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Lifecycle Cost Analysis of Readymix Concrete Plant

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ABSTRACT: India, being a creating country is encountering significant development in its framework. Cement is the significant segment of this infrastructural blast. This has prompted the necessity of good nature of cement in extensive amounts. This prerequisite can be satisfied by the prepared blend concrete clustering and blending plants. To fill the crevice between the interest and supply of cement countless plants are appearing. The principle target of this study is to ascertain the life cycle expense of a RMC office, which will help a financial specialist or any individual or an association to take venture choices in regards to a RMC office. The study builds up the income for the RMC office accommodating in speculation and capital era related choices. The business sector has been overviewed and the reasonable expenses for working and keeping up the RMC office are gathered as likewise the expense of charging and raising the RMC plant are gathered from the producers. Travel blenders shape a critical segment of the RMC office and their expense of owning and working frame a noteworthy part of the life cycle expense of RMC. In view of the day by day request from some destinations in the city of Mumbai, the quantity of travel blenders that would be required on the RMC plant to satisfy that request has been reenacted utilizing Monte Carlo reproduction. The life cycle expense of the RMC office has then been ascertained. Further with the assistance of this study the life cycle expense of whatever other limit RMC office can be computed and in light of necessities and capital accessibility, the monetary alternative can be chosen.

KEYWORDS: Ready mix concrete (RMC), life cycle cost, Monte Carlo simulation

I. INTRODUCTION

The country is experiencing an economic growth, which is fueled further by the infrastructural development that is taking place all over the country. The large infrastructural construction works demand high quantity of concrete. For the construction of high rise buildings, bridges, pavements, dams or any such mass concreting works the amount of concrete required is too high and also it demands a continuous supply of concrete. This high and continuous demand of concrete can be met effectively by the ready mix concrete. The ready mix concrete (or the RMC) is the concrete, which is delivered in ready to use manner. The RMC facilities in India have state-of-the-art plants, with sophisticated micro-processor based controls having ability of accurate weighing and batching, automatic charging, adjustments for moisture compensation, inventory control, etc., besides having a fleet of transit mixers of various capacities, most of these plants possess well equipped facilities for pumping concrete. In addition to the quantity, the quality of the concrete also needs to be good. At such centralized plants there is accuracy of controlling the quality of components like cements, steel and sand etc. Due to the centralized production there is production of very good quality of concrete, which is a basic necessity for the construction of the bridges, roads, high rise, etc. Also, due to the constraints of construction space and for prevention of environmental pollution the popularity of RMC has soared up in the recent times. Due to this increased demand and the improved quality of concrete, which is possible to be manufactured at the RMC there is a need for more RMC plants in this metropolitan city. The study aims at computing the total life cycle cost of the RMC plant.

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II. OBJECTIVE OF STUDY

The study mainly focuses on the Value Engineering tool, Life Cycle Cost Analysis (LCCA), its study and its application for finding out the life cycle cost of the RMC plant facility. The activity of calculating the life cycle cost has been aided by tool of simulation. The main objective of the simulation activity is to find out the optimum number of trucks that would be required for satisfying a particular demand of RMC which in turn is used in the life cycle cost calculation of the transit mixer, a major component of the RMC facility. Finally, this will enable us to find the total cost incurred and the cash flow for a RMC facility.

