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Moin Naim: Life Cycle Costing for an External Envelope

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We certify this thesis for the award of degree of Master of Science in Civil Engineering

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INSTITUTE OF APPLIED AND SOCIAL SCIENCES

LIFE CYCLE COSTING FOR EXTERNAL ENVELOPE OF BUILDINGS

Moin Naim

Master Thesis

Department of Civil Engineering

Nicosia - 2006

ABSTRACT

LIFE CYCLE COSTING FOR AN EXTERNAL ENVELOPE

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M. Sc. in Civil Engineering
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The cost of buildings and other structures is an important factor to be considered by anyone associated with a construction project. It is one of the trios of fundamental needs of the industry's clients.

Therefore, all efforts have been expended not to make any mistake and try to increase the value (to approach its maximum point) by means of good management from concept to completion of project.

The subject of this master thesis is based on claims due to imperfections that exceed the costs and result less value of most of the North Cyprus housing projects. The reasons are investigated by using Value Management (vm) principle and Life Cycle Cost (lcc) techniques on such projects.

To approach the prove of this claim, this study involves; the literature survey of vm, the techniques of Life Cycle Costing (one of the vm fundamental principles) and application of (lcc) on the newly designed student dormitory in the Near East University. The application of (lcc) on the project showed that, it is beneficial for the owner or user reach the best decision while choosing any alternative of the building elements.

DEDICATION

To the soul of my father, **Naim Mohammed NAIM**, who were my first and main supporter and whose encouragement was my major source of motivation during all my educational life but he passed away in the last months of this study.

ACKNOWLEDGMENT

This research has been completed within the subject area of construction Management in Civil Engineering Department, at Near East University.

The author wishes to extend his gratitude to the following individuals and organizations:

- Professor Dr. Tahir Çelik, the director/supervisor of this research for his excellent guidance and advice.
- All construction managers, architects, engineers, and supervisors in different organizations who contributed by their knowledge, time and experience during the research.
- The members of my family for their encouragement, support and patience.

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CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND

Complains by the clients about a constructed facility mainly arise from the increased prices and dissatisfactions of the performances of some parts or all of the end product. Construction prices have increased substantially during the recent years. Architects and engineers ask increased fees, manufacturers raise their prices and contractors raise their bids accordingly. Complains by the owners about the dramatic increase of the construction costs become an owner's revolt [1]. Parties involved in construction management can have substantial impact upon the clients own fortune. Clients are suffering from increasing costs and not getting the quality and value for their investment. This causes dissatisfaction of the design and the constructed facility.

Value of a constructed facility reflects client's desire to obtain and retain the facility and depends on how much the design details and performances of its components agree with his/her own value system. Most clients have little experience or qualifications to analyze alternatives in selecting the best alternative in view of getting the optimum value for the construction materials and technology to be used for their investment. Traditionally, selection of design details is performed by the designers with little consultation with their client. The success of selection of components of a construction facility needs knowledge of design alternatives and of client's value system.

Recently, a new approach called value management evolved especially in Europe. Value Management in construction concerns with client value system and his/her optimum satisfaction of the constructed facility. It helps client to ensure that his/her investment in construction produces valuable assets.

And one of the techniques to do the economical part of the value management is the life cycle costing technique. Life-cycle costing is a trivially obvious idea, in that all costs arising from an investment decision are relevant to that decision. The image of a life-cycle is one of progression through a number of phases, and it also implies renewal as the project undergoes changes throughout its existence. The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition, defines Life Cycle Cost (LCC) as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time.[2]

In this study we applied the LLC to the external envelope, wall, plastering, painting, windows, etc… of a dormitory building in the Near East University and we reached the result that in this building some external envelope existing elements are good choices according to their life cost with respect to the suggested alternatives and some not which means there is a suggested alternative for that element and has less life cost than the existing element.

1.2. Objectives

In this study the imperfections, expensiveness and alternatives of the external envelope of a student dormitory in the Near East University is taken into consideration.

Throughout this study the philosophy and principle of value management and life cycle cost techniques were used to analyse both existing system and the offered alternatives for that system.

The main objectives of this thesis may be summarized as follows:

i. To become acquainted with the value management philosophy and framework in order to maximize the necessary value of a housing project.
ii. To become acquainted with the life cycle cost techniques and its benefits in economic analysis of projects.
iii. To examine the advantages of applying value management and life cycle cost techniques on a housing project.
iv. To offer alternatives and recommendations to external envelope system to improve the value of the project.
v. To show that savings can be obtained by deleting unnecessary expenditure in building projects.

1.3. Reasons for objectives

Nowadays the aim of building (house) is not summarized under the words 'hut' or 'hovel', because it has to involve some other peculiarity such as; stability, health, hygiene, economy, esthetic etc. Therefore, more consideration should be paid in houses projects to increase its utilities and values.[4]

Here, the reasons for objectives of this thesis may be summarized as listed below:

i. Most of the North Cyprus residential projects do not meet the necessary value. Value management is 'maximization value methods', therefore, it is beneficial to be acquainted to the value management philosophy and framework.

ii. The cost of residential projects is not just its total initial cost, but it includes all future costs during the service life of the building. The life cycle cost is a technique which considers all future costs as well as the initial cost and can give a proper present value of the project. In order to have more alternatives, with consideration of all the future costs in economic analysis, it is beneficial to be acquainted to the life cycle cost techniques.

iii. By applying the value management and life cycle cost techniques on a residential project it is expected that the value of the structure will be maximized and the project life cost will be optimized.

iv. It is believed that, during design stage of a building, all applicable alternatives are needed to be considered for every element of a building. By applying value management and life cycle cost techniques, at least two alternatives for the external envelope system of the building is compared in terms of value and cost.

v. It is aimed to examine how much money can be saved from some parts only of the external envelope of one dormitory building which is Student Dormitory No.8 in the Near East University in Nicosia- North Cyprus.

1.4. Works done

In order to achieve the aims and objectives of this thesis, the following works were done:

- The study of value management (vm) principles.

- The study of life cycle cost (lcc) techniques.
- Identification of some problems and difficulties in the external envelope of the buildings in North Cyprus by direct interviews and arguments with the expert, construction managers, sand site engineers.
- Analysis of the existing external envelop of the dormitory
- Preparation of alternatives against existing external envelop of the dorm.
- Collection of data and information in Cyprus for constructability of offered alternatives and their costs.
- Application of lcc technique on both existing and offered alternatives.
- Comparison of all systems based on present value, utility and total system value.
- Driving the saving amount on each division of the external envelope of the dormitory building
- Driving a check list for implementation of life cycle cost.

1.5. Achievements

The achievements in this study may be summarized as follows:

- It is observed that value management is a philosophy that can maximize the value of housing projects.
- It is observed that application of life cycle cost technique provides more alternatives and gives proper present value (or equivalent uniform annual value) including initial and all future costs to make decision in selecting an optimized alternative.

- The analysis of external envelope of the dorm building and examination of value management and life cycle cost by applying them on this project the following advantages and benefits were obtained:
  - Insure that the existing system in some parts is well chosen like the aluminum windows and doors and saving a good amount of money.
  - Saving from %10 to %35 in different parts of the external envelope by the offered alternatives.
  - Having applied the value management on the water installation system, the value increased about 3.54 times of its existing value.
  - Increasing the insulation and aesthetic conditions of the building by changing the plastering and painting systems.
  - The importance of using a proper economic analysis during design stage is once more understood.

1.6. Guide to thesis

This is a study report due to residential project in North Cyprus and importance of application vm principle and lcc techniques on such projects, and the report involve five chapters, started by general introduction and objectives of this research.

Chapter II concentrates on definition of lcc and its techniques. the activity and stages to implement lcc on any projects, and the cost reduction potential on life and time horizon of project. Insight of some clients on a project cost which is the initial cost of project. The feature of costs that should be considered in proper economy analysis and cost evaluation of project. The calculation of lcc and cash flow diagram. And the difficulties in application of 1cc is the content of this chapter.

Chapter III is dealing with the literature survey of vm, its background, principles, key elements and framework, The definition of 'value' and its relation with cost, worth or utility, importance of functional analysis in order to elimination of un-necessities, client and his/her role in vm perspective, comparison of vm with its some similarities in order to prevention of confuse between those philosophies, the last part is to make acquainted the new version of vm that is 'SMART Value Management'.

Chapter IV is the application of lcc on external envelope of the student dorm project in the near east university and it was done into two main parts in the first part the external envelope is explained (roof, walls, plaster, windows, doors, and paint) and in the second all the components of external envelope is analysed economically and many alternatives is offered and also studied in the same way in order to compare the alternatives easily. This work is limited with structure part of the building and for leak of information energy conservation, heat transfer, humidity, and other aspects' effects are note considered.

Chapter V is the conclusion about the results of lcc application on the external envelope for a residential projects in Cyprus. The results of application of vm and lcc on student dorm in the Near East University in North Cyprus, and recommendation for future studies that may give better result.

CHAPTER TWO

LIFE CYCLE COSTING

2.1.INTRODUCTION

Construction industry has a nature that indeed there is no clear definition as to just what the construction industry is, but, it is possible to say that:

The construction industry is a complex and prodox in many ways as it has many characteristics common to both manufacturing and service industry. Certainly, as in other manufacturing, there are physical products, and often these are of mind-boggling size, cost, and complexity. But in other ways, construction is more like a service industry because it does not accumulate significant amounts of capital when compared with industries such as steel, transportation, petroleum, and mining. [3]

It has long been recognized that to evaluate the costs of buildings on the basis of their initial costs alone is unsatisfactory. Some consideration must also be given to the costs-in-use that will be necessary during the lifetime of the building. The latter factor will be influenced by the type of client and will be a more important consideration to some than to others. For example, developers who construct buildings for sale will be concerned only with future costs-in-use items that may make the project an acceptable proposition for ownership by intending purchasers. Different degrees of importance will therefore be attributed to costs-in-use factors depending on whether the project is to be constructed for sale, lease or owner occupation.

Life-cycle costing is a trivially obvious idea, in that all costs arising from an investment decision are relevant to that decision. The image of a life-cycle is one of progression through a number of phases, and it also implies renewal as the project undergoes changes throughout its existence. The pursuit of economic life-cycle costs is the central theme of the whole evaluation. The method of application incorporates the combination of managerial, financial and technical skills in all the phases of the life-cycle. The proper consideration of the costs-in-use aspects of a project during the design stage is likely to result in a building offering better value for money. [4]

The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition, defines Life Cycle Cost (lcc) as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time.[2]

The life cycle cost method is applied by the large contractor corporations systems; the total cost over the system life is many multiples of the initial cost. And the life cycle costing system is a meaningful for smaller systems, for example, an automobile where the manufacturer and a series of owners experience many costs in additional to the initial design, manufacture and purchase costs as the car is maintained, repaired, and finally disposed of. And there are some other costs like research and development costs, operating cost, and etc. that's why it's useful to use lcc for the projects where we have relatively long lives such as 15-30 years [5]

2.2.THE IMPORTANCE OF LONG-TERM FORECASTING

The importance of counting the cost before you build was recognized at least 2,000 years ago. The emphasis in this example is also on the life cycle cost Forecasting is required for a variety of purposes such as early price estimating, the setting of budgets, and invitation of tenders, cash flow analysis, final account predictions, and life-cycle costing. While it is recognized that there are confidence and reliability problems associated with initial cost estimating, these are not of the same magnitude as those associated with life-cycle costing. A large amount of research has been undertaken in an attempt to improve the forecasting reliability of the former. By comparison the acquisition of life-cycle costing knowledge and skills through research and application is still in its infancy, with a considerable gap between theory and practice. It is also difficult to provide confidence criteria, due largely to an absence of historical perspectives, professional judgment and a feeling for a correct solution. The fundamental problem associated with the application of life-cycle costing in practice is the requirement to be able to forecast a long time ahead. While this is not in absolute terms, it must be done with sufficient reliability to allow the selection of project options which offer the lowest whole-life economic solutions. The major difficulties facing the application of life-cycle costing in practice are therefore related to predicting future events. While some of these events can at least be considered, analyzed and evaluated, there are other aspects that cannot even be imagined today. These therefore remain outside the scope of prediction and probability, and cannot even be considered, let alone assessed in the analysis. The key criterion, however, for life-cycle costing is not so much in the accuracy of the forecast as in allowing the correct economic solution to be made. [4]

2.3.BUILDINGS' LIFE

Over a period of time, existing buildings decay and become obsolete and require maintenance, repair, adaptation and modernization. The life-cycles of buildings are diverse from their inception to construction, use, renewal and demolition. There also lies a varied pattern of existence, where buildings are subject to periods of occupancy, vacancy, modification and extension.

As soon as buildings are erected, deterioration and obsolescence commence their life-cycle. During the 1960s, at a time of rapid expansion and growth in construction activities, there were those who thought that buildings should be designed with short lives and be disposable after a life of about twenty years. Society would require modern buildings to reflect the rapid advances in the age of the white heat of technology. Others have suggested that building designs need to be as flex[illegible] adaptable as possible with theories promulgated by the architect A[illegible] upon long life, loose fit and low energy. This wou[illegible] obsolescence as long as possible. [4]

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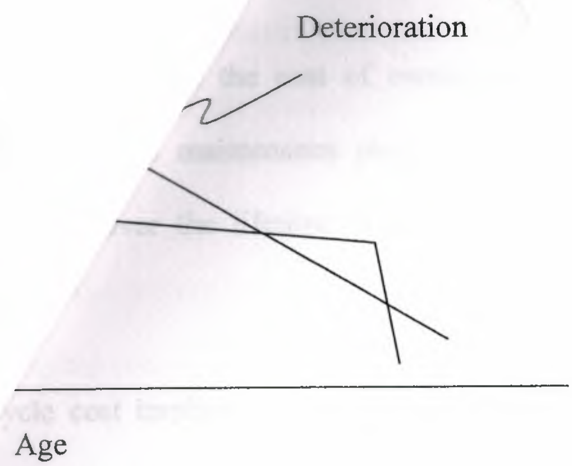

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timescale should be the lesser of physical, functional and economic life. Sensitivity analysis can then be usefully applied to test the validity of lifespan selected. Where the physical lifespan is the shortest then this will be used as the basis. However, in practice this is rarely the case, with one of the different forms of obsolescence being of overriding importance. Physical repair is possible in the majority of cases. It is more likely that one of the forms of obsolescence triggers the need for building renewal. [4]

2.3.1. DETERIORATION AND OBSOLESCENCE

The physical deterioration of buildings is largely a function of time and use. While it can be controlled to some extent by selecting the appropriate materials and components at the design stage and through correct maintenance while in use, deterioration is inevitable as an ageing process. Obsolescence is much more difficult to control since it is concerned with uncertain events such as the prediction of changes in fashion, technological development and innovation in the design and use of buildings. Deterioration eventually results in an absolute loss of use of a facility, whereas buildings that become obsolete accept that better facilities are available elsewhere. While deterioration in buildings can be remedied at a price, obsolescence is much less easy to resolve. Obsolescence can be defined as value decline that is not caused directly by use or passage of time.

The word obsolescence, which has been in use since the middle of the sixteenth century, has the following meanings: That which is no longer practiced or used, discarded, out of date, worn out, effaced through wearing down, atrophy or degeneration. Such a definition relates to the decay of tangible and intangible things. All human products have an irresistible tendency to become old, but the speed of ageing is different for different objects and circumstances. Obsolescence is largely to do with changing requirements which the object is no longer able to fulfill. For example, when existing standards of performance are replaced by new ones, functional obsolescence takes place. The long-term costs arising from this can be minimized through the appropriate application of life-cycle costing techniques. However, the problems associated with obsolescence are less easily allowed for, since their impact is unpredictable, as shown in **Figure 2.1**. An important criterion to delay early obsolescence is to design flexible and adaptable buildings. Buildings wear out at different rates depending upon the type and quality of materials used and the standards and methods that were adopted for their construction. Ultimate physical deterioration is reached when a building is likely to collapse due to structural failure. However, in practice buildings rarely reach this stage before they are demolished, normally for one of the reasons of obsolescence.

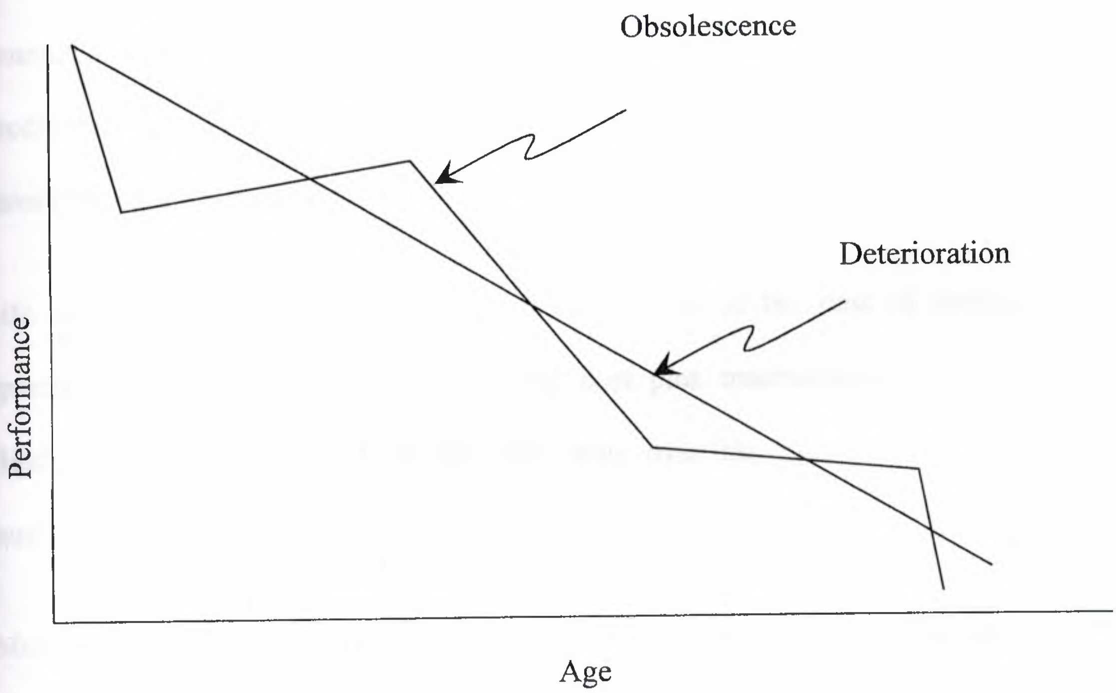

Figure 2.1 Relationship between deterioration and obsolescence.

