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APPLICATION OF VALUE ENGINEERING TECHNIQUES IN BUILDING CONSTRUCTION PROJECTS

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ABSTRACT

Value Engineering is a creative, organized effort, which analyzes the requirements of a project for the purpose of achieving the essential functions at the lowest total costs over the life of the project. Through a group investigation, using experienced, multidisciplinary teams, value and economy are improved through the study of alternate design concepts, materials, and methods without compromising the functional and value objectives of the client. Value engineering is the process of relating the functions, the quality and the costs of the project in the determination of optimum solutions for the project. A cost-effective solution is achieved by an application of VE principle for different components of the structures relating its quality and quantity. This study mainly focuses on new techniques, methods and materials that can be adopted in construction industry, in which, its cost, quality, process time and feasibility are considered. Value Engineering focuses on accomplishing the required functions at the lowest overall cost. It helps in eliminating or minimizing wastage of material, time, and unnecessary cost, which improves value to the customer.

KEYWORDS: Value Engineering, Value Engineering Job Plan Techniques, Cost, Quality, Value Analysis.

INTRODUCTION

The engineers have always tried to reduce the cost of construction without affecting the quality and the functional utility, however their approach was based mainly on the past experience. Keeping the costs low with traditional cost management has been a commonly applied measure to improve competitiveness. However, keeping cost down alone is not enough, there is an increasing need for improve in schedule as well as efficiency and effectiveness. Saving money at the same time, providing better value is a concept that everyone emphasizes. Value Engineering is a proven management technique that can make valuable contributions to value enhancement and cost reduction of the construction industry. With the advancement of science and technology, it became comparatively easy to reduce the construction cost, but the concept of functional utility was not given due consideration. Reliability and durability were of little importance. Now a day's Engineers and Architects have started taking Into consideration these important factors i.e. reliability and durability with functional utility to optimise the cost. This subject has got emphasize in last few years whose object is to effect economy, in the cost of construction of project. Value Engineering is an organized, creative and cost search technique for analyzing the function of any product, service, or system with the purpose of achieving the required functions at the lowest overall cost consistent with all the requirements that comprise its value, such as performance, quality, reliability and appearance. Value Engineering uses the best combination of any proven tools and techniques in management process. Value engineering is thus arguably of greater importance than cost management efforts. [1]

Both value engineering and cost reduction aim at reducing costs but there is a basic difference between these techniques. Value Engineering is functional oriented where as Cost Reduction is production oriented. Value Engineering aims at functional cost effectiveness by avoiding unnecessary costs; it involves multi discipline team effort, and applies innovative and creative techniques to maximize value. On the other hand Cost Reduction aims at changing the method of production to reduce the production cost of an item, it involves usually an individual effort and generally its emphasis is on analysis of the past practices and processes to reduce costs.[2]

LITERATURE REVIEW
Neetu B. Yadav, Rakesh Kacha, Neeraj D. Sharma & Hiren A. Rathod,(2013)[3], states that Application of Value Engineering/Analysis is done by using Job Plan which is an organized and systematic approach. VA job plan is the key of success for a value management exercise. It is through this plan that the already identified areas of value study are subjected to in-depth application to seek new and creative alternatives. The Job plan required the formation of a multidisciplinary team representing a cross section of technical field to conduct the program. A multi-disciplinary approach generates more and better ideas, gives greater impact of decisions and costs on all services, and develops better communication among the members of team. There are different job plan existing and are selected as per suitability of the project and requirements. Five phase job plan also known as standard job plan is the most suitable job plan of value engineering in Indian context.

Shichao Fan, Qiping Shen, Gongbo Lin,(2007)[4], defines value management (also known as value engineering in the United States) is a structured and analytical process that seeks to achieve value for money by providing all necessary functions at the lowest cost consistent with required levels of quality and performance. Shichao Fan, Qiping Shen, Gongbo Lin also adopted Group decision support system (GDSS) for identifying the problems. This study presented an experimental comparative study between Interactive Value Management System (IVMS) and the traditional ways of conducting VM workshop for generating new ideas.