III. MOTIVATION

In order to accomplish the objective outlined above, a thorough review of the literature has been completed first to identify and understand the parameters involved associated with the topic. The study utilizes the existing procedure for finding out the life cycle cost of RMC plant facility by implementing Value Engineering tool, Life Cycle Cost Analysis (LCCA). A mathematical cost model is used to determine the life cycle cost. The cost model has different cost components like initial investment and erection cost, operation cost, maintenance cost, indirect cost etc. for RMC batching plant and it also considers the various costs related to transit mixers. Operation cost covers electricity cost, water cost, labour cost etc. Important maintenance cost includes spares, lubricants, fitting cost etc. All the cost data related to RMC plant and transit mixer is collected by visiting the RMC facility. Optimum number of transit mixers for meeting the expected demand is calculated by implementing tool simulation. The expected economic life and the salvage or resale value of RMC facility are assumed. All these costs associated with the RMC facility will have to be converted to the present value using discount rates and factors available in various specifications and codes. The data from World Bank’s official website is used for getting the discount rates and the discount factors have been computed. Finally, the life cycle cost computation of RMC facility is done by using present value method.Calculating the life cycle cost of any facility helps a person or a company to know how much capital investment is required for a project as also how much money will be required throughout the useful period of the facility. The LCCA tool can be used to compare different alternatives and find out the more economic one. But the scope of this study is limited to the application of the LCCA tool on an RMC facility. No comparisons are made as no alternatives are involved. The various costs associated with an RMC facility are collected. The optimum number of transit mixers required to fulfill the required demand has been calculated and the life cycle cost computation has been carried out. The scope of the study is limited to learning the application of life cycle cost Analysis. This scope and the objective have been achieved by following the methodology to be discussed now.

IV. LITERATURE REVIEW

The worth of any product or utility or any service is judged on the basis of the value it provides to its user. Unless the product is worth its cost it does not represent good value. Value can be defined as the ratio of function by cost. Good value will indicate that the product or service accomplishes the desired function at the least cost. The value of a product can thus, be increased by either improving the function or decreasing the cost. The Value Engineering or value analysis is one such tool or technique which is used to optimize the value of the product by using its various tools like improving the function by identifying and eliminating product and service features that add no true value to the customer or the product or by selecting the most cost effective alternative. [5]

Value Engineering was first used in 1947, by L.D. Miles, Design Engineer in G.E.C. USA while attempting to reduce the manufacturing cost of some products. His attempt was to search for unnecessary manufacturing cost and indicate the ways to reduce it without lowering down the performance of product. Value engineering is defined as an organized effort directed at analyzing the functions of systems, equipment, facilities, service and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with the required performance, reliability, quality and safety. [3]

Thus, value engineering is a highly potent and powerful management technique. Value analysis is carried out to increase the value of the product or service. Cost cutting shouldn’t interfere with efficiency i.e. reliability or quality of

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the product. Value Engineering does not mean only cost cutting but it also involves improving the function of the product. Only by doing this can the value of any product or service increase, which is the basic requirement of value engineering. The value engineering has many tools and techniques, which can be used to increase the value of the product or service. [2]

These include fast diagram, creative thinking and life cycle costing of the product. They are basically used in decreasing or eliminating the non-significant costs associated with the product. It provides a method for generating ideas and alternatives for possible solutions. In today's competitive world, every company's aim is to make maximum profit. One of the best ways to keep a check on budget and to increase the profitability of the project is to make strategic and significant use of the value engineering technique. The value analysis helps to compete by reducing the cost, improving the profits, improving the quality, saving time, using the resources more judiciously and effectively and meeting the customer satisfaction.The value engineering methodology consists of systematic approaches, which follows the job plan. Value methodology is used to improve the value of projects through analysis of functions. Various activities are conducted during each phase of the job plan. This methodology helps the VE team to gather, generate and implement various ideas through alternatives during various phases of project. [9]

V. FLOW OF THE SYSTEM

a) Information Phase

This phase consists of obtaining project data and information and key documents such as scope of work definition, drawings, specifications, reports, detailed project cost information, quality data, marketing information, process flow charts, etc. This phase brings all team members to a common, basic level of understanding of the project, including tactical, operational and specifics of the subject.

b) Functional Analysis Phase

This consists of identifying the project from functional point of view rather than how it is conceived. Determination of functions of project and its elements as per requirement is done in this phase. Generally the basic and secondary functions are determined and analysis is done accordingly. The FAST diagrams and tools are used in this phase, which helps in analyzing the project functionally.