2.4.MORE ABOUT LIFE CYCLE COST

Life cycle costing is an economic assessment of design alternatives, considering all the significant costs of ownership over an economic life expressed in equivalent currency (i.e. in dollars) In other words it is a technique for economic evaluation of alternatives. It is a cost centered engineering economic analysis whose objective is to systematically determine the costs attributable to each of one or more alternative courses of actions over a specified period of time.

Cost activities initiate the first requirement which is the input data. It would normally consist of data such as (1) program of requirements and operational mode and (2) criteria and standards, quantities, and economic data such as time value of money and life cycle period. Next, input data for facility components, such as initial cost, useful life, and maintenance and operation costs and site data such as climatic and environment conditions would be collected. With these data, alternatives would be generated. This would be followed by the life cycle cost predictions. These predictions would be tempered by non-economic comparisons before a final recommendation is made. [1]

Life cycle costing establishes a realistic comparison of the cost of owning and operating products. The formula of initial cost plus maintenance plus operation divided by useful life identifies the best price over the lifetime of the product purchased. [2]

Most major facility decisions have life cycle cost implications, but the important point is which ones have the greatest impact. While life cycle cost techniques can be applied in any area of economic decision making, they are particularly relevant to the proper identification and evaluation of the costs of durable assets. As a result, they are of special relevance to the building industry. Whether complete buildings or individual building elements are considered, a decision is being made to acquire assets that are intended to last and to be used for a number of years. These assets will commit the owner or user not only to initial capital costs, but also to subsequent running costs, day to day operating, cleaning and maintenance costs, and periodic repair or replacement costs. Equally importantly, decisions made at the initial design stage will invariably affect future running costs and the economic use of the building. For instance there are numerous ways to heat a building, to illuminate it, to clam it, and divide the space in to workable areas, each with different initial and running cost profiles. [6]

A life cycle cost analysis or study is not primarily about costs but about resources: material items (hardware, software), personnel, finance and time. It concerns all the things needed to acquire, purchase, deploy and used to get the project in to service and to then run it for the reminder of its service life.

A life cycle cost analysis has a major secondary benefit in that it is one of the parts of the project evaluation process where a whole system view is taken of the procurement of a system and its operation. It is thus a consistent vehicle for trading-off all parts of the system among all phases of its life.

A life cycle cost analysis is a major element in the project decision-making process that allows a project manager to determine the cost consequences of all the technical, schedule and procurement options.

It can be seen that concentration s on initial cost will give very imperfect view of the actual costs being incurred. This discussion can be summarized by stating that the client of **figure 2.2,** concerned with, or informed of short term considerations only is a thing of the past. It is becoming increasingly important for quantity surveyors in the building industry to offer total cost advice and become proficient in life cycle cost methods on which such advice is based.[6]

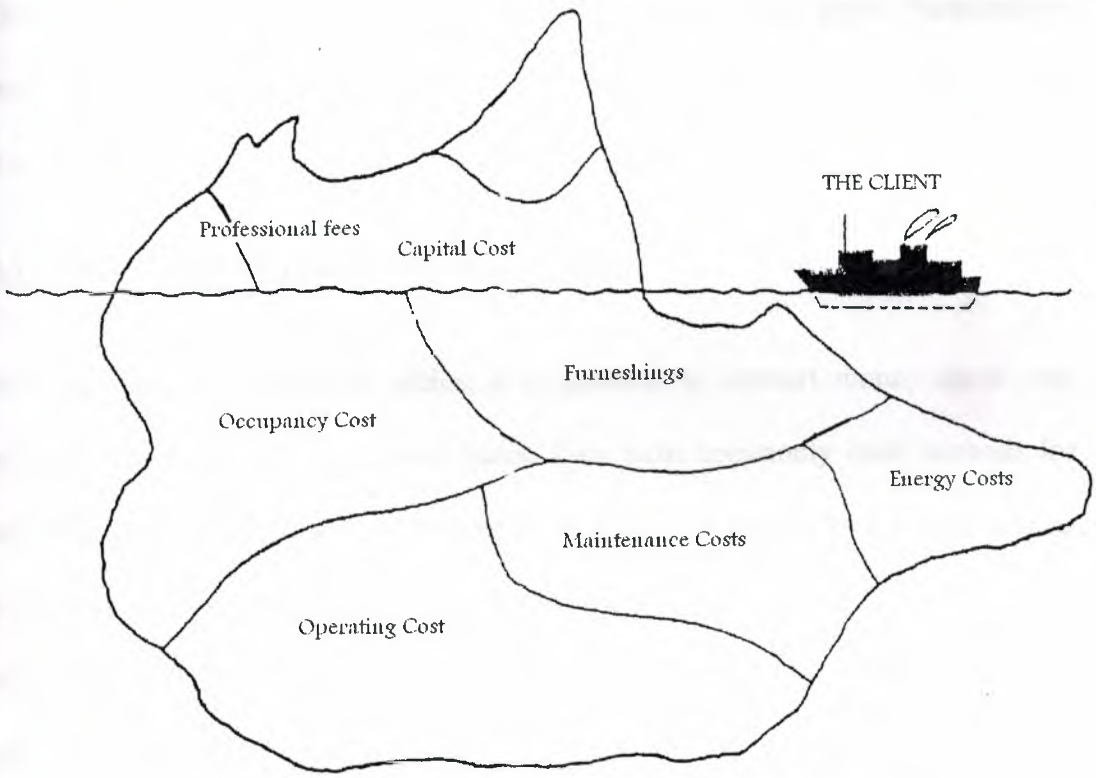

Figure 2.2 Total life cycle cost.

2.5.LIFE CYCLE COSTING FUNDAMENTALS

Life cycle costing concerns with time value of money, basic equivalent economic approaches, inflation and cost growth, life cycle of the project and all relevant costs for the project.

2.5.1. TIME VALUE OF MONEY

Time value of money is the ability of money to earn and thus increase in amount over time. In determining the total cost of ownership, sums of money that are invested or received at various times should be considered. Cash flow diagrams are used in sorting out and keeping track of both outlays of money and money received. Interest formulas which are simple mathematical equations are used to compute the amount to which a single investment or a series of equal investments will grow. Furthermore, interest tables may also be used for the same purpose which may require a minimum of computation. [4]

2.5.2. BASIC EQUIVALENT APPROACHES.

Using the interest formulas or tables, it is possible to convert money spent over various points in time to a common basis. Two most commonly used methods for converting present and future costs of an item, system, or facility to a common basis are the present worth and equivalent uniform annual cost (annualized) methods. Both methods account the time value of money and therefore are interchangeable as measures of life cycle cost. Furthermore, since costs are 'discounted to a smaller value when converted to the present time, it is common practice to use the term "discount rate" in reference to "interest rate". [5]

2.5.3. PRESENT WORTH METHOD

Present worth method allows conversion of all present and future costs to a single point in time, usually at or around the time of the first expenditure.

Using an interest rate which represents the cost of the money or acceptable rate of return, all future receipts and payments involved are converted to present worth, for each alternative. The alternative which has the lowest present worth is, economically, the best alternative. If the lives of the alternatives are not the same, comparisons should be made over a period of time which is the lowest common multiplier. [7]

2.5.4. EQUIVALENT ANNUAL COST (ANNUALIZED) METHOD

Equivalent annual method allows conversion of all present and future costs involved for an alternative to an equivalent uniform annual cost.

Using an interest rate which represents the cost of the money or acceptable rate of return, all future and present payments and receipts involved for an alternative, are converted to an equivalent uniform annual cost. The alternative with the lowest annualized cost is more favorable. [8]

2.5.5. ANALYSIS PERIOD

The analysis period is the number of years over which the total cost of ownership will be determined for the various design alternatives.

The more commonly used criteria for establishing the analysis period are;

1. **COMPONENT LIFE:** If the several alternatives being considered all have the same economic life, then that life, or a multiple of it, may be used as the analysis period.

2. **COMMON MULTIPLE OF COMPONENT LIFE**: If the design alternatives have different economic life, it may be possible to choose, as the analysis period, a

common multiple of these lives. For example, if the economic life of two competing alternatives is 6 years and 8 years, then, a common multiple of 24 years may be selected as the analysis period. The uses of this criterion simplify calculations of involving unequal life and eliminate residual values.

3. FACILITY LIFE: This is the technological or useful life of the facility as a whole.

4. INVESTMENT OR MISSION LIFE: This is the expected number of years, until the owner's investment objective is fulfilled. For example, the economic life of an investor who wishes to build and sell a building is short, while for the other owner wishing to keep the building for other purposes is longer.

5. ARBITRARY LIFE: Arbitrary analysis period may also be selected, which does not include such important considerations such as component life, facility life or mission life. This analysis life might be established by organizational policy as a limit of the planning period. [1]

2.5.6. PRESENT TIME

In a life cycle cost analysis, present time marks the beginning of the analysis period. Present time sets the base year in the analysis, and in the present worth approach; it represents the time to which all the cash flows are discounted for combining and comparison. [9]

2.5.7. TYPES OF COSTS

All significant costs attributable to the alternative should be considered in the analysis. This would include all the construction, construction related, and procurement costs; all the disposal, demolition, and other terminal costs or salvage values at the end of the analysis period; and all the various types of costs incurred between the construction and end of the analysis period. [1]

These costs could be of the following types;

1. INITIAL PROJECT (INVESTMENT) COSTS : Costs associated with the initial design and construction of the facility, including, costs of labor, materials, equipment, overhead, tests, project management fees, land, insurance, permits, financing etc.

2. ENERGY COSTS: Costs associated with the ongoing energy consumption of the facility. These include electricity, oil, natural gas, coal, other fuels necessary for operation of the facility and its components.

3. OPERATION AND MAINTENANCE COSTS: All costs associated with the operation, maintenance, repair and services, these include, personnel costs, supplies and contract services, security, routine maintenance and repair, cleaning necessary for ongoing operation.

4. ALTERATION AND REPLACEMENT COSTS: These are costs associated with planned additions, alterations, and other improvements to the facility to meet the functional requirements, and the replacement costs required to restore the facility to its original performance, such as redesign, demolition, relocation all the construction costs to alterations.

5. TERMINAL COSTS OR SALVAGE VALUE: Costs or values associated to the demolition and/or disposal of the facility at the end of the period.

6. ASSOCIATED COSTS: These are other costs such as functional use costs incurred by the organization in using the facility or lost sales during the alterations and improvements.

Costs which are common to all alternatives, common costs, can be excluded from the analysis. Furthermore, costs that have been incurred before the analysis, sunk costs have no direct connection to the result of the analysis. [1]

2.5.8. INFLATION:

Much has been written on the causes and the possible cure. The effects of inflation and the problem that it causes in capital investment decisions need to be taken into account in a life-cycle costing comparison. The following are some of the characteristics of inflation.

- Inflation refers to the way that the price of goods and services tend to change over time.
- Inflation causes money to lose its purchasing power because the same amount buys less.
- The nominal rate of return on an asset or investment is the amount you get back. The real rate of return is the return after inflation has been taken into account.
- Cash deposits such as savings accounts, although secure, do not keep pace with inflation.
- Interest rates are used to control inflation. By raising interest rates, governments can dampen consumer spending which results in reducing economic activity.

- Low inflation is supposed to be a good thing because it leads to price stability.
- The opposite threat of deflation is considered to be just as much a threat as inflation.
- Zero inflation is rarely desirable. The level of interest rates needed to achieve this would discourage economic activity.

Even with relatively low levels of inflation (say, less than 5%); prices will be substantially affected over long periods of time. An item costing $100.00 today would cost $127.60 after five years at a rate of 5% per annum.

Today $100 = 100/ 0.7835 = $127.6

Where 0.7835 is the interest factor, which can be found from the interest factor tables.

The principal problem facing the decision-maker is whether to forecast future cash flows associated with an investment project in real terms or in money terms. A real term here means in terms of today's (the date of decision) price levels. Money terms refer to the actual price levels which are forecast to obtain at the date of the future cash flow.

Two different approaches may therefore be used to deal with the problem of inflation. First, inflation could be ignored on the assumption that it is impossible to forecast future inflation levels with any reasonable degree of accuracy. The argument is reinforced in that there is often only a small change in the relative values of the various items in a life-cycle cost plan. Thus, a future increase in the values of the cost of building components is likely to be matched by it similar increase in terms of other goods and commodities. There is therefore some argument for working with today's costs and values. Also, since we are attempting to measure comparative values real costs can perhaps be ignored.

It should be noted that building costs do not necessarily increase in line with inflation. Reference to a range of different material or component costs over a period of time will show that these do not follow a uniform trend or pattern. Even similar materials, such as plumbing goods, can show wide differences even over a ten-year cycle of comparisons. To ignore such differences will at least create minor discrepancies in the calculations.

It needs to be remembered that the main purpose of life-cycle costing is to correctly inform on the evaluation of options. When such evaluations are economically comparable, it would be unwise to make the selection on the basis of a minor cost advantage to one particular system or commodity.

The alternative approach in life-cycle costing is to attempt to make some allowance for inflation within the calculations. This may be done, with some apprehension, using evidence of market expectations, published short- and long term forecasts and intuitive judgments relating to the prevailing economic conditions. [4]

2.5.9. INTEREST RATE (DISCOUNT RATE)

Discount rate is the time value of money.

Much has been written on discount rates and methods of determining them, but there is no universally accepted method or resulting rate used by various organizations [8].

More commonly, it is established as the actual rate of increase in the value of money.

In other words it is the rate over and above the general economy inflation rate. Normally, the owner or the policy makers select the discount rate. It could be any of the following.

1. The discount rate may be established as the cost of borrowing money in the market place. Usually this is the highest interest the organization (owner) expects to pay to borrow the money needed for the project. This is relatively simple way to select the discount rate. However, it does not take into account the risk of loss associated with the loan or the expected return from the investment itself

2. Discount rate may also be established as the minimum attractive rate of return encouraged by the owner or policy maker. It includes the basic cost of borrowing the money plus an increment which reflects the risks associated with undertaking requiring the investment. As it is not easy to quantify risk as a percent increment, this selection may be difficult to apply. However, it is a better indicator of the value of money to the user than the simple cost of the borrowing money.

3. Discount rate is sometimes established as the rate of return that could be earned from some alternative investment opportunity which is foregone in favor of the project in question. This is called as opportunity rate of return. For example, if it is possible to earn a 30 percent rate of return elsewhere, then the discount rate for the project in question would be set to 30 percent. As it is based on the actual earning power of the money, this approach is more realistic.

4. Discount rate may be taken as equal to average rate of return in the private sector less the inflation rate. This is called as after-inflation discount rate, and based on the assumption that private industry will seek a certain rate of return over and above the

general inflation rate no matter what the inflation rate will be. Because the inflation rate is removed from the discount rate, there is no need to predict future inflation rates. However, all costs must be state in terms of constant dollars, which is the purchasing power of money exclusive of general inflation or deflation but including differential escalation rate which is cost growth less inflation or plus deflation. Main problem in the use of after-inflation discount rate is the artificiality of the resulting total costs of ownership which are in constant dollars and not in real current dollars, which is the purchasing power of money in which actual prices are stated, including cost growth and inflation or deflation. Nevertheless, for comparison purposes, the use of after-inflation discount rate and constant dollars produces the same result as other methods of analysis.