Urmila A Mahadik,(2015)[5], states that VE is applied in an organized process known as VE job plan. The purpose of job plan is to assist a study team to identify and focus on key project functions in a systematic manner, in order to create new ideas that will result in value enhancements. The VE job plan consists of five phases: Information Phase, Creative Phase, Evaluation Phase, Development Phase, and Presentation Phase. She also concluded that using value engineering by multidisciplinary team, value and economy are improved through study of alternative design concepts, material and construction methods without compromising functional requirement and quality.
Akintola Omigbodun,(2001)[6], stated an optimal solution for the building project design problem by various contributing factors subjected to its costs and performance. This study also mentioned various methods and optimal design with respect to concurrent engineering and total quality management, and these methods are compared with various other methods for its cost minimization based on VE aspects. Akintola Omigbodun also concluded that in applying value engineering to a building project, the multidisciplinary team obtains a solution that emphasizes the functions of the project and the best judgment of the team in making final choices, and which results in a cost effective design for the project.

Xueqing Zhang, Xiaoming Mao and Simaan M. AbouRizk,(2009)[7] develops a Value knowledge Management system (VE-KMS), which applies the theory of inventive problem-solving. This system also helps in creating phase of the VE process by making it more systematic, organized and problem focused. This study proposes a VE-KMS to support the knowledge creation process, code and retain ideas from historical VE ideas.

VALUE ENGINEERING JOB PLAN TECHNIQUES
The value engineering is a structured, disciplined procedure aim at improving value. The value engineering study uses a systematic procedure called job plan. The job plan outlines specific techniques to effectively analyze a product or service in order to develop the maximum number of alternatives to achieve the products or services required functions. Adherence to the job plan will better assure maximum benefits while offering greater flexibility. [3]

The VE study is composed of five phases: information phase, creative phase, evaluation phase, development phase and presentation phase. All phases and steps are performed sequentially. As a value study progresses new data and information may cause the study team to return to earlier phases or steps within a phase on an iterative basis. [5] Following are the five phases used in value engineering,

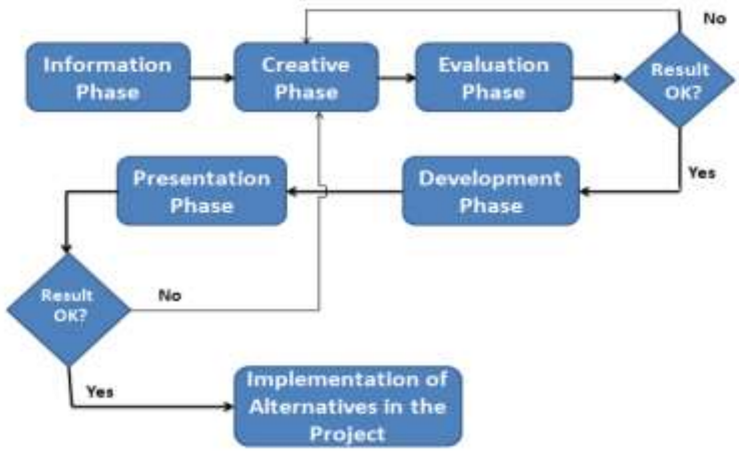


Figure 1 The Job Plan

CASE STUDY

Value Engineering is applied to the Shreenath Enclave Offices Complex, Nashik by using following value engineering job plan phases.

A. Information Phase:

All necessary and possible information regarding the project were collected by visiting the site office and company directly. The information includes financial and technical aspects of the projects. The data were collected though meetings, interviews and questionnaire with owner, consultant, contractor, architect and users.

B. Creative Phase:

In our value engineering study of the creative phase, we have used the brainstorming techniques. During brainstorming the various problems are identified that may affect the cost, time, quality and quantity of work and also durability of construction. These problems were mainly identified on the basis of construction material cost saving without compromising the quality of work. The main problems identifies were,

1. As river sand is the basic component for preparation of concrete for R.C.C work, as it is required in bulk quantity in the construction project. But from the recent study in the Nashik region, it has been found that there is shortage for availability of river sand because of various reasons due to which price for river sand has hiked.
2. For any concrete structure, reinforcement is as important as concrete also it is required in huge quantity in construction project. So, in the overall material cost reinforcement costing is considered as a major cost.