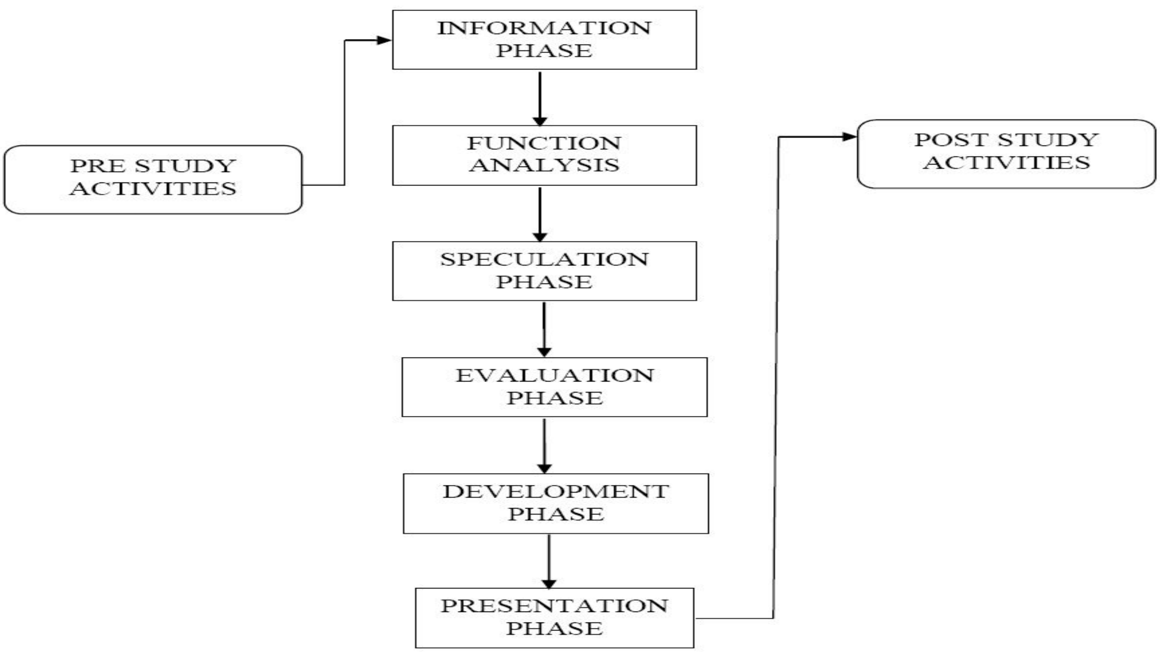

Fig No 01 Flow of the System

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c) Speculation Phase

In this phase different ideas are generated for same function. Hence it is also called as creative phase. The ideas are generated as much as possible, which will provide alternatives to perform the same work. This provides wide variety of possible alternative ways to perform the function that helps to improve the value of project.

d) Evaluation Phase

All the ideas that are generated in above phase will not be always advantageous and hence according to the requirements they will be finalized. This phase helps to categorize and clarify each idea, which follows short-listing them as per their purpose and worth for any function. The ideas are discussed and evaluated by taking into consideration their effect on project cost and performance parameters. Tools like life cycle cost analysis (LCCA) are used to evaluate the cost effective alternative for any particular task or whole project.

