Labmat	ezs	20.00	4930.00	13.28	15.35	5.95	0.00	20.00
Labmat3	ezs	20.00	5110.00	13.01	15.59	5.85	0.00	20.00
Sand	ezs	22799.00	25299.00	4050.81	24036.70	730.92	22799.00	25299.00
Water	ezs	159316.00	174316.00	4078.30	166742.19	4385.52	159316.00	174316.00
carlab	ezs	20.00	4930.00	0.03	0.04	0.62	0.00	20.00
carlab3	ezs	20.00	5110.00	0.10	0.12	1.55	0.00	20.00
stonecips	ezs	45597.00	50597.00	4050.81	48072.40	1461.84	45597.00	50597.00

Activity	Cur	Tot	1stSt	LstSt	AvDur	SDDur	MinD	MaxD	AvInt	SDInt	MinI	MaxI
Dump	0	491	6.19	4261.72	1.32	1.42	0.00	6.89	8.68	6.26	0.00	34.78
Dump3	0	509	4.35	4237.83	1.45	1.54	0.00	7.80	8.33	6.29	0.00	31.26
Haul	0	491	1.62	4242.47	9.10	8.06	0.00	39.16	8.65	6.09	0.00	27.73
Haul3	0	509	0.00	4235.85	8.69	8.05	0.00	35.55	8.34	6.20	0.00	31.88

Return 0 491 8.63 4261.72 2.88 3.15 0.00 13.62 8.68 6.40
0.00 34.34
Return3 0 509 5.49 4237.83 2.83 3.14 0.00 14.42 8.33 6.32
0.00 32.26
mixture 0 491 0.00 4233.99 4.04 3.84 0.00 17.44 8.64 6.44
0.00 30.33
mixture3 0 509 0.00 4225.71 3.69 3.73 0.00 16.60 8.32 6.27
0.00 33.86

The Future Events List is empty at simulation time **4263.54**

Total Number of Named Objects : 57
Total Number of Variables : 99
Total Number of Statements : 19

Integral Stat Ave. Wait
========================

Execution Time = 529.70 seconds

The project titled “Concrete Casting Process Simulation Of A Mat Foundation”, Submitted by A.K.M Ruhul Amin, Roll No. 100504307P, Session: October 2005 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering (Civil and Structure) on 00st September, 2008.

BOARD OF EXAMINERS

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