To overcome these identified problems various alternative value engineering technique are analyzed and quantified for achieving benefits in the terms of cost reduction, quality of work and time saving. VE techniques that can be adopted are,

1. As river sand has shortage for its availability so use of crush sand can be an alternative as it is much cheaper than river sand. Investigation carried out by varying 0 to 100% replacement of natural sand with manufactured sand with increment of 20 % and in critical zone the increment is of 10 % in M25 mix. The compressive strength was determined at 7, 14 and 28 days.
2. For reducing the quantity of reinforcement at the execution stage, use of reinforcement couplers can eliminate the method of lapping of bars. Moreover, reinforcement couplers give higher strength than lapping of bars at a feasible cost. Investigation carried out for 16, 20 and 25 mm diameter samples by calculating ultimate tensile stress by using universal testing machine.

C. Evaluation Phase:

1. Use of Crush Sand Instead of River Sand

The experimental work of use of crush sand instead of river sand was initiated with characterization of the locally available materials used for the making of concrete. Prior to starting the experimentation, mix design of M25 were carried out as per IS 10262-2009. Design mixes as shown in table 1.1 The standard cast iron cube moulds of size 150 X 150 X 150mm are casted and compacted on vibrating table. The compressive strength of specimens is determined after 7, 14 and 28 days. The change in compressive strength of the sample for 28 days is shown in table 1.2 respectively. A graphical representation of this result is shown in Graph 1.1

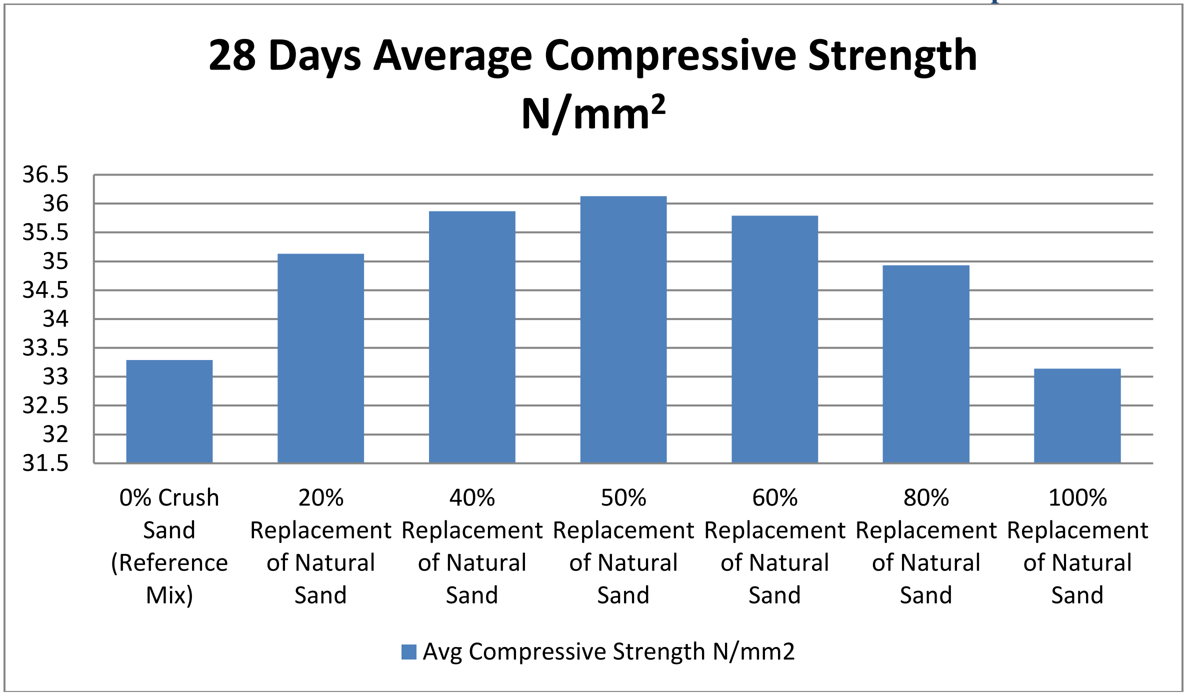
Table 1.1 :- Design Mixes (M25 Grade Concrete)

Mixes Crush Sand : Natural Sand	Control Mix	00:100	20:80	40:60	50:50	60:40	80:20	100:00
Cement (kg/m^3)	447	447	447	447	447	447	447	447
Coarse Aggregate (kg/m^3)	1291	1291	1291	1291	1291	1291	1291	1291
Crushed Sand (kg/m^3)	00	00	109	219	273	328	438	547
Natural Sand (kg/m^3)	533	533	426	320	267	213	107	00
Water (kg/m^3)	192	192	192	192	192	192	192	192
W/C Ratio	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43