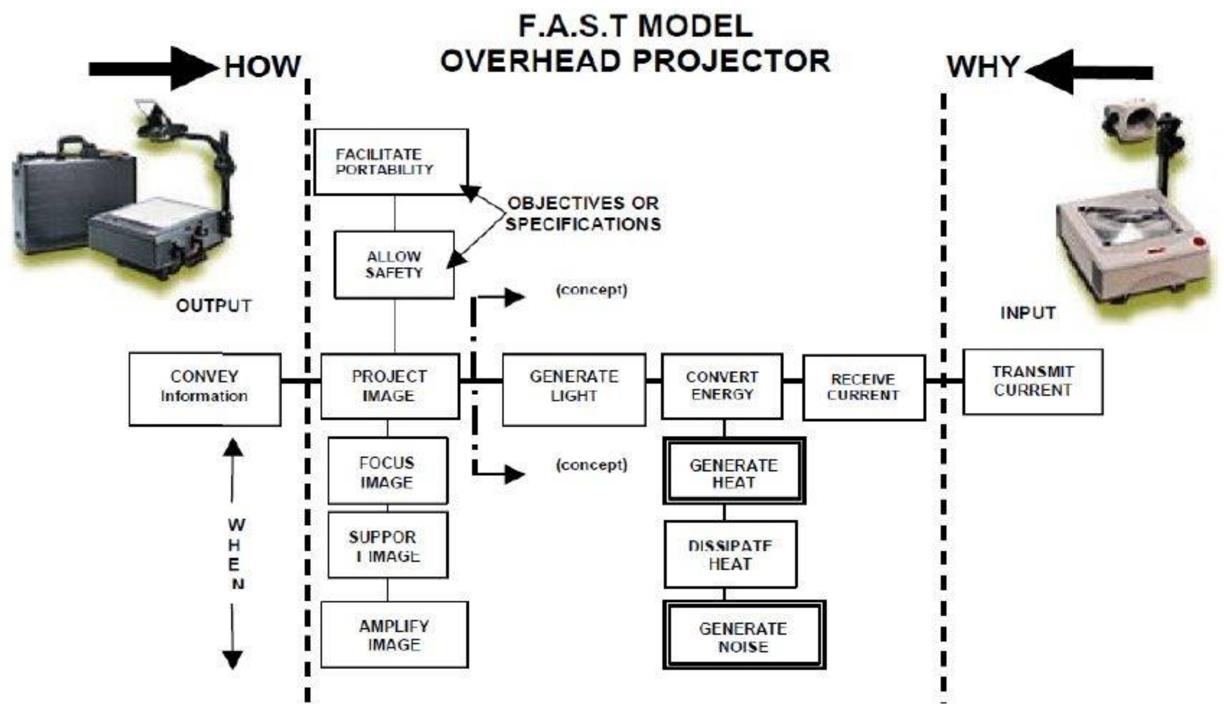
e) Development Phase

Further the shortlisted ideas are analyzed and developed in this development phase. Informative description is prepared for all the ideas, which are selected mentioning their merits over rejected ideas and any exclusive things they have.

f) Presentation Phase

The value alternatives are presented to the management team, other project related managers and to decision makers. These are presented via presentations and supporting documents, in which comparison between the study conclusions is done to the success requirements established during the information phase.

V. SYSTEM ARCHITECTURE



Fin No 02 System Architecture

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Explanation-

FAST provides an organized step-by-step method for the determining the function required and exploring the complicated processes of a product. FAST is used to determine the project functions as well as the function of each part of the product. The FAST modeling process with the facilitator asking several questions designed to identify the scope of the model, its objective function, and basic function, or basic functions.

These questions are designed to identify the mission of the system while bounding the scope of the problem, or opportunity. By stating the mission of the system as a problem, or opportunity helps the team specify what the system has to accomplish. The basic structure of a FAST model looks somewhat similar to a process flow chart. However, there are some very significant differences. FAST serves as a problem solving technique to determine the essential functions to be performed and the supporting functions. Each function is evaluated to usefulness for reducing functions.

VI. MECHANISM OF READY MIX CONCRETE

Ready-mix concrete is concrete, which is manufactured in a factory or batching plant, according to the requirements, and then delivered to a work site, by truck mounted transit mixer. It was first patented in Germany, way back in 1903. By 1950s, the use of ready mixed concrete picked up in most of the advanced countries in Europe and America. Presently, nearly 75 % of the cement used in the USA is routed through ready-mixed concrete outlets. The corresponding average figure in Europe was 46.7% in the year 2005. Technologically speaking, the production process of ready mixed concrete has been continuously been upgraded, leading to improvement in product, quality and uniformity. Today's plants are highly automated and consist of state-of-the-art equipment having computerized controls on the entire production process. Compared to the advanced countries, India was a late starter in ready-mixed concrete the past more than a decade, RMC-India and many other leading manufacturers have expanded their operations to various metropolitan and other big cities in India. Sufficient experience and expertise have been now obtained in the production and use of ready-mixed concrete. Technically speaking, RMC is certainly advancement over the age-old site mixed concrete. The RMC gives advantages like increased speed of construction, improved quality, reduces site labour requirement, reduction in wastages etc. The raw materials used for ready-mix concrete, namely, cement, sand, coarse/fine aggregate, water and admixtures are mixed at a centrally located computer controlled plant that monitors weigh-batching, water-cement ratio, dosage of admixture, moisture content etc. with precision, to produce the ready mix concrete.