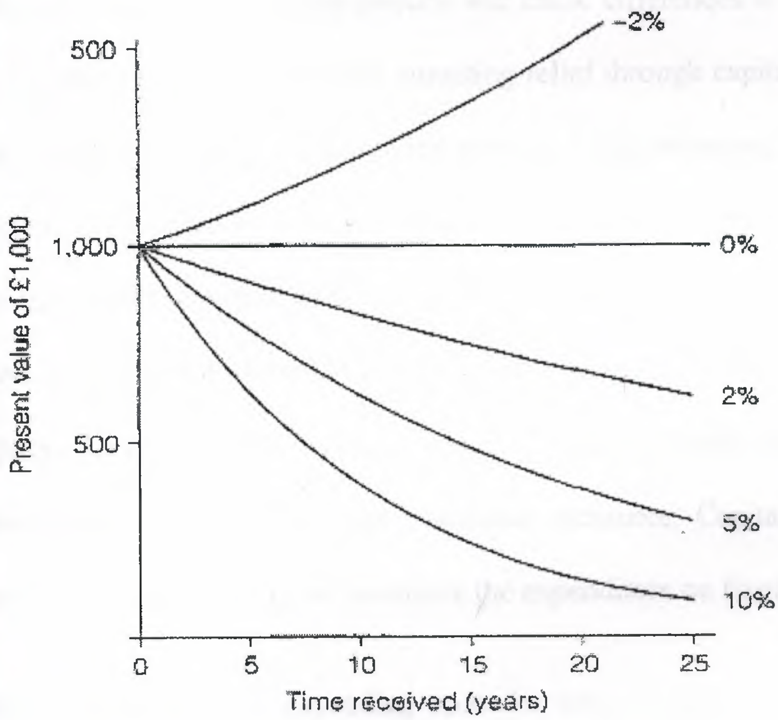

Figure 2.3 Present value £1000 at various discount rates.

2.5.9.1. INFLATED INTEREST RATE :

It's a rate composite of both interest and inflation rates which is the close to the real life and it can be calculated from the equation:

$$\mathbf{i_f = i + f + i \times f} \tag{2.1}$$

i: is the interest rate and f : is the inflation rate

And this rate can be used in the rate tables to find future or present time values of money.

2.5.10. TAXATION

Cash flows associated with taxation must be brought into the calculation during the assessment of the project. Most projects will cause differences to corporation tax. This may be due to capital expenditure attracting relief through capital allowances, profits from the project resulting in additional taxes or losses attracting tax relief. Tax is not assessed by the Inland Revenue project by project but for the company as a whole. Cash flows must therefore be considered in this context and calculated on whether the project is carried out, delayed or abandoned. The matter is further complicated since the project may be spread over one or more tax years. Careful accounting may result in beneficial effects through tax avoidance measures. Capital allowances are set against taxable profits in order to relieve the expenditure on fixed assets.

Relief varies, sometimes depending upon the type of building and in some cases in order to encourage development of certain types of buildings. In the case of industrial buildings, for example, companies are able to deduct %4 of the cost of the building from the taxable profit in each year of its ownership and use. [4]

2.5.11. CASH FLOW

Cash flow is one of the fundamental elements of engineering economy which is described as the actual inflows and outflows of money. Every person or company has cash receipts—revenue and income (inflows); and cash disbursements—expenses, and costs (outflows). These receipts and disbursements are the cash flows, with a positive sign usually representing cash inflows and a negative sign representing cash outflows. Cash flows occur during specified periods of time, such as I month or 1 year.

Cash inflows, or receipts, may be comprised of the following, depending upon the nature of the proposed activity and the type of business involved.

Samples of Cash Inflows

- Revenues (usually incremental due to the alternative).
- Operating cost reductions (due to the alternative).
- Asset salvage value.
- Receipt of loan principal.
- Income-taxations.
- Receipts from stock and bond sales.
- Construction and facility cost savings.
- Savings or return of corporate capital funds.

Cash outflows, or disbursements, may be comprised of the following, again depending upon the nature of the activity and type of business.

Samples of Cash Outflows

- First cost of assets (with installation and deliver).
- Operating costs (annual and incremental).
- Periodic maintenance and rebuild costs.
- Loan interest and principal payments.
- Major, expected upgrade costs.
- Income taxes.
- Bond dividends and bond payment.
- Expenditure of corporate capital funds.

Net cash flow	***= receipts - disbursements***
	= cash inflows - cash outflows

Since cash flow normally takes place at frequent and varying time intervals within an interest period, a simplifying assumption is made that all cash flow occurs at the end of interest period. This is known as the end- of- period convention.

❖ CASH FLOW DIAGRAM

A cash-flow diagram is simply a graphical representation of cash flow drawn on a time scale. The diagram, which represents a restatement of the situation, includes what is known and what is needed. That is once the cash-flow diagram is complete; another person should be able to essentially work the problem by looking at the diagram. [7]

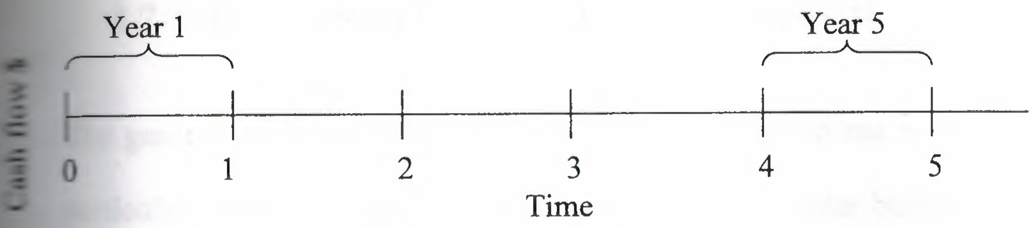

Figure 2.4 A typical cash-flow time scale For 5 years.

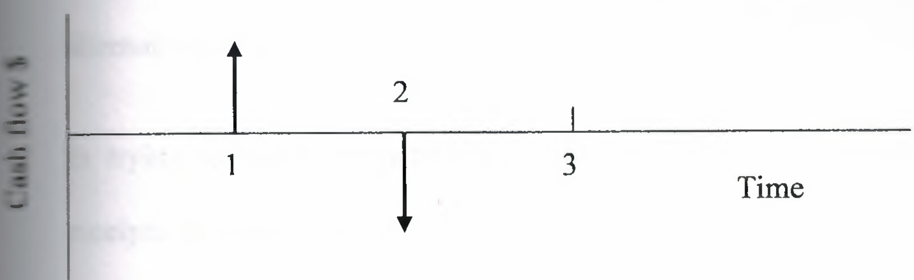

Figure 2.5 Example of positive and negative cash flows.

2.6.LIFE CYCLE ANALYSIS (LCA)

Life cycle cost analysis includes all costs incident to the planning, design, construction, operation, maintenance, supply, disposal, and relocation of system for a facility, calculated in terms of present value or uniform annual owning and operating cost. An in- depth knowledge of design and system performance is required in order to properly quantify life cycle cost.

Companies are increasingly using life- cycle analysis (LCA), for three main reasons: to stand up the claims they make in green advertising; to tend off unwanted regulatory pressures; and to look for ways to reduce the polluting impact of their products and production process. [3]

2.7.THE PRESENT VALUE (PV) APPROACH

The general idea underlying life-cycle costing or costs in use is that in choosing a particular material, a particular heating system, a particular building component or indeed in making any choices, we should be aware of and if possible calculate both the immediate and future costs; only by doing that can the relative merits of different alternatives be assessed.

In trying to make comparisons of this sort (whether of expenditures or incomes, receipts or payments), the difficulty arises because it is not sensible in a modern economy to treat future and immediate costs (or receipts) as equivalent. There is a considerable difference between knowing one has to spend \$1000 tomorrow and knowing one has to spend \$1000 in a year's time; or between knowing one is going to receive money tomorrow or the same amount in a year's time.

The application of economic analysis techniques requires a unique approach at different phases of the LCC, however, the integration of economic- based decision making into the development of a project helps accomplish smooth transition from one life- cycle step to the next. This blending of economic analysis techniques with other decision criteria assist in answering early in the design process the two important questions: "Is it cost effective?" and "Does it appear to be a profitable venture?" [8]

It is note that in the case of selection of an alternative by present value the life of alternative must be same, if it is not so, in economy study it must analysis for same period of time (life cycle), or instead of using present worth it is better to use equivalent uniform annual worth (EUAW) method.

The present worth "P" and equivalent uniform annual worth "A" formulas which have been used in LCC calculation are as:

For single year payment

$$P=F\ [1/\ (1+i)^{n}] \qquad (2.2)$$

For any n numbers of years payments

$$P=A\ [((1+i)^{n}-1)\ /\ (i\ (1+i))] \qquad (2.3)$$

Where:

P: the present value of the money

A: annual payments

F: is the future value of the money.

i: is interest rate.

n : is number of year or period.

And $[1/\ (1+i)^{n}]$, $[((1+i)^{n}-1)\ /\ (i\ (1+i))]$ are called interest factors.

Most of the engineering economy books have tables of the interest factors for the most useful interest rates. (The interest factors` tables). [7]

And similarly the future payments also can be calculated by the following formulas:

For single year payment

$$F = P\times [1+i]^{n} \qquad (2.2)$$

For any n numbers of years payments

$$F = A\ [((1+i)^{n}-1)/\ i] \qquad (2.3)$$

EXAMPLE

If heating bills are expected to be £1500 per year for the next five years (and we make the simplifying assumption that the bills are paid at the end of each year) and we wish to calculate the present value of that total, then we could simply make the following calculation (again using an interest rate of 5%):

	Payment	Present value at 5%
Year 1	$1500	1500 x 0.9524* = **$1428.6**
Year2	$1500	1500 x 0.9070* = **$ 1360.5**
Year3	$1500	1500 x 0.8638* = **$ 1295.7**
Year4	$1500	1500 x 0.8227* = **$ 1234.05**
Year5	$1500	1500 x 0.7835* = **$ 1175.25**
Sum	**∑ F = $7500**	**∑ (PW) = $ 6494.1**

* The interest factor that can be found by the formulas or from the Tables in all economy books

If the above calculation was made using a discount rate of 10% the total would be **£6532.**

By in effect converting future payments to their present values we can compare them with current payments. We can then treat immediate expenditures and future expenditures together. We could for example add them. If we wished to compare the total costs of two heating systems, A and B, one way of doing this should be to add the initial cost of A with the present values of the heating bills for say the next ten years and compare that with the cost of system B plus its heating bills for the next ten years. The system giving the lower total costs (present plus discounted future costs) would be the most economic over the ten years.

In reality there is not much point in trying to look too far ahead; no-one knows what is going to happen in 20 years time; and the effect of discounting means that there is little difference between assuming a life of, say 30 and 60 years . [8]

And the present value approach can be used to check the best alternative when we more than one even if they have different economic lives by calculating the Pv for each of them for the minimum common multiple and the next example is clearly explaining this condition .[8]

EXAMPLE

Present-Worth Comparison of Different-Life Alternatives

A plant superintendent is trying to decide between two excavation machines with estimates presented below.

	Machine A	**Machine B**
Initial Cost $	11,000	18,000
Annual operating cost $	3,500	3,100
Salvage Value $	1,000	2,000
Life (years)	6	9

(a) Determine which one should be selected on the basis of a present-worth comparison using an interest rate of 15% per year.

(b) If a study period of 5 years is specified and the salvage values are not expected to change, which alternative should be selected?

(c) Which machine should be selected over a 6-year horizon if the salvage value of machine B is estimated to be $6000 after 6 years?

Solution

(a) Since the machines have different lives, they must be compared over their LCM, which is 18 years. For life cycles after the first, the first cost is repeated in year 0 of the new cycle, which is the last year of the previous cycle. These are years 6 and 12 for machine A, and year 9 for B. The cash-flow diagram in

Figure 3.6

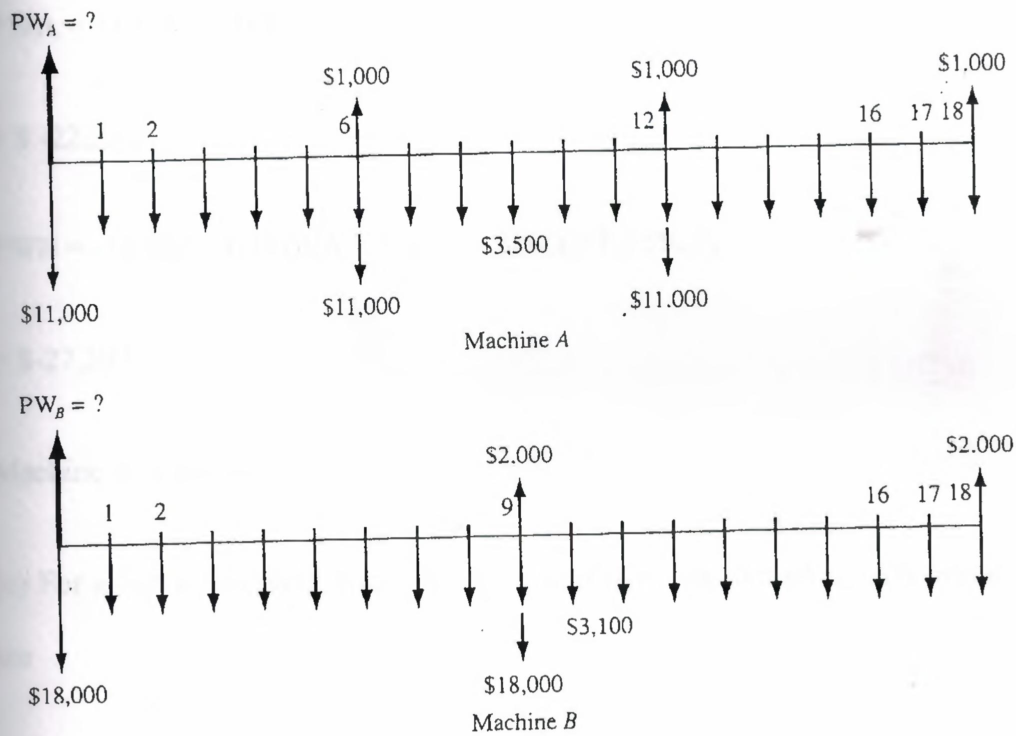

Figure 2.6 Cash-flow diagrams for different-life alternatives.

assists in performing the PW analysis.

PW_A = -11,000 - 11,000(P/F.15%.6) + 1000(P/F, 15%, 6)

-11, 000(P/F, 15%.12) + 1000 (F/F, 15%, 12) + 1000(P/F, 15%, 18)

- 3500(P/A, 15, 18) = $-38.559

PW_B = -18.000 - 18,000(P/F, 15%, 9) + 2000(P/F.15%, 9)

+ 2000(P/F.15%.18) - 3100(P/A, 15%, 18) = \$-41, 384

Machine A is selected, since machine **A** costs less in PW terms than machine B.

(b) For a 5-year planning horizon no cycle repeats are necessary, and SV_A = \$1000 and SV_B = \$2000 in year 5. The PW analysis is

PWA = 11,000 3500(P/A, 15%, 5) + 1000 (P/F, 15%, 5)

= \$ -22.236

PWB = -18.000 - 3100(P/A, 15%, 5) + 2000(P/F.15%.5)

= \$-27,397

Machine A is still the better choice.

(c) For a 6-year planning horizon, SV_B = \$6000 in year 6, and the PW equations are

PW_A = -11.000 - 3500(P/A, 15%, 6) + 1000(P/F, 15%, 6) = - \$ 23.813

PW = -18.000 - 3100(P/A, 15%, 6) + 6000(P/F, 15%, 6) = -\$27,138

Machine A is still favored.

Comments

In part (a) the salvage value of each machine is recovered after each life cycle, that is, in years 6, 12, and 18 for machine A, and in years 9 and 18 for machine B.

In part (b), it is assumed that the salvage values will not change when the horizon is shortened. This clearly is not usually the case. In part (c), machine A is still favored even though the salvage value of machine B is increased from $2000 to $6000. [7]

2.8.LIFE-CYCLE COSTING APPLICATIONS

The following are some of the advantages of life cycle costing associated with capital works projects.

- The emphasis on a whole- or total-cost approach undertaken in the acquisition of any capital cost project or asset, rather than concentrating on the initial capital costs alone.
- It allows a more effective choice to be made between competing proposals of a stated objective. The method will take into account the capital, repairs, running and replacement costs and express these in consistent and comparable terms. It can allow for different solutions for the different variables involved and set up hypotheses to test the confidence in the results achieved.
- It is an asset management tool that will allow the operating costs of premises to be evaluated at frequent intervals.
- It will enable these costs to be correlated with changes in working practices, such as hours of operation, the introduction of new plant or machinery and use of maintenance analysis.

Life-cycle costing can be used during the following phases.

a. AT INCEPTION

Life-cycle costing can be used as a component part of an investment appraisal. This is the systematic approach to capital investment decisions regarding proposed projects. The technique is used to balance the associated Costs of construction and maintenance with rental values and needs expectancies. The way that future costs in use are dealt with therefore depends largely on the expected ownership criteria of occupation, lease or sale, or indeed a combination of these alternatives.

b. AT THE DESIGN STAGE

A major use of life-cycle costing is at the design stage or pre—contract phase of a project. Life-cycle costing can be used to evaluate the various options in the design in order to assess their economic impact throughout the project's life. It is unrealistic to attempt to assess all the items concerned; indeed the cost of undertaking such an exercise might well rule out any possible overall cost savings.

Life cycle costing is perhaps most effective at this stage in terms of the overall cost consequences of construction. It can be particularly effective at the conceptual and preliminary design stage, where changes can be made more easily and resistance to such changes is less likely. When a design is nearing completion, the designer may be reluctant to redesign part of the project even though long-term cost savings could be realised.

c. AT PROCUREMENT STAGE

The concept of the lowest tender bid price should be modified in the context of life-cycle costing. Under the present contractual and procurement arrangements, both manufacturers and suppliers are encouraged to supply goods, materials and components which ensure their lowest initial cost irrespective of their future costs in use. In order to operate a life cycle cost programme in the procurement of capital works projects, greater emphasis should be placed on the economic performance in the longer term, in order to reduce future maintenance and associated costs. The different methods of procurement which are available may make it easier and beneficial for the contractor to consider the effects of life cycle costing on a design.

d. AT THE CONSTRUCTION STAGE

While the major input of life cycle costing is at the design stage, since its correct application here is likely to achieve the best overall long term economic savings, it should not be assumed that this is where the use of the technique ceases. At the construction phase, three broad applications should be considered.