Table 1.2 :- Comparison of compressive strength for 28 days

Concrete Mix Crush Sand : Natural Sand	Average Compressive Strength (Mpa)	% of Variation With Respect to Control Concrete
00:100 (Reference Mix)	33.29	-
20:80	35.13	5.53
40:60	35.87	7.75
50:50	36.13	8.53
60:40	35.79	7.51
80:20	34.93	4.93
100:00	33.14	-0.45

The table 1.2 shows that at the age of 28 days, compressive strength of reference mix (0 % crush sand) was 33.29 MPa and mixes 20:80, 40:60, 50:50, 60:80, 80:20, 100:00 were 35.13, 35.87, 36.13, 35.79, 34.93, and 33.14 MPa, respectively. Maximum compressive strength (36.13 MPa) was observed for 50:50 concrete mix; it was 8.53 % more than the reference mix (0% crush sand). At the age of 28 days, percentage increase in compressive strength was 5.53, 7.75, 8.53, 7.51, 4.93, -0.45 % for mixes 20:80, 40:60, 50:50, 60:40, 80:20, and 100:00 than reference mix (33.29 MPa). In investigation, it was observed that compressive strength of concrete increased with the replacement of river sand by crush sand up to 50%.



Graph 1.1 M25 Concrete mixes with varying % of crush sand for 28 days

2. Use of Reinforcement Coupler Instead of Lapping of Bars

The ultimate tensile test is conducted for couplers as per IS.1786.2008 which is the mandatory test compulsory for the manufacturer in house test laboratory. The materials used in this experimental work were mechanical threaded coupler and HYSD Rebars (Fe 500). Fe 500 steel bars of diameters 16, 20, 25 mm were used for study. Table 1.3 shows the average tensile test result for 16, 20, and 25 mm bars.

Table 1.3 :- Average tensile test result for 16,20 and 25 mm diameter rebar for splicing

Results				**Requirement as per I.S. 1786-2008**
Diameter of Bar	16	20	25	
ID Mark	SHREE OM-500 TMT	SHREE OM-500 TMT	SHREE OM-500 TMT	
Sectional Weight (kg/m)	1.581	2.441	3.831	
Cross sectional Area (mm^2)	201.47	310.96	488.02	
Gauge Length (mm) 5.65√A	80.00	100.00	125.00	
0.2% Proof Stress Obtained (N/mm2)	547.70	522.10	548.77	> 500
Ultimate tensile stress (N/mm^2)	638.07	618.87	642.90	> 545
% Elongation	17.76	16.19	16.21	> 12
Distance of Fracture from Centre of Coupler (mm)	20.80	25.80	32.04	
Remark	Bar broken outside the splice joint	Bar broken outside the splice joint	Bar broken outside the splice joint	

D. Development Phase:
The results indicates that the alternatives, use of crush sand instead of river sand and use of reinforcement couplers instead of lapping of bars is better than the existing idea. The cost analysis is done for above both alternatives along with the existing one. Cost analysis comparison is made between crush sand and river sand in terms of the strength, economy and feasibility. The result shows that when 50 % crush sand used instead of river sand the cost is reduced for per cubic meter of concrete. For second alternative cost analysis comparison is made between lap splices and mechanical splices in terms of the strength, economy and feasibility. The results showed that the use of coupler instead of lapping of bars can achieves the best savings in the cost.
E. Presentation Phase:
In value engineering presentation phase oral as well as written report is put up to the management / finance department for approval, mentioning the cost of the concrete and steel after the application value engineering is considerably less.

CONCLUSION
It resulted that, using 50% crush sand in concrete for R.C.C. work instead of river sand; cost is reduced by 3.90% for 1 Cu.m. of designed M25 mixes of concrete. Instead of using lapping of bars, use of reinforcement couplers resulted that cost is reduced by 47.95% for 16 mm diameter bars, 49.39% for 20 mm diameter bars and 58.09% for 25 mm diameter bars. The results showed that the use of coupler instead of lapping of bars can be considered one of the most important methods of the new construction techniques, which achieves the best savings in the cost and time. The case study indicates that the proposed value engineering technique can be successfully applied to a real construction project. The proposed technique greatly assists the decision making process to the owner, designer, and the contractors. In addition, this method can be used for the evaluation and selection of any construction system by following the procedure presented in this research.

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