Ready mix concrete is then transported to the site in transit mixers in plastic condition, without affecting the composition and without any further treatment. Transit mixers are trucks fitted with rotating drums for carrying ready mix concrete. Generally the capacity of the transit mixers is 2 to 14 cubic meters. The process of RMC manufacturing and supply is as follows: Generally the hydraulic weigh batching is adopted to deliver the concrete as for the requirements/mix design of clients with appropriate water cement ratio. At the start of production, dry materials from the upper storage bins are discharged into the plant's stationary central mixer. The proportion of materials in the mix is custom-designed to meet the specifications for each project. Proportioning is controlled by computer to ensure quality control. The customer typically works with the ready-mixed concrete producer to determine characteristics such as aggregate size, slump, air content, and strength based on the intended use. Typical composition by volume is about 10-15% cement, 60-75% aggregates, and 15-20%water. Entrained air bubbles may also account for 5-8%. Using less water generally results in a higher quality concrete.After mixing is complete, the mixture is discharged into a truck-mounted, rotating drum mixer. Rotating-drum truck mixers typically have a capacity ranging from 2 to 14 cubic meters and discharge the concrete from the rear. Because slump loss can occur during transit, it is required that the concrete be discharged on the job site within 90 minutes or before 300 revolutions after the addition of water to the cement.

Admixtures may be added to the concrete mix in situations of extreme temperature or long delivery times. Types of admixtures include air-entraining agents, water reducing agents, and set-retarding agents. Vehicle maintenance is extremely important for ensuring safe and efficient transport of concrete products. Concrete plants typically include a full service garage to maintain their fleet of trucks. Further the concrete is pumped to the actual point of concreting through high efficiency concrete pumps. At the site when the transit mixer arrives the concrete is pumped or manually transported by wheelbarrows and placed at required location. The waiting time of transit mixers at site depends on placing operation.

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VII. MECHANISM OF LIFE CYCLE COST ANALYSIS

Life–cycle cost analysis (LCCA) is an economic method of project evaluation in which all the cost arising from owning, operation, maintaining, and ultimately disposing of a project are considered to be potentially important to that decision.
Life cycle costing is a process to determine the sum of all the costs associated with the any facility, including acquisition, installation, operation, maintenance, refurbishment and disposal cost. LCCA is a powerful tool of an economic analysis which can be applied to any capital investment decision in which higher initial costs are traded for reduced future cost obligation. The LCCA can be used to identify an economical alternative as also it can be used to prioritize the funding of the project. However, the aim of this study is just to understand the application of the LCCA tool and so comparisons are not drawn between alternatives rather, the calculation of the life cycle cost of an RMC facility is done. The LCC method, contributes the total cost of owning, operation, maintaining and disposal of the system over a study period with all the costs discounted to reflect the time value of money. In calculating the LCC of the facility present value method is used, in which all the future costs are generally discounted to their present value equivalent. This report consists of LCCA of the RMC facility with present value method.

1. Define the project objective.

2. Set the study period.

3. Establish the common assumptions.

4. Estimate costs and time of occurrence for each cost.

5. Discount future costs to present value.

6. Compute LCC by present value method.

The first step in life cycle cost analysis is to identify what has to be analyzed. It is important to understand how the analysis will be used and what type of decision is to be made in structuring the analysis and in selecting a method of economic evaluation.
In case of RMC facility, our project deals with to minimize the idle time of the plant and the transit mixers. The tool of simulation has been used to find the optimum number of transit mixers required for fulfilling a particular demand. The optimum number is so selected that the total idle time of the plant and the transit mixer is minimum. The time over which the costs and benefits related to capital investment are taken into consideration is termed as study period. The study period begins with the base date and includes the planning/construction period and the service period. The study period is so selected that the facility is in efficient use during that period.

a) The Base Date

The point in a time to which the entire project related costs are discounted in an LCCA is base date. Instead of declaring a particular date, a year is declared which is the best-suited method for selecting the base date in LCCA. All the initial investment costs are incurred at the beginning of this year and all the future costs are incurred during the study period are discounted to the base date. All the future costs specified by year only, then those costs are discounted from the end of year in which they occur. As the initial investment costs incurred on base date then such cost need not to be discounted as they are already in present value.
The base date is generally taken as the date of start of the analysis and all the future costs are discounted. The base date in this Study has been considered as July, 2013.