The first of these concerns the contractor's method of construction, which unless prescribed by the designer is left to the contractor to determine. The method of construction the contractor chooses to employ can have a major influence on the timing of cash flows and hence the time value of such payments.

Second, the contractor can benefit from adopting a life-cycle costing approach to the purchase, lease or hire of the construction plant and equipment. The probable savings resulting from this evaluation may then have an impact on future tendering and estimating strategy and project costs.

Third, the construction managers can provide a professional input to the scrutiny of the design, if involved sufficiently early in the project's life. They may be able to identify life-cycle cost implications of the design in the context of manufacture and construction and in the way that the project will be assembled on site.

e. DURING THE PROJECT'S USE AND OCCUPATION

Life cycle costing has an important part to play in physical asset maintenance management. The costs attributable to maintenance do not remain uniform or static throughout a project's life, and therefore need to be reviewed at frequent intervals to assess their implications within the management of costs—in—use. Taxation rates and allowances will change, and can have an impact on the maintenance policies being used. Grants may become available for building repairs or to address specific issues such as energy usage or environmental considerations. The changes in the way the project is used and the hours of occupancy, for example, need to be monitored to maintain an economic life-cycle cost, as the project evolves to meet new demands placed on it.

When a project nears the end of its useful economic life, careful judgment needs to be exercised before further expenditure is apportioned. The criterion for replacing a component is a comparison of the rising running costs with the costs of its replacement and the associated running costs.

f. FOR ENERGY CONSERVATION

A major goal of the developed nations is a reduction in the use of energy in all its costly and harmful forms. This is true for the governments concerned, who have introduced taxation penalties, and for private industry, which is seeking ways of reducing its own energy consumption and hence the associated costs. Life-cycle costing is an appropriate technique in the energy audit of premises. The recommendations may include, for example, providing additional insulation in walls and roofs, replacing obsolete equipment, and suggesting values for temperature gauges, thermostats and other control equipment. An energy audit is not a one-off calculation, but one that needs to be repeated frequently in order to monitor the changes in the variables which affect the overall financial implications. [1]

2.9.LIFE-CYCLE COST PLAN

A life—cycle cost plan is a plan of the proposed expenditure of a construction project over its entire lifespan. Table 1 is a summary of the items which may need to be considered for inclusion. The total information is shown as either a net present value (NPV) or an annual equivalent (AE). Capital cost is the estimate of the initial cost, and this is already a PV amount. It should be remembered that all estimates include errors of prediction, and this will be especially true of the estimate of costs— in—use. Maintenance costs would be estimated on an annual basis using historical information coupled with current knowledge.

Table 2.1: Life Cycle Cost Plan.

	Project: Date: Discount Rate:		
SUMMARY			
Description	Discount Factor	Estimated cost	Present Value
1. Capital Cost			
2. Maintenance (per annum)			
3. Redecoration (intervals)			
4. Minor new works (year)			
5.Energy (per annum)			
Heating			
Lighting			
Power			
6. Cleaning (per annum)			
7. General Rates (per annum)			
8. Insurance (per annum)			
9. Estate Management (Annual)			
10. Additional tax (per annum)			
Total net Present Value (NPV)			
Annual equivalent (AE)			

2.10. COSTS-IN-USE

The costs-in-use of a building project depend on the owners and the users of the building, and the designer's efforts to minimise recurring costs. It should be recognized that some costs-in-use are largely beyond the scope and control of the designer, e.g. rate able values and some other occupancy costs. Costs—in—use data cover the **three 'R's**: ***running***, ***repairs*** and ***replacements***. These costs may usefully be classified as follows. Figure 6 shows the distribution of running costs for a number of different building types

2.10.1. MAINTENANCE COSTS

The expenditure of money in time and materials on building maintenance is high and growing because of the necessity of having to maintain an ever—increasing stock of older properties. There is generally some relationship between maintenance costs and the age of a building.

- The major factors which make buildings inefficient or expensive to maintain are incorrect specification of materials used either initially or during subsequent repairs.
- Incorrect use of spaces.
- Poor constructional detailing, resulting in inadequate weather resistance, rapid corrosion and deterioration.
- Inadequate care in use by owners and occupiers.[4]

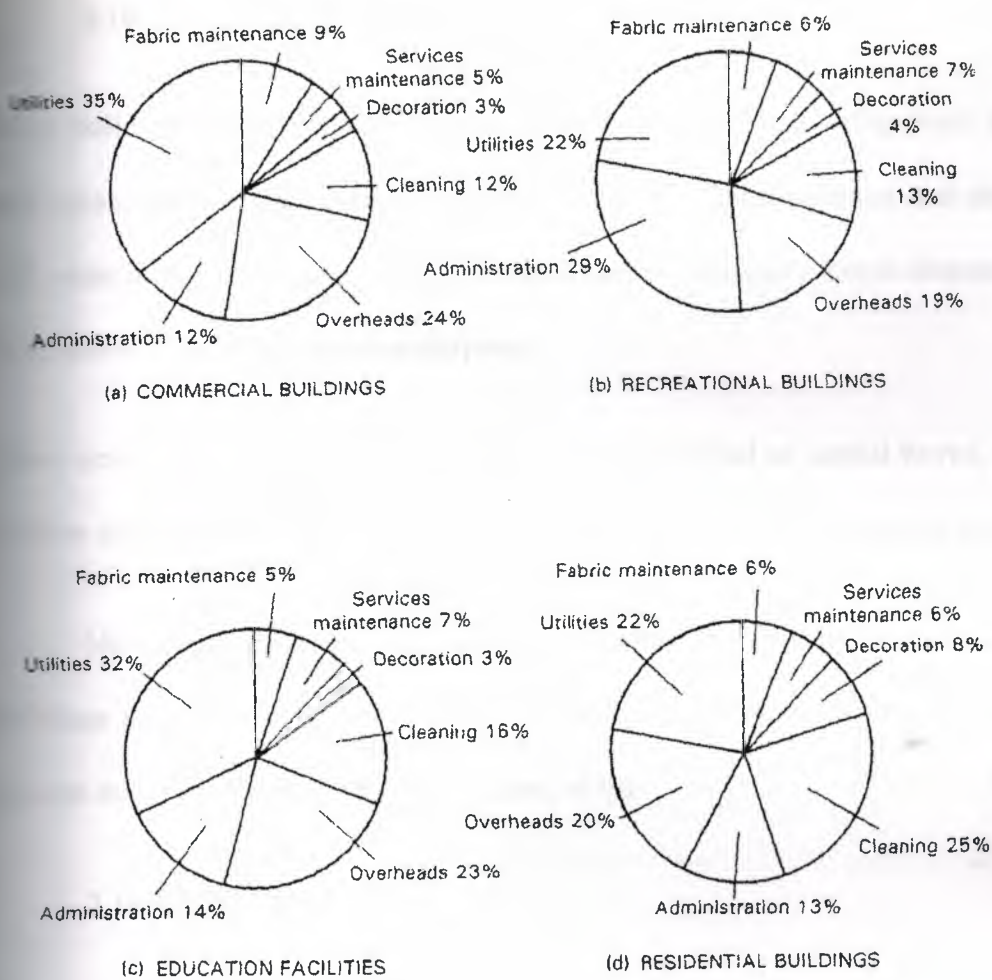

Figure 2.7 Distribution of running costs for a number of different building types.

2.10.2. REDECORATIONS

Redecorations are somewhat different in character from other maintenance costs. They normally follow a predetermined cycle and can therefore be anticipated. An estimate of Cost can therefore be obtained in advance. They are also works which in time of recession are often deferred. The cycle of redecorations depends on many factors, such as user requirements, type of use, finish and exposure. During the early years of a building's life, no costs will be allocated to this element of Costs-in—use.

2.10.3. MINOR NEW WORKS

Many buildings often incur expenditure which cannot be truly categorized as repair and maintenance in the context of fair wear and tear. Refurbishment and alterations will occur in varying degrees, some of which may be necessary due to changes in use of premises or for modernization purposes.

Minor new works in some circumstances may be classified as capital works, whereas in other circumstances the funding may be from a maintenance and repairs account.

No general guide can be given for predicting this expenditure, since in some buildings no minor new works are ever carried out, whereas in others they may become necessary during the first few years of life.

2.10.4. ENERGY

The term 'energy' is used in the context of providing all the required fuel for heating, lighting, cooling and power requirements of a building. Although the individual costs of the above items are important, it is necessary to measure the total energy consumption when comparing this element between buildings. The cost of any attendant labor for stoking boilers and adjusting controls, or for servicing and maintenance, must also be included under this heading. A wide variation in annual costs may be expected depending on the type and amount of services provided, the building's design and insulation provision and the control and use of equipment.

2.10.5. CLEANING

The cleaning costs of buildings, which are generally very labour intensive, depend on the function of the spaces to be cleaned, the type of finishes used and the cleaning interval. Offices tend to have a higher cleaning cost than most other types of building.

2.10.6. GENERAL RATES AND INSURANCE

Designers have little control over the rateable value of the buildings they design, since this is largely determined by location, size and the amenities provided. The client can be advised to build in a less expensive area, provide a building of a smaller plan size or reduce the amenities within the building. Insurance costs of the building in use are also largely self—determinable by the nature of the project. Factors such as type of structure, method of construction, materials used, class of trade, materials stored and number of employees will influence the premium to be charged. For example, timber—frame houses generally require the payment of a higher premium than the more traditionally constructed types. Where insurance claims are excessively high, a review by the insurance company of premiums generally may become necessary.

2.10.7. ESTATE MANAGEMENT

Large construction projects when in commission may require some form of expenditure on estate management, security, porterage etc. Such sums can be determined in advance by the owners, but a good design and method of construction can help to reduce the required amounts. There will be times when a greater input of estate management is required, particularly prior to extensive refurbishment or alteration. [1]

2.11. CALCULATIONS

One of the apparent difficulties of using life-cycle costing in practice is the mathematics associated with the evaluation. An understanding of the principles involved in discounting the value of future receipts and payments is an essential feature of such an evaluation. Although the arithmetic associated with discounting may appear complicated, the concept is simple. This is that the capital in the hand today is worth more than the capital at some time in the future. Even ignoring inflation, it would be more profitable to choose to receive a given sum today than the same sum next year.

Money is generally invested at compound interest; discounting can therefore be viewed as the reverse of this process. When discounting we know the future sum and wish to find the PV. In order to use the technique in practice it is not necessary to understand the mathematical basis of the subject, since the relevant information is contained in discounting tables. The most commonly occurring calculations when discounting are

- Calculating the PV of a lump sum to be paid in the future
- Calculating the PV of a regular annual payment for a number of years
- Calculating the AE of a lump sum to be paid now

It is already presumed that the material selection will be made not on the basis of initial costs alone but on their life-cycle costs. [1]

EXAMPLE

A choice is available between the use of **softwood, hardwood** or **aluminum** windows for a detached house. The economic life for buildings is assumed to be **60 years**. And the interest rate is **8%**.

The information about the alternatives is shown bellow:

	Softwood windows	**Hardwood windows**	**Aluminum Windows**
Initial Cost	£2500	£4500	£5500
Renewal period	Each 15 years	Each 30 years	—
Renewal's extra Costs	£10 for removing each old window	£10 for removing each old window	—
Redecoration period	Each 5 years	Each 5 years	—
Redecoration Costs	£ 10 per window	£ 5 per window	—
Cleaning costs	£ 50 per year	£ 50 per year	£ 50 per year

The life-cycle calculation may be carried out as follows.

I. Softwood windows

Softwood double-glazed standard pattern windows, Fixed to brickwork including decoration and window furniture = £2 500

✓ Renewal (A) every 15 years:

Year	Interest Factor
15	0.3152
30	0.0994
45	0.0313

Σ of Interest Factor is %0.4459 x (£ 2500+10x £ 15) = £1182 (B)

✓ Redecoration every 5 years

Year	Interest Factor	Year	Interest Factor
5	0.6806	35	0.0676
10	0.4632	40	0.0460
15	Renewal (C)	45	Renewal (C)
20	0.2145	50	0.0213
25	0.1460	55	0.0145
30	Renewal (C)	60	End of Building supposed life
Σ of Interest Factor is %1.6537 x(£ 100) = £ 165			

✓ Cleaning (D) per year:

= £50x12.12.3766* = £619

* The number (12.3766) is found from the same tables but the Uniform series payments.

A. Renewal periods in practice will be different and will depend on initial quality, location, aspect, use and maintenance. The argument is often used that once softwood windows start to rot the only course of action is their renewal. Some authorities may attempt to splice in new sections of timber in order to prolong their life and the period to renewal. Opinions will vary, but fifteen to twenty years is assumed to be a good life expectancy

B. Inflation is generally ignored in life-cycle cost calculations, because the amounts are a comparative value. The renewal costs include a sum of £15 per window for taking out the existing window, clearing away off-site, preparing the opening to receive the new window and any making good required.

C. On average, external decoration may take place every three to seven years. Often when companies or individuals have to reduce their expenditure this is one of the items of work to have its maintenance period extended. The decoration of the renewed windows in years 1 5, 30 and 45 is included with renewal costs. It is assumed that because economic life is 60 years nothing will be done in year 60. There is an allowance of £10 per window for redecoration i.e. 10 windows x £10 = £100.

D. The cost of the cleaning of windows depends very much on the frequency of this work. Assuming they are tradesman-cleaned, an annual sum of about £50 may be expended.

Present Values PVs or Annual Equivalent AE are calculated from the tables or using the formulas shown before.

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And by the same way applied above the other two alternatives are studied and the results are listed

	Softwood windows	Hardwood windows	Aluminum Windows
Initial Cost	£2500	£4500	£5500
Renewal's Costs	£ 1182	£ 462	—
Redecoration Costs	£165	£ 100	—
Cleaning costs	£ 619	£ 619	£ 619
Total (NPV)	£ 4466	£ 5681	£ 6119
(AE)	£ 360.83	£ 459.00	£ 464.38
Initial	56 %	79 %	90 %
Renewal	26 %	8 %	0 %
Redecoration	4 %	2 %	0 %
Cleaning	14 %	11 %	10 %
	100 %	100 %	100 %

CHANGE IN THE LIVES OF COMPONENTS

Life of components (softwood windows 25 years and redecoration every seven years)

Renewal every 25 years:

$$\left.\begin{array}{l} 25 \rightarrow 0.1460 \\ 50 \rightarrow 0.0213 \end{array}\right\} \Sigma = 0.16734 \times £\ 2650 = £\ 443$$

Redecoration every 7 years:

Year	Interest Factor	Year	Interest Factor
7	0.5835	39	0.0497
14	0.3405	46	0.0290
21	0.1987	57	0.0124 (50+7)
32	0.0290 (25+7)	Σ of I = 1.2990 → x £100 = £ 130	

Cleaning as previous = £619

NPV = £ 3692 which is less than the same materials with different renewal and redecoration periods which shows the effect of the component lives at the project cost.

The effect of extending the life of the building will be to increase its NPV, but often by only a minimal amount. Where components are used in buildings that are demolished before the end of their life expectancy, some form of bonus will be added to their evaluation. The one factor militating against this is that costs so far into the future, i.e. beyond 60 years, are of minimal value when they are discounted in terms of either NPVs or AEs. The 60-year life is therefore taken as being realistic in practice, and also for life—cycle cost evaluation purposes.

2.12. SUMMARY

Life-cycle costs include cradle to grave costs converted to NPV economic models. When failure costs are included, the quantity of maintenance manpower required can be engineered which avoids the use of antique rules of thumb about how maintenance budgets are established. LCC is a method to correctly consider long term business decisions which have advantages for profitability. LCC is not easy, but it is effective for building a sound business case for action. [6]

LCC techniques provide methods to consider trade-off ideas with visualization techniques as described above which are helpful for engineers. Likewise LCC analysis provides NPV techniques of importance for financial organizations, and LCC details give both groups common ground for communication to aid in insuring sound business decisions and actions. LCC is the "laser guided missile" attack on important business problems for projects and processes—of course it requires greater sophistication than attacking problems with proverbial "hammers, tongs, and brute force".

Good alternatives for LCC require creative ideas. This is the role of the engineer to suggest and recommend cost effective alternatives. Much lower LCC are obtained when creative efforts are employed in the design area--making changes downstream in the operating plants has smaller chances for improvements because it's employed too late in the improvement cycle. Design engineers are the most important link in devising cost effective plants and naturally the burden of LCC falls on their shoulders—but design engineers can't perform an effective analysis unless they have reasonable failure data from operations. Thus the need for plant and industry databases of failure characteristics— remember, to obtain good failure data, both failure and success data must be identified.

LCC is simply a way-stop on the never ending journey for reducing costs. LCC is clearly not a destination. LCC provides the tools to engineer maintenance budgets, ownership costs, and present decision making scenarios in a financial perspective to achieve the lowest long term cost of ownership.

CHAPTER THREE

VALUE MANAGEMENT

3.1. INTRODUCTION

The construction industry needs to be more competitive, not just in the area of cost but also value. The final product of most construction project does not provide the client with the best available value of money, particularly in terms of function (what things actually do) in the present economic climate, the construction industry is as competitive as it will ever be in terms of cost. The industry can improve dramatically in the area of functional value.