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b) The Service Date

The service date, is the date, on which project is expected to be implemented. Operating, maintenance costs including energy and water related costs are generally incurred after this date. The service date marks the start of the service period of the facility. The service date in this case is taken as 1st January 2014.

c) The Service Period

The service period is the total period in which the facility operates efficiently. Sometimes the period of the analysis during which the operations on the facility are going on, that period is considered as the service period. Here, a service period of 6 years has been considered for the LCCA study.

d) The planning/construction period

The planning and construction period (P/C) is the time, which is taken for the acquisition and the erection of the components of the facility. During the P/C period the operations of the project do not take place. Whenever there is delay between beginning of study period and the service date the intervening time is planning/construction period. All the costs occurring in planning and construction period are discounted to the base date. This study has considered a P/C period of 6 months or half a year. Hence the total study period, which comprises of the P/C and the Service period, is considered as 6.5 years in this study.

VIII. EXPERIMENTAL SETUP

Probability distribution functions are plotted from the data collected for the input parameters. In our case the input parameters for the simulation are discharge time (batching, mixing and loading time), travel time and the placing time. The placing time collected from the site consists of position time, pumping time and the delay if it occurs. The position time is the time required by the transit mixer to move from the queue to the concrete pump and prepare to discharge the concrete. If no queue is present the position time will be the time taken by the transit mixer to position at the pump and prepare for discharging only. Pump time is the time required to unload the transit mixer completely. In this model since a finite number of transit mixers are used, the probability distribution function selected for the return time of the transit mixer is same as the travel time function. Since there are four sites eight probability distribution functions are plotted (one for the travel to a particular site and the other for placing at that site).

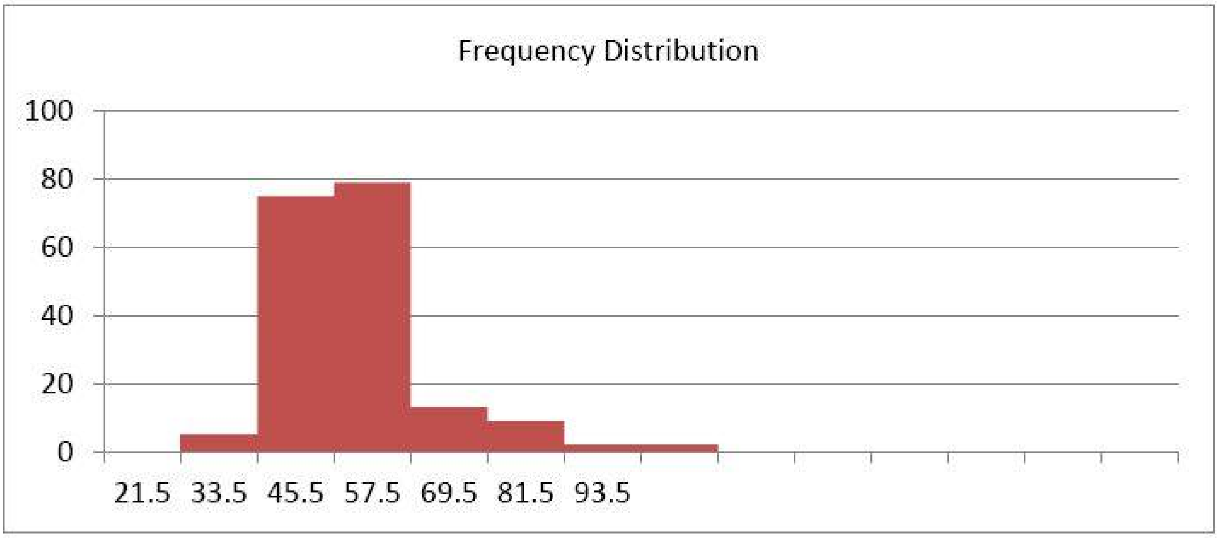

Fig. No 03. Frequency distribution of the travel time to placing site 1.