The use of value concept has increased dramatically during the past few years especially in construction industry. The reason for this is the rising construction costs which are even doubled by the follow-on costs and the increasing dissatisfaction of clients of the components of the constructed facility. [1]

Value concept evolved in the forties, first as value analysis, and later as value engineering. Value engineering is a disciplined procedure directed towards the achievement of necessary function(s) for minimum cost without detriment to quality, reliability, performance or delivery. It is a hard-system thinking approach to design and construction problems which are well structured and easily defined.

Recently, a new approach called value management evolved especially in Europe. Value management is a soft-system thinking approach especially to problems which are dominated by conflicting objectives and value judgments. Value Management in construction concerns with client value system and his/her optimum satisfaction of the constructed facility. It helps client to ensure that his/her investment in construction produces valuable assets.

The discipline of value management is attracting a growing amount of attention in the construction industry. Clients are increasingly concerned with the achievement of 'value for money' in their construction projects. In response, an increasing number of construction companies and consultant are claiming to offer a value management service. However, there is a diversity of option regarding the theoretical validity of the service offered. Whilst many advocates of value management are almost evangelistic in their enthusiasm, there are also others who question the extent to which it differs from established design and cost management procedures [10].

This chapter explains the characteristics of value engineering and value management within value concept, develops a definition of value of a constructed facility in units of currency and outlines the steps of value management in construction.

3.2. ORIGINS OF VALUE ENGINEERING

The origin of value engineering is generally attributed to Lawrence Miles of the General Electric Company (GEC) in the USA during the Second World War. The technique has since been used extensively in a variety of industries and situations. While it was originally applied to the purchasing function within GEC, it soon became a part of the manufacturing and production processes that were employed. Value engineering was an innovation resulting from a shortage of materials and other resources due to wartime activity. Out of necessity the company began to search for alternative materials and to substitute these wherever possible in their designs and processes. Surprisingly, they found that many of these materials not only did the job, but in a great many cases they offered superior performance for a lower cost. Because of this the application of the technique was extended, developed and made more formal. In order to improve product efficiency they began to intentionally develop substitute materials and methods of manufacture to replace the hitherto more expensive materials and components that had been used in their manufacturing business.

The application of value engineering in the construction industry is supposed to have started in the USA in 1963. The use of the technique in that industry spread rapidly and by 1972 the US General Services Administration required that a clause on value engineering was to be included in all public sector construction contracts. The estimated cost savings reportedly ran into millions of dollars. [4]

3.3. TERMINOLOGY

Like many embryonic subjects it takes time for a body of knowledge to be developed and during this time the terminology that is used often adapts and changes in meaning as new directions are considered [3]. The following are some of the definitions that have been used for value engineering by key writers on the subject:

- **Crum, 1971**: A disciplined procedure directed towards the achievement of necessary function for minimum Cost without detriment to quality, reliability, performance or delivery.

- ***Macedo et al., 1978:*** The systematic review and control of costs associated with acquiring and owning a facility or system.

• ***Dell'Isola, 1982:*** The creative organized approach whose objective is to optimize cost and/or performance of a facility or system.

• ***Kelly and Male, 1988:*** Value engineering is an organized effort to attain optimum value in a product, system or service by providing the necessary functions at the lowest cost.

• ***Green, 1992:*** A systematic approach to delivering the required functions at the lowest cost without detriment to quality, performance and reliability.

The debate about the subject used to centre on the distinctions made between value engineering and value analysis. The definition given for value analysis is

• ***Miles, 1972:*** Value analysis is an organized approach to providing the necessary functions at the lowest cost

The subject is now more correctly referred to as value management, where value engineering and value analysis are incorporated as a part of the overall process. Value management is a strategy for identifying the project that provides the best value for money through the best use of the limited resources that are available.

A definition given for value management is:

• ***Connaughton and Green, 1996:*** A structured approach to defining what value means to a client in meeting a perceived need by clearly defining and agreeing project objectives and how they can be achieved. [4]

The short answer to the question "what is value"? is: Value is a point of view. The value of any item may differ due to whether it is viewed from the stand point of the seller, the buyer, or the user. Different concepts may exist between individual users, depending on the time, place, situation, or availability of substitute items. In order to prevent the confusion of value with the monetary price of an item, it is better to break it down in to four general categories listed bellow:

-**Use Value**; The properties and features which satisfy a need.

-**Esteem Value**; The appeal, appearance, or other features which create a desire to own the item.

-**Cost Value**; The sum of labor, materials and other costs over the expected life of the item to meet the user's required functions.

-**Exchange Value**; The properties or features which enable an item to have a trade value for something else we want.[3]

Worth: The worth of a product involves many features. The most common cited are: benefits received, services obtained, satisfaction of the product performance, quality, safety, and convenience. The worth of the product is a measure of what is in it for the customers involved. It is a measure of how well the end product meets the involved essential needs and the added desires of those that have a voice in the product selection or its use. An end product must always supply the essential need, or its worth will be poor. [4]

Mathematically Value may express as a ratio of worth (or utility) to the cost as realized by the owner, based upon his/her satisfaction (need & resources) in any given situation. This ratio is the principle measure of value and it may express as follow: [3]

$$\mathbf{VALUE = (worth\ /\ cost) = (utility\ /\ cost)} \tag{3.1}$$

3.4. MORE ABOUT VALUE MANAGEMENT

There are a number of alternative mechanisms that can be used for project auditing as part of an economic management service for clients. Some of these alternatives for managing the economics of projects are:

1- Value Management (VM) studies using functional analysis and other problem solving tools and a multi- disciplinary design/building team.

2- Structured Cost Management studies, utilizing the 'job plan' and using the criteria of cost reduction or substitution and a multi- disciplinary design/building team.

3- Cost Management studies using traditional quality surveying skills.

Method 1 and 2 have the advantage of using a multi- professional, structured, creative group approach where the third method is undertaken with the context of a single profession. [11]

Value Management is a team approach to creativity. With value engineering the design team, contractors, construction managers and specialist contractors should adopt a challenging and systematic approach to their work. To achieve the required results, a climate must be created which encourages multi-disciplinary co-operation. Close contact should be maintained between different design team specialists. Successful value engineering depends on:

i. *A multi-disciplinary approach.*

ii. *Developing a shared commitment to achieving project objectives.*

iii. *Developing the attitude which seeks to beat cost targets.*

iv. *Encouraging responsible innovation.* [1]

Over the years quality surveyors have developed a range of techniques and services which for convenience can be summarized under the term called Value Management.

VM service involved the Life Cycle Costing (LCC), Value Engineering (VE), Energy, and Maintenance cost audit and similar techniques which are devoted to evaluating the economic performance of a project and increase functional value of the project. Management contract contain the potential for the quality surveyor to obtain more detailed cost information than is normally available under conventional arrangements. This should have a beneficial impact on quality surveyor's ability to provide value management services. [3]

3.5. THE VALUE MANAGEMENT APPROACH

Value management utilizes structured functional analysis and other problem solving tools and techniques in order to determine explicitly client's needs and wants related to both cost and worth. Value management concerns with cost but it also takes account of the subjective decision making criteria of the client organization in perceiving what is or not an acceptable level of cost for any given level of project performance and technical specification. [1]

3.5.1. VALUE MANAGEMENT APPLICATION

A standard way for the application of value management has become widely established and is referred to the job plan following the outline described by its originator, Miles (1972), as shown in Table 2.1

Table 2.1 the outline of value management

Phase	Title	Description
1	Orientation	What is to be accomplished
2	Information	Provision of drawings, specifications, quantities, costs, methods, etc.
3	Speculation	Consider alternative solutions
4	Analysis/ evaluation	Analyse costs of alternative solutions
5	Development	Accept ideas are considered in further details
6	Selection	Refined ideas are further developed
7	Conclusion	Proposals are presented to the client

3.5.1.1. Phase 1 Orientation

Phase 1 is the introductory phase when it is being decided just what is to be accomplished. It will seek to separate the client's needs from the client's wants and to establish what is to be accomplished and the desirable characteristics of the proposed project. And it is a meeting or meetings chaired by the value engineer for the project and attended by the design team and those who have an interest or possess some ownership of the problem being addressed to allow everyone who is involved in the project to understand the issues and constraints. [4]

3.5.1.2. Phase 2 Information

In Phase 2 as much as possible of the information appertaining to the project is collected together. The objective of this is to identify the functions of the whole or parts of the project, as seen by the client. As much factual evidence as possible should be collected. The quality of the decision making is based upon the reliability of this information.[2] this phase secures all costs, quantities, drawings, specifications, manufacturing and construction methods, samples and prototypes. Specify information like, client needs, client wants, project constraints, budgetary limits and time for design and construction is gathered. During this phase, the value engineering team construct Functional Analysis System Technique (FAST) diagram. FAST diagram is a kind of function logic diagram, resembling a decision tree. [1]

3.5.1.3. Phase 3 Speculation

Phase 3 is the creative phase of value management and engineering. The team along with the value management consultants seeks to develop ideas for the project. Research has indicated that good and original ideas are just as likely to come from any member of the team as from the individual experts. [3]

3.5.1.4. Phase 4 Analysis and evaluation

This phase forms a crude filter for reducing the ideas that have been generated to a manageable set of propositions. The value engineering and management team will analyse what has been suggested and eliminate the various options using appropriate evaluative techniques like idea comparison and cost comparison, many of which depend upon some form of weighted assessment to eliminate the various options. [4] This phase estimates the dollar value of each idea and rank in order of highest gain and highest likely acceptability. It forms a filter for reducing the ideas generated to a manageable number for further study [1].

3.5.1.5. Phase 5 Development

The ideas that have not been eliminated during Phase 4 are now examined in detail. Outline designs will be prepared and technical and economic feasibility and viability studies will be carried out [3]. Life Cycle cost models and computer aided calculations are used. At the end of the development stage, those ideas which do not comply with the basic value engineering philosophy will be dismissed. In other words, ideas which either cost more than the original or are found to reduce quality are rejected. [1]

3.5.1.6. Phase 6 Selection

The refined ideas will now be carried forward towards the final proposal along with working drawings, calculations and costs [4]. And will be presented by the value engineering team to the body which commissioned the value engineering exercises. [1]

3.5.1.7. Phase 7 Conclusion (Feedback)

The final phase involves presenting the findings to the client. Throughout the whole process the client will have been kept informed about progress and possible solutions. The final result should not therefore present the client with any unwanted surprises. [4]

If some of the ideas are put into practice and given the opportunity of testing, then it is important to the value engineer to receive some details as feedback.

While the job plan is followed there are various approaches at different stages of the project. The four identifiable formal approaches to value engineering are the charette, the forty hour study, the value engineering audit and the contractors change proposal these can be defined as follows:

i. **The charette**: The meeting following the compilation of the clients brief, attended by full design team and by those members of the client's organization who have contributed to the brief. This meeting is conducted under the chairmanship of the value engineer.

ii. **The 40 hour study:** This is an examination of the design developed to sketch-design stage. This is carried out by an independent team of design professionals, who have not been involved with the design until the time of the study, again under the chairmanship of the value engineer. Usually it takes a full week's study.

iii. **The value engineering audit:** This is a service offered by the value engineers to large corporate companies or government departments to review expenditure proposals put forward by subsidiary companies or regional authorities. The procedures employed follow exactly those of the job plan. The value engineer, at the end, will submit a report detailing the objective and the most cost-effective method for its accomplishment.

iv. **The contractor's change proposal:** This is a post tender change encouraged by the contractor. In USA especially in governmental contracts, contractors are encouraged to submit ideas for reducing costs. If the proposal is accepted by the design team then the contractor shares in savings. [1]

3.5.1.8. CREATIVITY

Once a workable solution to a particular design has been achieved then it becomes extremely difficult to persuade designers to change their minds. They become closed to other solutions and defend their original concepts against most arguments that are put forward. Once a scheme has been committed to paper, changes proposed by others are resisted. Some designers claim that the principles involved in value management should already have been considered as a normal part of the design process. Clearly as more designers become fully aware of the practice and implications of value management then these will begin to influence the shape of the design. However, no matter how good the designer is who works on a scheme, the involvement of others will often bring positive aspects to the design. Sometimes it takes a third party to point out and identify weaknesses in a design, such as unnecessary costs. Also the continuing success of value engineering studies and applications with the identification of solutions that were not previously considered provides considerable evidence in support of value management.

3.5.2. VALUE MANAGEMENT WORKSHOPS

Value management uses a set of creative problem-solving techniques to evaluate key project decisions. With those techniques, problem is defined, the options for resolving the problem are identified, the options are then evaluated and the option that offers the best value for money is selected. Workshops, involving key participant(s) of the client and project team are needed and important to find the best value for money for client needs. Workshops must be tied closely to key stages in project development if they are to provide the best opportunity for identify needs and challenging key design decisions before they are made. Value management, therefore, is most useful in the early stages of the project development. [1]

The number of workshops is also important. Too many workshops may disrupt and delay the design and construction process. Too few workshops may loose the opportunities for the improvement of the value of the design proposals. The key to a successful workshop lies in giving it a clear objective. It is important that client agrees with project objectives from the start. Workshops are organized and managed by an experienced facilitator who is the participant chairing the workshop. This is usually the value manager. Whilst the principles of value management are centered on a series of workshops, it is a continuous process from the concept to the completion of a project. [1]

Value management approach uses two main workshops; one during the concept stage (VM1) and one during the feasibility stage (VM2). However the timing and number of workshops depends on size and complexity of the project. Value management approach is illustrated in **table 3.2**. [1]

The 40-hour workshop is the most commonly adopted approach used for a value engineering study. The 40-hour workshop is usually carried out at a point when 35% of the design has been completed. There will be a considerable amount of information to assimilate within this time period in terms of the overall concepts, design, specification and costs. In addition, the group dynamics involved, unless the team are familiar with each other, will take some time to get used to. It can be argued that the appropriate duration of a value engineering workshop is really dependent upon the scope of the study. Case studies of value engineering in practice indicate that the period of time required is frequently in excess of the supposed 40-hour workshop. Familiarity with the value engineering process could result in a shorter period of time. Other workshops have been arranged on a 3+2±2 day basis, a total of 56 hours. In this case a three-day intensive study is proposed followed by a break of about one week, two days' study followed by another week's break and finishing off with a further two days of study. [4]

Table 3.2 Value management approach for a construction project. [1]

Stage of the project	Major Parties Involved	Process	Methods or Techniques	Output
Concept	Client Value Manager Operator/User (if any) Construction Manager Designer (if appointed)	Identifying need of a Project Defining and structuring project objectives	Value management workshop (VM1) Value Tree	Project need Project objectives
Feasibility	Client Value Manager Operator/User (if any) Construction Manager Designer.	Evaluating alternative design options. Selecting best options	Value management workshop (VM2) Revised value tree SMART Sensitivity analysis	Best design option
Scheme Design	Client Value Manager Operator/User (if any) Construction Manager Designer.	Evaluating Project outline Design Proposal	Function analysis Life Cycle Costing	
Detail Design	Client Value Manager Operator/User (if any)	Evaluating Final Project design developments	Life Cycle Costing	Project Design
Construction	Construction Manager Designer. Contractors Suppliers		Construction management methods and techniques	
Completion	Client Value Manager Operator/User (if any) Construction Manager	Handing over to the client or operator / user		Constructed facility

3.6. COST-VALUE REDUCTIONS

Cost-value savings can be made on a project at any time from inception to completion. However, it is easier to make such changes during the earlier stages of a project than when the project design or the construction phase is nearing completion.