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For plotting the probability distribution function a frequency table is first constructed from the data collected. The travel time for the transit mixers are calculated using the timestamps on the transit mixer tickets obtained from the RMC plant. From the frequency table the probability distribution functions are plotted. The probability is obtained by dividing a particular frequency with the total frequency (the number of observations). Following the same process the placing time and travel time functions are plotted for all the four sites. As shown below the probability of obtaining 45.5 minutes as the travel time is 0.405. For the discharge time a uniform distribution of 8 to 10 minutes is selected. The reason for selecting a uniform distribution is due to the difference in variation of the grade of the concrete. A uniform probability distribution function means the probability of selecting any value is the same. Different grades of concrete require different batching and mixing time, which affects the discharge time. Once the probability distribution functions are plotted the simulated values can be obtained using the generated random numbers.

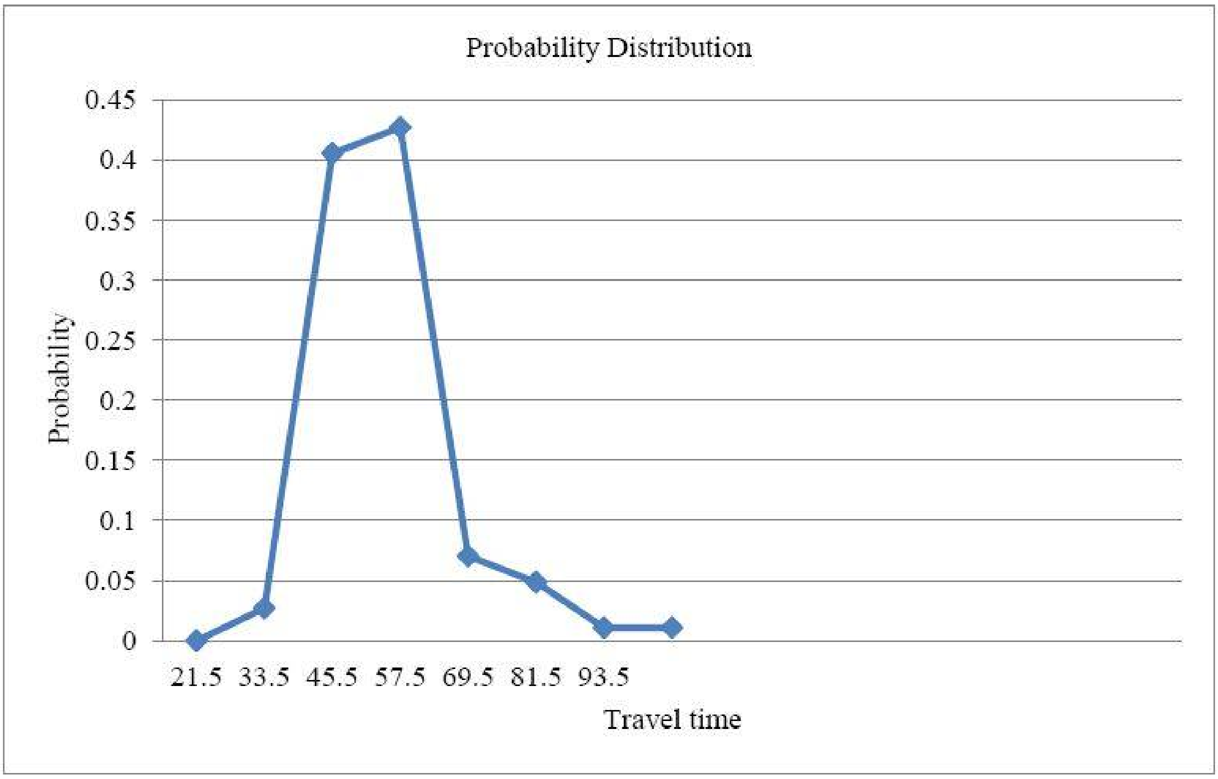

Fig. No 04. Probability distribution function for travel time to placing site 1

The results of the spreadsheet simulation have been tabulated so that the different combinations can be compared as per the set decision criteria. The number of iterations of the simulation run considered for the study is 71. Only some of the truck combinations have been taken for simulation. The truck combination of 1111 corresponding to four numbers of trucks is able to