Designers are reluctant to become involved in abortive design work, because it is De-motivating and is often done at their own expense. Changes to design are more difficult because of the possible knock on effects with other aspects of the project. It is also not a good policy to spend more on preparing design changes that result in cost reductions that are less than the administrative costs involved, unless this also achieves some longer term cost savings. **Figure3.1** illustrates the likely opportunity to revise or make changes to the design of a project. **Figure 3.2** suggests that, as the project develops, the ability to change costs decreases rapidly during the design stage. [4]

UNNECESSARY COSTS

The main purpose of value management is the reduction of unnecessary costs. A well-developed understanding of the nature of construction costs is therefore required prior to embarking on a value management study of a particular project. Some of the costs involved in construction projects are unnecessary and these are the costs that are targeted through value management. They have been defined in various ways. They may be costs that do not make any meaningful contribution to the project, costs that add no intrinsic value to the project or costs that do not add any of the attributes of quality, function, appearance, life expectancy or client requirements. [4]

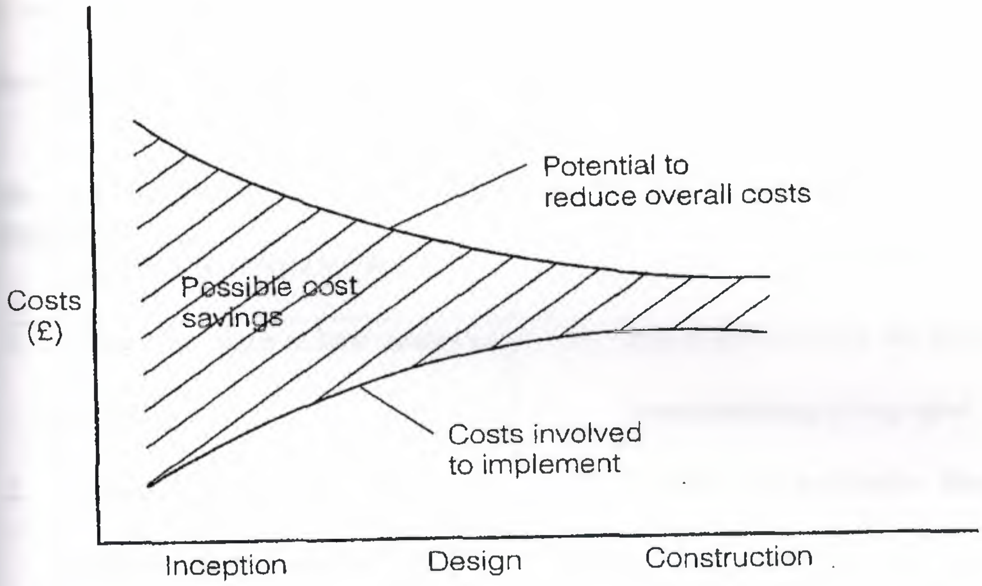


Figure 3.1 Opportunity to change a design

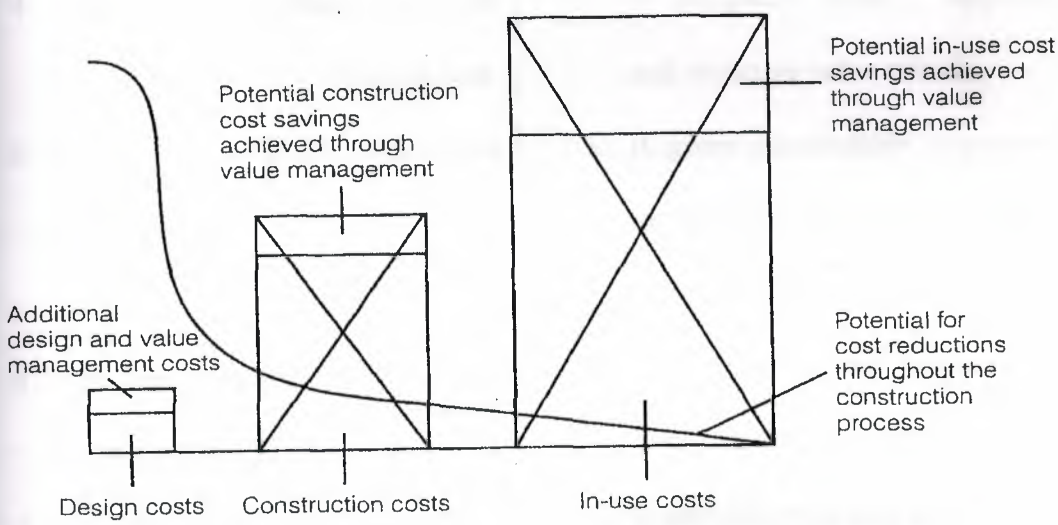


Figure3.2 declining influence on costs

3.7. VALUE MANAGEMENT IN COMPARISON

Whilst it is being considered by some commentators that there is no real distinction between value engineering and value management and the practitioner tend to use the name with which they feel most comfortable, the principles and methodology of the two are not exactly the same, although, well documented principles of value engineering provides basis for the methods of value management.

Table 3.3 illustrates the differences between value engineering and value management.

VALUE ENGINEERING	VALUE MANAGEMENT
1. It may take place at later stages of a project	1. It is a service from the concept to commissioning of a project
2. It aims to achieve the necessary functions for minimum cost	2. It aims to maximize functional value of a project
3. It is based on hard-system, more objective thinking	3. It includes client's subjective aspects considerably in thinking.
4. It generally assumes that value can be improved by reducing cost	4. It integrates client's subjective and objective value criteria
5. It gives considerable importance to job plan	5. It gives considerable importance to function analysis and multi-attribute rating techniques
6. The best solution, usually, is the most economical	6. It decides on the best solution based on client's value system
7. It uses life cycle cost analysis	7. It uses life cycle cost analysis

3.8. VALUE MANAGEMENT TECHNIQUES

This section explains major techniques used in value management, namely function analysis method, life cycle costing and simple multi-attribute rating technique. [1]

3.8.1. FUNCTION ANALYSIS METHOD

The analysis of function has been considered important for at least two thousand years the analytical description of function is more recent and it has two apparently unrelated sources. One can be followed to the operational technique of objectives hierarchies and the second to functional analysis diagramming developed within the framework of value management. [11]

Functional analysis (FA) is a specific technique or methodology used to establish objectives and to eliminate uncertainty. It focuses the mind on the price task in hand, and sets targets for the creative problem solving techniques to follow. It is often described as the "heart" of value management. [3]

In functional analysis method, component is defined as a single manufactured item, such as a brick, a hinge, a gear wheel, a length of pipe, a switch, or as a unit comprised of a number of components, such as a window, a door, a kitchen unit. An element is defined as a unit that fulfills a specific function or functions such as a window, an external wall, a floor. Functional analysis is a powerful technique in the identification of the prime functional requirements of a project. However, the techniques for diagramming or other forms of representation lie within the skills and experience of the value manager. [1]

In a functional analysis the function of each component is examined by asking the question 'what dose it does?' and in the value management exercise the next question would be 'how else can this be achieved?' [11]

3.8.1.1. CHARACTERISTICS OF FUNCTIONAL ANALYSIS

1. VERB/NOUN DEFINITION: Most texts recommend that the function of an item or a system be expressed in as concise a phrase as possible, ideally one comprising just a verb followed by a noun. Some useful active verb is given as amplify; attract; change; collect; conduct; control; create; emit; enclose; establish; filter; etc. [1]

2. FUNCTIONAL DEFINTTION/TECHNIICAL SOLUTION: A technical solution to a problem is represented by a component or element. For example, where light is required in a room, a technical solution is to install an electric light bulb. To search for alternatives to a technical solution functional definition should be realized. Therefore, for the above example;

Functional definition:	Light is required in a room.
Technical solutions:	Install an electric light, install a sheet of transparent material, install a gas light, etc. [1]

3. BASIC/SECONDARY FUNCTIONS: Basic functions are defined as those without which the project would fail or the task would not be accomplished. Secondary functions are those which are a characteristic of the technical solution chosen for the primary function and are not required. However, both basic and secondary functions should be sought in order to fully understand a problem.[1]

4. COST/WORTH The main assumption in functional analysis with respect to cost/worth appreciation is that secondary functions have zero worth, as by definition, the project does not fail if a secondary function is omitted. The task is, therefore, is to correctly identify the basic functions. [1]

For example, consider a door within a fire-check partition in a plant room area and also consider a door within a fire-check partition between an office and the foyer of a quality hotel.

Door within a plant room area;

Basic functions:	maintain access, Prevent the spread of fire
Technical solutions	a fire-check door which is open for access and automatically closed in the case of fire to prevent fire spread.

Maintain access function is worth the amount required to form a hole in the partition and prevent the spread of fire function is worth the amount paid for the least expensive fire-check door and automatic door closer. Design solutions should be checked against the worth. Alternative technical solutions which could cost less than the worth could be found through the creativity process. [1]

Door between an office and the foyer;

Basic functions:	establish access, restrict access, prevent the spread of fire, contribute to aesthetic environment, and insulate office from foyer.
Technical solutions:	a fire-check door which has a acceptable aesthetic standard.

Establish access, prevent the spread of fire and insulate office from foyer could be provided by the least expensive fire-check door, and the cost of the door is their worth. The worth of the function, restrict access, is zero because the door could be placed behind the reception counter. Again other alternative solutions could be created for costs less than the worth established. [1]

3.8.1.2. FUNCTION ANALYSIS SYSTEM TECHNIQUE (FAST)

Function analysis system technique concerns with the hierarchy of functions showing logical Why/How relationships, which provides an analysis of functions to achieve an objective or end result. [1]

There are two type of Functional Analysis System Technique (FAST) diagram which they entitle 'Technical FAST' and 'Task FAST'.

The Technical FAST diagram is one, such as that for the hand-drill (Figure.3.3) which tends to be linear and answers the question HOW? When reading from left to right and WHY? When reading from right to left. [11]

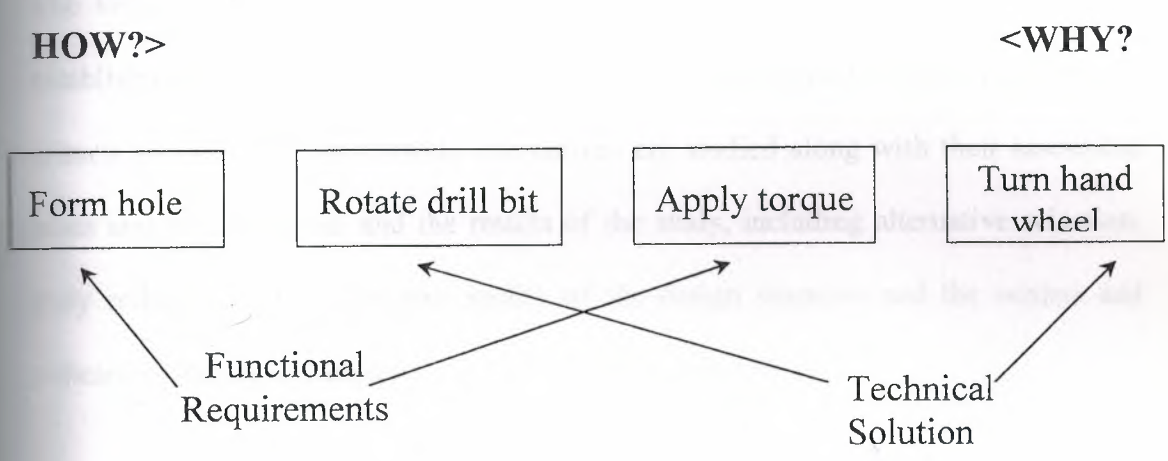


Figure 3.3 A FAST diagram of a hand- held, hand- powered drill.

The task FAST diagram, unlike the technical FAST diagrams above, is described as having a primary function representing client need and four supporting functions representing client wants, namely: assure convenience, assure dependability, satisfy user and attract user. In a task FAST diagramming exercise a concept is taken and developed from left to right.[11] The techniques for diagramming or other forms of representation unfortunately lie within the skills and experience of the value manager.

3.8.2. LIFE CYCLE COSTING

Life cycle costing is an economic assessment of design alternatives, considering all the significant costs of ownership over an economic life expressed in equivalent currency (i.e. in dollars) In other words it is a technique for economic evaluation of alternatives. It is a cost centered engineering economic analysis whose objective is to systematically determine the costs attributable to each of one or more alternative courses of actions over a specified period of time.

VALUE MANAGEMENT USING LIFE CYCLE COSTING

The value management using the life cycle cost analysis study concerns with the establishment of the goal of ensuring that the correct economic and performance criteria are followed, all feasible alternatives are studied along with their associated costs and performances, and the results of the study, including alternative selection, truly reflect both the economic reality of the design situation and the wishes and policies of the organization for which the study is conducted.

General steps of value management using life cycle cost analysis study can be listed as follows;

I. Identifying economic criteria.

In this step the economic criteria used is explained as, the economic approach, project life cycle, Discount (interest) ate, Present time, Inflation, Cost growth and cash flow.

II. Generating design alternatives.

Using creativity techniques, like brainstorming, alternatives are generated for the project.

III. Life cycle cost analysis

Present worth method is used making life cycle cost analysis.

IV. Weighted evaluation

To include non-monetary benefits which might be of interest to the decision makers, the alternatives therefore are assessed by the weighted evaluation technique.

The procedure for weighted evaluation consists of criteria identification and weighing and evaluating the alternatives to the criteria selected.

V. Risk assessment

Economic risk assessment could be made by using different approaches. Confidence index and sensitivity analysis approaches can be used for risk assessment.

i. CONFIDENCE INDEX APPROACH

The confidence index for best and next best design alternatives is calculated as follows:

1. Calculate high estimate as 10% higher than best estimate. Calculate low estimate as 10% lower that best estimate. Low side will be best estimate minus low estimate. High side will be high estimate and best estimate.

2. Determine whether high side and low side differences, (DELTA %), are within 25% of each other for each cost. If so, continue; if not, use the sensitivity approach to assess the effects of uncertainty.

3. Determine the differences of the present worth of the two alternatives, based on best estimates. This is numerator of the confidence approach.

4. Compute the present worth of the larger of the high-side and low-side differences for each cost, and compute its square. Add the squared present worth of all cost differences for both alternatives, and find the square root of this sum. This is the denominator of the confidence index ratio.

5. Divide the result of 3 by the result of 4 to obtain the confidence index. Use the confidence index to evaluate the result as follows;

a. If confidence index (CI) is below 0.15, then the confidence to the results of the life cycle cost analysis is low.

b. If CI is between 0.15 and 0.25, then the confidence to the results of the life cycle cost analysis is medium.

c. If CI is greater than 0.25, then the confidence to the results of the life cycle cost analysis is high.

ii. SENSITIVITY ANALYSIS APPROACH

This is a procedure for determining and verifying how sensitive the alternatives to changes of a particular input-data element.

VI. RANKING AND SELECTION

The final step consisted of ranking the four alternatives on the basis of the previous calculations. It also gives the benefit-to-cost ratio for each alternative. Benefit-to-cost ratio is calculated by dividing the benefit score by the life cycle cost. [1]

3.8.3. SIMPLE MULTI-ATTRIBUTE RATING TECHNIQUE (SMART)

Simple multi-attribute technique is a soft-system approach of weighted evaluation technique used in value engineering. SMART approach to value management is based on client's value system and entirely consistent with the design workshops to ensure user participation in the design of buildings. Main contribution of SMART to value management is the way in which it provides a framework for facilitating thought and communication. This is particularly important when responsibility is shared within a group of different value systems. [1]

Stages of SMART methodology in value management can be summarized as follows:

STAGE 1. INFORMATION

At this stage, decision makers are identified, and they are represented at senior level in the meetings.

STAGE 2. OBJECTIVES

Each participant is invited to discuss his/her initial understanding of the problem and the associated design objectives. Differences are discussed until an agreed list of key objectives can be produced.

STAGE 3. VALUE TREE

The objectives listed in stage 2 are structured into a value tree. It is often necessary to limit the number of attributes to a manageable level. This can usually be achieved by eliminating those which do not directly the choice of outline design.

STAGE 4. ASSIGNMENT OF IMPORTANCE WEIGHT

The importance weights are assessed for each branch of the value tree. Final weights are calculated by multiplying through the tree, and the weights are checked for consistency.

STAGE 5. UTILITY ASSIGNMENT

Each outline option is then assessed against each attribute on a scale of 0 to 100. A decision matrix is then used to obtain an aggregated utility rating for each design option.

STAGE 6. SENSITIVITY ANALYSIS

The results of the utility assessment stage are tested to changes in the chosen importance weights and utility scores by the use of a sensitivity analysis.

STAGE 7. COST/VALUE RECONCILIATION AND SELECTION

The estimated capital cost of each proposal is compared with the aggregated utility ratings, and the decision is made as to which design option represents the greatest value for money.

STAGE 8 MARGINAL IMPROVEMENTS

A brainstorming session is then held to generate ideas of how the cost of the chosen option could be reduced without compromising the design utility rating. [1]

3.9. PROPOSED DEFINITIONS

Value of a product, such as a constructed facility is defined in units of currency. A method is developed for the determination of value in units of currency. This section explains the proposed definition of value of a product and its determination. This section also highlights value management methodology in construction.

3.9.1. VALUE OF A PRODUCT

Value is a measure expressed in currency, effort, exchange, or on a comparative scale which reflects the desire to obtain or retain an item, service or idea. Value can also be defined as, the fair equivalent in service or commodities that an owner/buyer receives in exchange for money Economists define values in terms of environmental interactions, choices and preferences that emphasized the person holding values Value engineering considers cost in relation to function, and recognizes that there is a three-way relationship between function, cost and value. This relationship symbolizes value as a ratio of function to cost.

Different value situations could be, (a) exchange value, being the amount for which an item may be sold, (b) esteem value, being the amount an owner or user is prepared to pay for prestige or appearance, (c) use value, being a measure of the function(s) of an item and (d) other value situations like, aesthetic, judicial, moral and religious. [8]

Value of a product, therefore, includes cost and a subjective part associated with cost. This subjective part of value reflects the owner(s)/buyer(s) desire to obtain or retain the item or how much owner(s)/buyer(s) are prepared to pay for prestige, appearance, aesthetic, judicial, religious or moral reasons, or any combination of these reasons. [1]

3.9.2. DEFINITION OF VALUE OF A PRODUCT

The value of a product is a measure expressed in a currency, which reflects the desire to obtain or retain the product, and equal to the cost of the product plus or minus a subjective marginal value. Interrelation of cost and value could be expressed as follows;

Value = Cost ± marginal value (3.2)

Where marginal value is the subjective part of value and depends on the owner(s)/buyer(s) value system. [1]

3.9.3. DETERMINATION OF VALUE OF A PRODUCT

The cost of the product is the total price paid for the product and could be calculated, considering all relevant costs of the product. The methodology is illustrated in the following (figure 3.4) first column shows the steps of the method, the second and third columns show market input and owner(s)/buyer(s)' confirmations.