meet the average demand of 10 cubic meters but because of the long duration required for the placing activity to end, it is not a feasible solution. All such combinations are not selected. The main objective of this simulation is to select that solution which has the least idle time cost for the system. From the above table it can be seen that the least idle time cost is obtained for the transit mixer combination of 2323 corresponding to 10 numbers of trucks. Hence the optimum number of transit mixers, which will be used for life cycle cost analysis, is 10.

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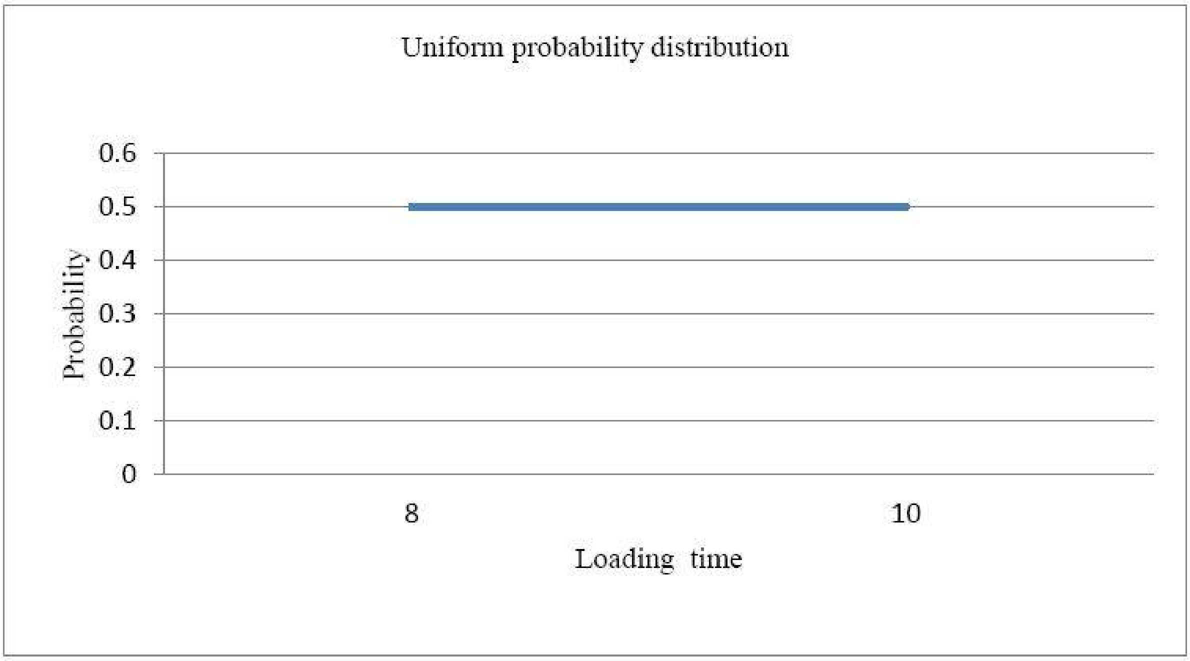

Fig No 05 Uniform probability distribution function for discharge time at RMC plant

IX. CONCLUSION

The calculation of Life Cycle Cost of the 30cu.m./Hour capacity RMC Batching and Mixing Plant has been carried out with the help of LCC Model and simulation activity. Thus, the application of the value engineering tool, life cycle cost analysis has been learnt. The activity has some limitations as it is based on assumptions. The various operations, maintenance and repair costs associated with the RMC facility is spread throughout the year. Instead, the study has made an assumption that the costs are occurring at one point that is the end of the year. The initial investment and erection cost occurs throughout the P/C period but the study considers it to be occurring on the base date. The data has been collected from a limited source. No economic alternative has been provided by this study. Model does not take into consideration the wash out time for the transit mixers and their positioning time.

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