To determine the value of a product, such as of a constructed facility, **first** select the design alternatives and refer these alternatives to the client/owner/buyer for confirmation that the selected alternatives are of his/her interest and in agreement to his/her individual value system. Client can change the selected design alternatives. **Next step** is to propose criteria to the product and ask for client's confirmation of the criteria and their importance weights. **Third step** is to assess the utility ratings of each alternative against the product's criteria, based on client's value system and calculate the total utilities. **Final step** concerns with the use of SMART technique as a weighing method and determine the marginal value which is the subjective part of value and adding to or subtracting from the cost of the product. [1]

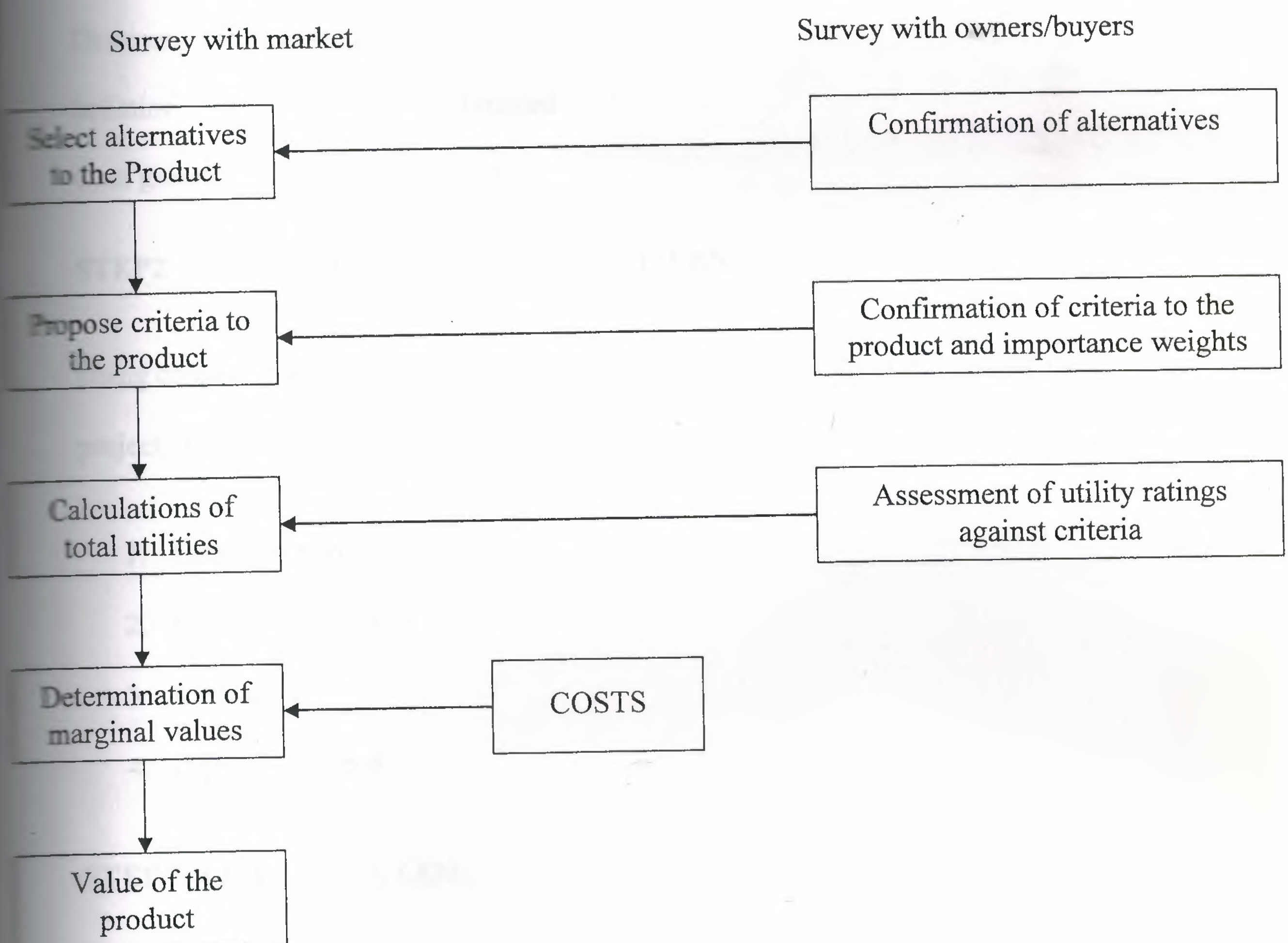


Figure3.4 Determination of value of a product

3.10. AN EXAMPLE OF VALUE MANAGEMENT.

To illustrate a value management decision making for the floor cover materials by using the life cycle costing method. The project is the selection of floor covering of a 250m^2 office in the Turkish Republic of North Cyprus TRNC. The quantities and prices all are real.

STEP1. IDENTIFYING ECONOMIC CRITERIA

The economic criteria used in this study are used as follows

Economic Approach	: Constant Dollars
Project Life	: 60 year
Discount (Interest) rate	: %10
Inflation	: ignored
Cost growth	: %0

STEP2 GENERATING ALTERNATIVES

Using creativity techniques, like brainstorming, alternatives are generated for the project. The four alternatives are:

1. Laminant parquet on screed
2. Ceramics on screed
3. Mosaics
4. Carpet on screed

STEP 3. LIFE CYCLE COST ANALYSIS

Present worth method is used in making life cycle cost analysis.

Table3.4: the life cycle cost analysis of the 4 alternatives.

		Carpet on screed	Laminant parquet on screed	Ceramics on screed	Mosaics
Initial Cost	Materials	\$ 3750	\$ 4500	\$ 4500	\$ 7625
	Screed	\$ 2575	\$ 2575	\$ 2575	-----
Renewal period		10 years	20 years	30 years	60 years
Renewal's extra Costs		200	\$ 500	\$ 500	0
Renewal's Costs		\$ 3750	\$ 4500	\$4500	0
Polish period		0	5	0	15
Polish Costs		0	\$3.2 / m^2	0	\$6 / m^2
Cleaning costs		\$3/ m^2	0	0	0

1) Carpet on screed

There are many different types of carpet in the offices from the cheapest ones \$8/m2 to \$100/m^2 but the most used types are about \$15/m^2 and as example of this type SAMUR ANADOLU carpet. The usage life of the carpet is assumed to be 10 years and a cleaning cost of \$4 /m^2.

✓ Renewal (A) every 10 years:

Year	Interest Factor
10	0.3855
20	0.1486
30	0.0573
40	0.0221
50	0.0085

Σ of Interest Factor is 0.662 x (\$3750+200) = \$2615 (B)

✓ Cleaning every 1 year

Annual cleaning is \$4 /m^2 but we have to be careful that in the renewal years there is no cleaning.

Cleaning cost	Factor
$250m^2$ x \$3 = \$750	9.9672

Cleaning cost is \$750x9.9672 = \$7475.5 (C)

But we have no cleaning in the years of change or the last year of the project life

Year	Factor
10	0.3855
20	0.1486
31	0.0573
40	0.0221
50	0.0085
60	0.0033

Σ of Interest Factor is 0.6253 x \$750 = \$469 (D)

The net cleaning cost is = \$7475.5 - \$ 469 = \$ 7006.5

Total PV is : 6325 + 2615 + \$7006.5 = \$15946.5

A. Renewal periods in practice will be different and will depend on initial quality, location, aspect, use and maintenance. The argument is often used that once Carpets start to wear off after a while but it may produce some materials or ways to prolong their life and the period to renewal. But the renewal doesn't include the screed as it life is 60 years. Opinions will vary, but ten years is assumed to be a good life expectancy

B. Inflation is generally ignored in life-cycle cost calculations, because the amounts are a comparative value. The renewal costs include a sum of $200 for taking out the existing Carpet only not the screed, clearing away off-site, preparing the floor to be suitable for the new carpet.

C. if we assume that the cleaning of the carpet is done every year including the years we replace the carpet (which is not true) but to find the exact cost of cleaning we have to calculate the cleaning cost for the years of replacement (D) and subtract that from the calculated cleaning cost.

2) ***Laminant parquet on screed***

The most used type of Laminant parquet is the Turkish product which cost is about $\$18/m^2$ and its usage life assumed to be 20 years and to be polished every 5 years.

✓ Renewal every 20 years:

Year	Interest Factor
20	0.1486
40	0.0221

Σ of Interest Factor is 0.1707 x ($4500+500) = $853.5

✓ Polish every 5 years

Year	Factor
5	0.6209
10	0.3855
15	0.2394
20	0.1486
25	0.0923
30	0.0573
35	0.0356
40	0.0221
45	0.0137
50	0.0085
55	0.0053

Σ of Interest Factor is 1.6292x ($900) = $1466

Total PV is: 7075+853.5+1466 = $9394.5

3) Ceramics on screed

There are 100s of ceramic types but the most used types in offices are the 45x45 types with simple colors and those types price is about $12/m2 and the ceramics doesn't need polish during its using life but it assumed to be changed after 30 years as it can't be maintained during that life.

✓ Renewal every 30 years:

Year	Interest Factor
30	0.0573

The renewal cost is 0.0573x ($4500 +$500) = $286.5

Total PV is : 7075+286.5 = \$7361.5

4) Mosaics

There many different types of mosaics produced in TRNC and one of the most used types is the 45cmx45cm with dark gravels called Perinç which costs \$19/m^2 for the mosaics. And it can be used as long as the building life but we have to have a hard polish which takes off a then layer and re-smoothen the surface each 10 years and this procedure cost \$6/m^2.

✓ Polish every 15 years

Year	Interest Factor
15	0.2394
30	0.0573
45	0.0137

Σ of Interest Factor is 0.3104x1500 = \$465.5

Total PV is : 7625+465.5 = \$8090.5

- **DISCOUNT PAYBACK PERIOD**

In Economy n_p is for asset or alternative is the estimated time, usually in years, it will take for the revenues and other economic benefits to recover the initial investment and a stated return [8]. But in VM it means how long it will take time for an alternative to cover the difference of initial cost with the reference alternative. This period can be used as one of the measure to select an alternative but not the sole one.

For Alternative 1and Alternative 2 PAYBACK PERIOD

$$\text{PW Saving} = \begin{Bmatrix} \text{Costs of alternative 2} \\ \text{except initial cost} \end{Bmatrix} - \begin{Bmatrix} \text{Costs of alternative 1} \\ \text{except initial cost} \end{Bmatrix}$$

$$= (853.5 + 1466) - (2615+7006.5) = -7302$$

- There is saving

+ There is loosing

Then the result's annual payment is found according the question data In this question the life of the project is 60 years and the interest rate is %10.

Annual payment = 7302/9.9672 = 732.6/ year

Divide initial cost difference between Alt. 1 and Alt. 2 to the answer:

750/732.6 = 1.02 years

And by the same way the other two alternatives n_p are found.

- **ANNUALIZED TOTAL LIFE COST**

It's the change of the life cycle cost of the alternative into equivalent uniform annual (End–of–period) amount which is the same each period. And to find that we divide the total life cycle cost into the interest rate belongs to the 60 years Vs %10 interest rate table which is found before to be 9.9672 which is :

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Annualized total life Cost	15946.5/9.9672 = $1599.9	$ 942.54	$ 738.57	$ 811.71

Table3.5: Present Worth Computation for alternatives.

Life Cycle Costing Analysis Present Worth (PW) Computation Subject : Value Manegment example Description: Ground Floor Covering			Alternative 1 Carpet On Screed		Alternative 2 Laminant parquet On Screed		Alternative 3 Ceramics on screed		Alternative 4 Mosaic on mortar	
Initial Costs	Quantity (Sq. m)	Unit price ($)	Est.	PW	Est.	PW	Est.	PW	Est.	PW
			6325.00	6325.00						
	250.00	29.80			7075.00	7075.00				
	250.00	30.50					7075.00	7075.00		
	250.00	28.30							7625.00	7625.00
	250.00	32.30								
Total Initial Cost				6325.00		7075.00		7075.00		7625.00
Initial Costs Savings (Compared to A1)						750.00		750.00		1300.00
Renewal Cost				2615		853.5		286.5		---
Polish cost						1466				465.5
Annual cost (Cleaning)				7006.5						
Total life Cost PW				15946.5		9394.5		7361.5		8090.5
Total life saving (Comp. To Alt.1)						6552.00		8585.00		7856.00
Discounted Payback Comp. To Alt.1					1.02 year		0.8 year		1.42 years	
Total life Cost Annualized			1599.90	per year	942.54	per year	738.57	per year	811.71	per year

As the difference in life cycle cost between alternatives 2, 3, and 4 is close, then further analysis based on high, best and low estimates are carried out. The best estimates are the original estimates. For high estimates best estimates are increased by 10 % and for low estimates they are decreased by 10 %.

Table 3.6: High, best and low estimates for alternative 1.

	Alternative 1 High Estimate (+10%)	Alternative 1Best Estimate	Alternative 1 low Estimate (-10%)
Initial Cost	6957.5	6325	5692.5
Renewal Cost	2876.5	2615	2353.5
Polish cost	0		0
Annual cost (Cleaning)	7707.15	7006.5	6305.85
Total life Cost PW	17541.15	15946.5	14351.85
Total annual cost	1759.89	1599.9	1439.91

Table 3.7: High, best and low estimates for alternative 2.

	Alternative 2 High Estimate (+10%)	Alternative 2 Best Estimate	Alternative 2 low Estimate (-10%)
Initial Cost	7782.5	7075	6367.5
Renewal Cost	938.85	853.5	768.15
Polish cost	1612.6	1466	1319.4
Annual cost (Cleaning)	0	0	0
Total life Cost PW	10333.4	9394	8454.6
Total annual cost	1036.794	942.54	848.286

Table3.8: High, best and low estimates for alternative 3.

	Alternative 3 High Estimate (+10%)	Alternative 3 Best Estimate	Alternative 3 low Estimate (-10%)
Initial Cost	7782.5	7075	6367.5
Renewal Cost	315.15	286.5	257.85
Polish cost	0	0	0
Annual cost (Cleaning)	0	0	0
Total life Cost PW	8097.65	7361.5	6625.35
Total annual cost	812.427	738.57	664.713

Table 3.9: High, best and low estimates for alternative 4.

	Alternative 4 High Estimate (+10%)	Alternative 4 Best Estimate	Alternative 4 low Estimate (-10%)
Initial Cost	8387.5	7625	6862.5
Renewal Cost	0	0	0
Polish cost	72.05	65.5	58.95
Annual cost (Cleaning)	0	0	0
Total life Cost PW	8899.55	8090.5	7281.45
Total annual cost	892.881	811.71	730.539

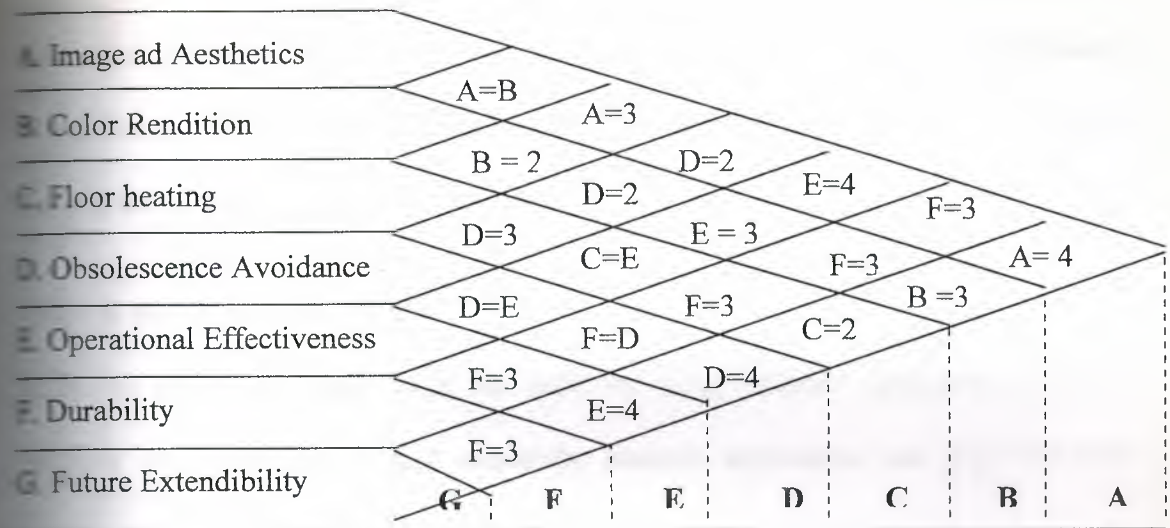
STEP 4. WEIGHTED EVALUATION

To include non-monetary benefits which might be of interest to the decision makers, the alternatives therefore are assessed by the weighted evaluation technique.

The procedure for weighted evaluation consists of criteria identification and weighing and evaluating the alternatives to the criteria selected. Figure 4 shows the weighted evaluation for the alternatives.

The criteria for the evaluation are chosen to be image/aesthetics, color rendition, environmental sustainability, obsolescence avoidance, operational effectiveness, durability and future extendibility. Each pair of criteria is compared and the stronger of the two is scored to the how important scale. For example, durability is more important over operational effectiveness, and there is a score of F=3 between two benefits. Similarly between operational effectiveness and future extendibility, there is a score of E=4 in favor of operational effectiveness.

Raw score as illustrated at the bottom of criteria scoring matrix, gives the addition of all the scores for each criteria. For example, raw score of 13 for obsolescence avoidance is the sum of the numerical of D-2, D-2, D-3, D-1, D-1, AND D-4.



	G	F	E	D	C	B	A	
Row score	0	16	12	12	3	6	8	
Alternatives analysis matrix / Im Wts (1-10)	1	10	8	8	2	4	4	Total
1. Carpet on screed	1 / 1	10 / 1	32 / 4	8 / 1	6 / 3	20 / 5	20 / 5	97
2. Laminant parquet on screed	3 / 3	30 / 3	40 / 5	24 / 3	8 / 4	8 / 2	16 / 4	129
3. Ceramics on screed	3 / 3	50 / 5	32 / 4	40 / 5	2 / 1	20 / 5	20 / 5	167
4. Mosaics on Mortar	5 / 5	50 / 5	32 / 4	32 / 4	2 / 1	8 / 2	8 / 2	137

Figure 3.5: Weighted evaluation floor covering system

Note that if the two criteria of a pair have the same importance level in comparison, then they both have one score each. Next line in the table shows the weighted importance of the criteria from 1 to 10, based on the raw scores. Note that if any criteria has zero raw score then a minimum score of 1 can be assigned for calculations.

The analysis matrix lists the alternatives and each alternative is then rated on the degree to which it provides each benefit, according to the scale (1 to 5) as shown at the bottom of the figure. A benefit score is then found for each alternative-benefit pair by multiplying the alternative rating by the benefit weight. For example, for alternative one and color rendition this sore is 5x4=20. The total benefit score for each alternative is the sum of its individual scores. Alternative with the highest total benefit score is the best recommended alternative.

STEP 5. RISK ASSESSMENT

Economic risk assessment could be made by using different approaches. In this example confidence index and sensitivity analysis approaches are used for risk assessment.

CONFIDENCE INDEX APPROACH

The confidence index for best and next best design alternatives is calculated as follows:

1. Calculate high estimate as 10% higher than best estimate. Calculate low estimate as 10% lower than the best estimate. Low side will be best estimate minus low estimate. High side will be high estimate minus best estimate.

2. Determine whether high side and low side differences, (DELTA %), are within 25% of each other for each cost. If so, continue; if not, use the sensitivity approach to assess the effects of uncertainty.

3. Determine the differences of the present worth of the two alternatives, based on best estimates. This is numerator of the confidence approach.

4. Compute the present worth of the larger of the high-side and low-side differences for each cost, and compute its square. Add the squared present worths of all cost differences for both alternatives, and find the square root of this sum. This is the denominator of the confidence index ratio.

5. Divide the result of 3 by the result of 4 to obtain the confidence index. Use the confidence index to evaluate the result as follows;

a. If confidence index (CI) is below 0.15, then the confidence to the results of the life cycle cost analysis is low.

b. If CI is between 0.15 and 0.25, then the confidence to the results of the life cycle cost analysis is medium.

c. If CI is greater than 0.25, then the confidence to the results of the life cycle cost analysis is high.

Table 7 shows the confidence index calculations for the two lowest life cycle cost alternatives, namely, alternative three and four. Confidence index is greater than 0.25, (CI = 0.283). The results of the life cycle cost analysis are assigned high confidence. In other words alternative 2, masonry wall system, may be selected for implementation with a high degree of confidence and it is actually the alternative with the lowest life cycle cost.

Table 3.10 Confidence index Computation

ALTERNATIVES	LOW	HIGH	BEST	LOW SIDE	HIGH SIDE	Δ % (Diff. bet/n sides)	BEST ESTE.	Δ The larger difference
ALTERNATIVE1	**Carpet on screed**							
Initial Cost (PW)	5693	6958	6325	633	633	0	6325	633
Renewal Cost (PW)	2354	2877	2615	262	262	0	2615	262
Polish Cost								
Cleaning Cost	6306	7707	7007	701	701	0	7007	701
TOTAL							15947	
ALTERNATIVE2	**Laminant parquet on screed**							
Initial Cost (PW)	6368	7783	7075	708	708	0	7075	708
Renewal Cost (PW)	768	939	854	85	85	0	854	85
Polish Cost	1319	1613	1466	147	147	0	1466	147
Cleaning Cost								
TOTAL							9395	
ALTERNATIVE3	**Ceramics on screed**							
Initial Cost (PW)	6368	7783	7075	708	708	0	7075	708
Renewal Cost (PW)	258	315	287	29	29	0	287	29
Polish Cost								
Cleaning Cost								
TOTAL							7362	
ALTERNATIVE4	**Mosaics on Mortar**							
Initial Cost (PW)	6863	8388	7625	763	763	0	7625	763
Renewal Cost (PW)								
Polish Cost	59	72	66	7	7	0	66	7
Cleaning Cost								
TOTAL							7691	

$$\text{Confidence Index} = \frac{\text{PW (High)} - \text{PW (Low)}}{\sqrt{\left[\left(\sum \text{DELTA (High)}\right)^2 + \left(\sum \text{DELTA (Low)}\right)^2\right]}}$$

Confidence Index = $(7691-7362)/\left((737)^2+(770)^2\right)^{1/2} = 329/1066 = 0.31$ → HIGH

Confidence Assignment: CI <0.15 Low, 0.15 < CI < 0/25 Medium CI > 0.25 High

SENSITIVITY ANALYSIS APPROACH

This is a procedure for determining and verifying how sensitive the alternatives to changes of a particular input-data element. **Figure3.6** shows the low, best and high estimated cost and the corresponding present worth value for each of the four alternatives. The data are presented in a graph at the bottom of the figure. The graph illustrates that under all possibilities, from low to high estimates, alternative two remains the lowest life cycle cost.

Table 3.11 Confidence index Computation

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Representative Values	Present Worth	Present Worth	Present Worth	Present Worth
LOW	14352	8455	6625	6921
BEST	15947	9395	7362	7691
HIGH	17541	10334	8098	8460

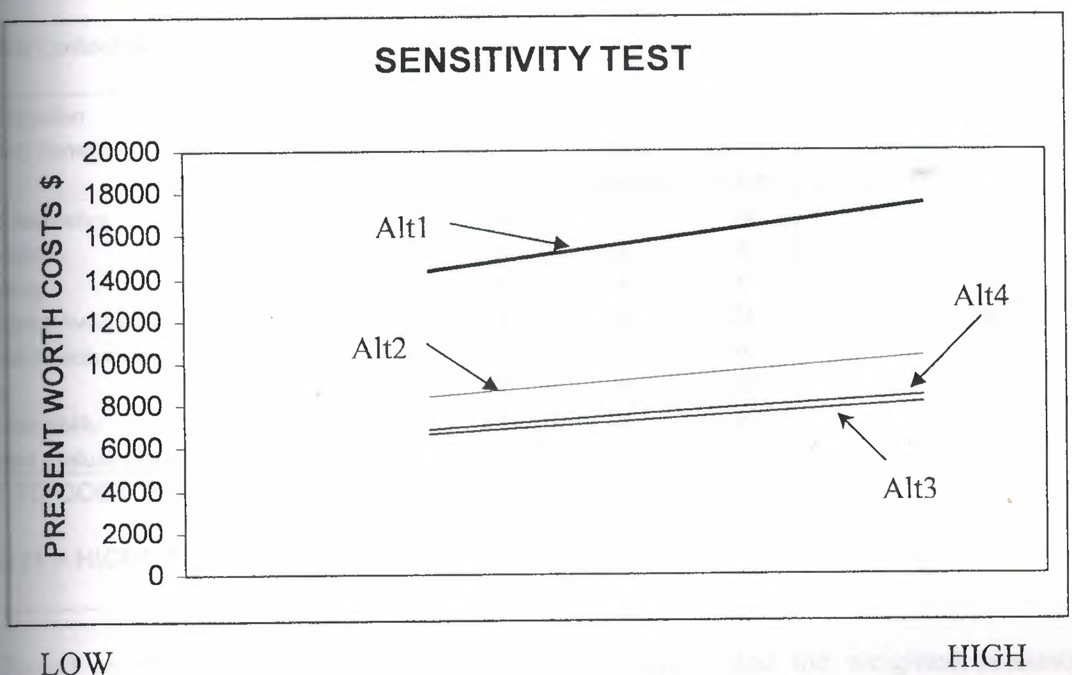


Figure 3.6 Sensitivity analysis computations

STEP 6. RANKIN AND SELECTION

The final step consisted of ranking the four alternatives on the basis of the previous calculations. Table 3.11 summarizes these calculations. It also gives the benefit-to-. cost ratio for each alternative. Benefit-to-cost ratio is calculated by dividing the benefit score by the life cycle cost. (i.e. for alternative one, benefit-to-cost = 97 / 15946.5 = 0.0061).

Table 3.12 Summary Table for both Life Cycle costing and Weighted Evaluation.

Costing Analysis (PW) Computation Value Management example Ground Floor Covering		Alternative 1 Carpet On Screed		Alternative 2 Laminant parquet On Screed		Alternative 3 Ceramics on screed		Alternative 4 Mosaic on mortar	
Cost Summary		PW		PW		PW		PW	
INITIAL COST		6325		7975		7075		7625	
Cost		2615		853.5		286.5		0	
cost				1466		0		465.5	
cost (Cleaning)		7006.5				0			
Life Cost PW		15946.5		9394.5		7361.5		8090.5	
Life saving (Comp. To Alt.1)				6552		8585		7856	
Life Cycle cost (Annualized)									
payback period				1.02 year		0.8 year		1.42 years	
Sensitivity Confidence		High		High		High		High	
Evaluation monetary Benefits)									
CRITERIA	WT (1-10)	Evaluation	Score	Evaluation	Score	Evaluation	Score	Evaluation	Score
ad Aesthetics	4	5	20	4	16	5	20	2	8
Rendition	4	5	20	2	8	5	20	2	8
heating	2	3	6	4	8	1	2	1	2
Obsolescence Avoidance	8	1	8	3	24	5	40	4	32
Operational Effectiveness	8	4	32	5	40	4	32	4	32
Durability	10	1	10	3	30	5	50	5	50
Future Extendibility	1	1	1	3	3	3	3	5	5
Weighted Evaluation score			97		129		167		137
BENEFIT TO COST RATIO			0.0061		0.0137		0.0227		0.0169
RANKING (1 = HIGHEST)		4		3		1		2	

Based on the results of both life cycle cost analysis and the weighted evaluation summarized above, Alternative 3 appears to best satisfy the requirements of this project and is therefore recommended for selection and use.

From the benefit-to-cost ratios, economic ranking is determined. Alternative Three is assigned to be of the highest rank (1 = highest rank).

Therefore, alternative Three, **Ceramics on screed concrete**, is the best selection based on the results of both the life cycle cost analysis and the weighted evaluation.

3.11. SUMMARY

Implementation of a construction project is a complicated and complex process. It requires the contribution of different parties, successfully developing project design, choosing best materials among a large range, using suitable methods and having capable labour and good supervision. Client satisfaction of the constructed facility, however, depends on how much the end product agrees with his/her value system.[1]

Value Management in construction concerns with client value system and his/her optimum satisfaction of the constructed facility. It helps client to ensure that his/her investment in construction produces valuable assets. Value management aims to maximize the functional value of the constructed facility to the client. It does this by ensuring that all decisions for the project are made in accordance with project requirements and against a value system determined by the client Value management service includes functional analysis, life cycle costing, operating in multi-disciplinary groups using creativity techniques, and establishing comparative cost in relation to function [3]. In summary, value management is a multi-disciplinary, team-oriented approach to problem solving. Chairman or facilitator has to harness the creativity of the team and direct it towards solving the client's problem through functional analysis. This involves group diagnostics and chairmanship as well as negotiation. Value based project management uses the principles of value management and a value manager is involved from concept to completion. Value manager's principal objective is to maximize the functional value of the project by managing its development from concept to completion and commissioning by auditing all decisions against a value System determined by the client. [1]

CHAPTER FOUR
LIFE CYCLE COST APPLICATION ON EXTERNAL ENVELOPE OF A DORMITORY BUILDING

4.1. INTRODUCTION

In the construction market in North Cyprus, because of the uncontrolled growing up of the construction companies, the probability of having unnecessary cost and low value is a usual fact in most of the projects. The application of value management and life cycle cost techniques can eliminate unnecessary cost and maximize the value.

In order to investigate the presence of imperfections, the amount of unnecessary cost and expensiveness of the external envelope for the buildings in the North Cyprus, the new designed student dormitory in the Near East University (the dormitory) is selected. Although in any project there are too many parts or activities to which the value management and life cycle cost techniques are applicable, and since there is many alternative for the external envelope components started to be widely used in the construction market in North Cyprus were taken into consideration. It was aimed to analyse the cost and value of the existing external envelope of the new designed student dormitory in the Near East University.

The chapter is studied in order to show the cost and expenses of the existing external envelop and the other alternatives and at the end the best composite of external envelope components will be shown.

4.2.EXTERNAL ENVELOP

Building enclosure, in general, consists of the external parts which in touch with environment and internal divisions that provide spaces/ rooms to the user(s) as shown in figure 4.1

External envelope is a building element which is acting both as barrier and as filter, makes important contributions to these expectations. External envelope is a barrier against the effects of cold or extreme heat, wind and rain. It moderates the conditions outside to those needed inside.

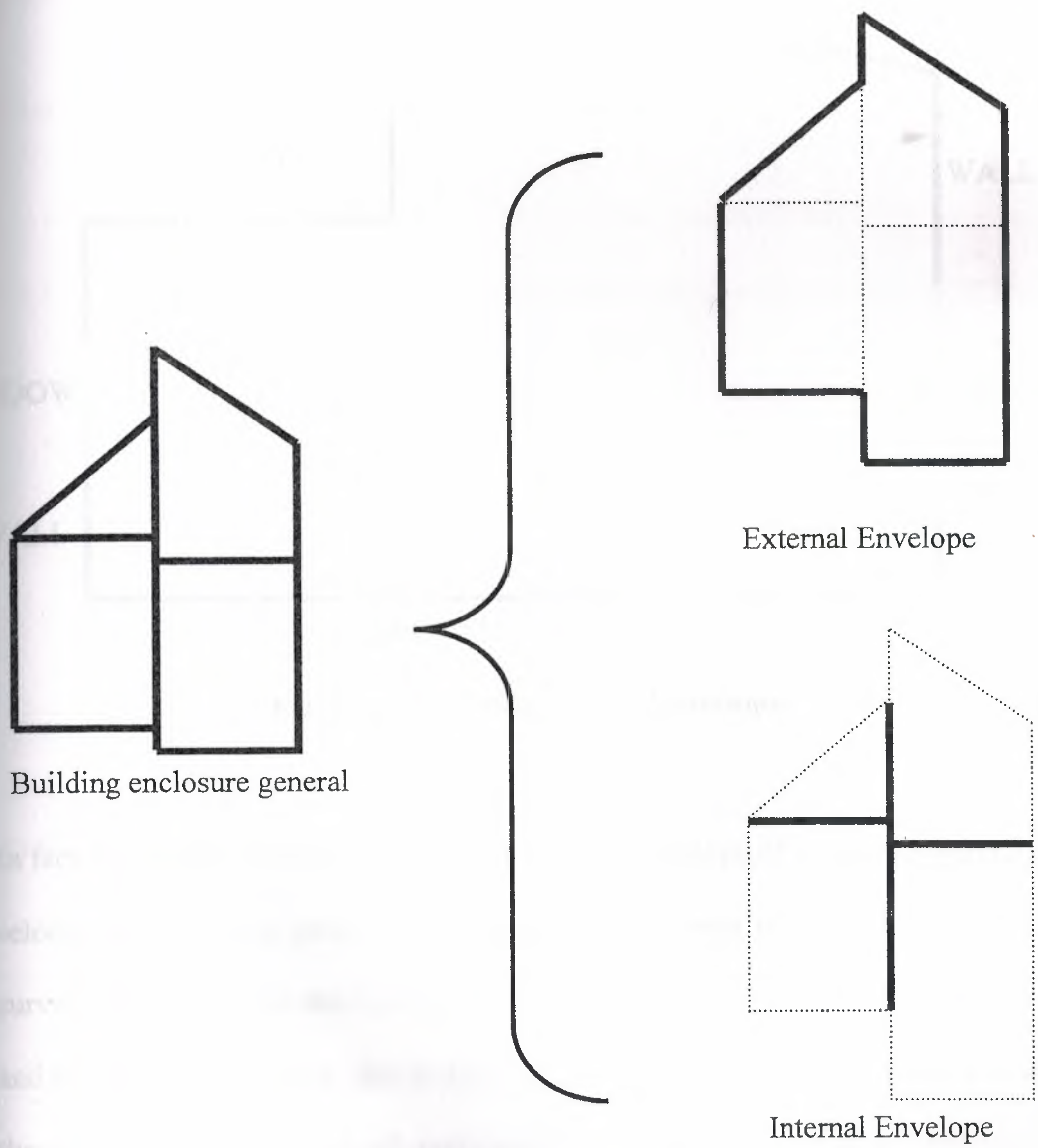


Figure 4.1. Building enclosre

The external envelope can be defined as the part(s) of the building that separate the internal spaces / rooms from the external space.

4.2.1. EXTERNAL ENVELOPE COMPONENTS

The components of the external envelope of a building can be classified as roofs, walls, Doors, windows, basement windows and ground slabs. External envelope components of a typical building are illustrated in the figure 4.2.

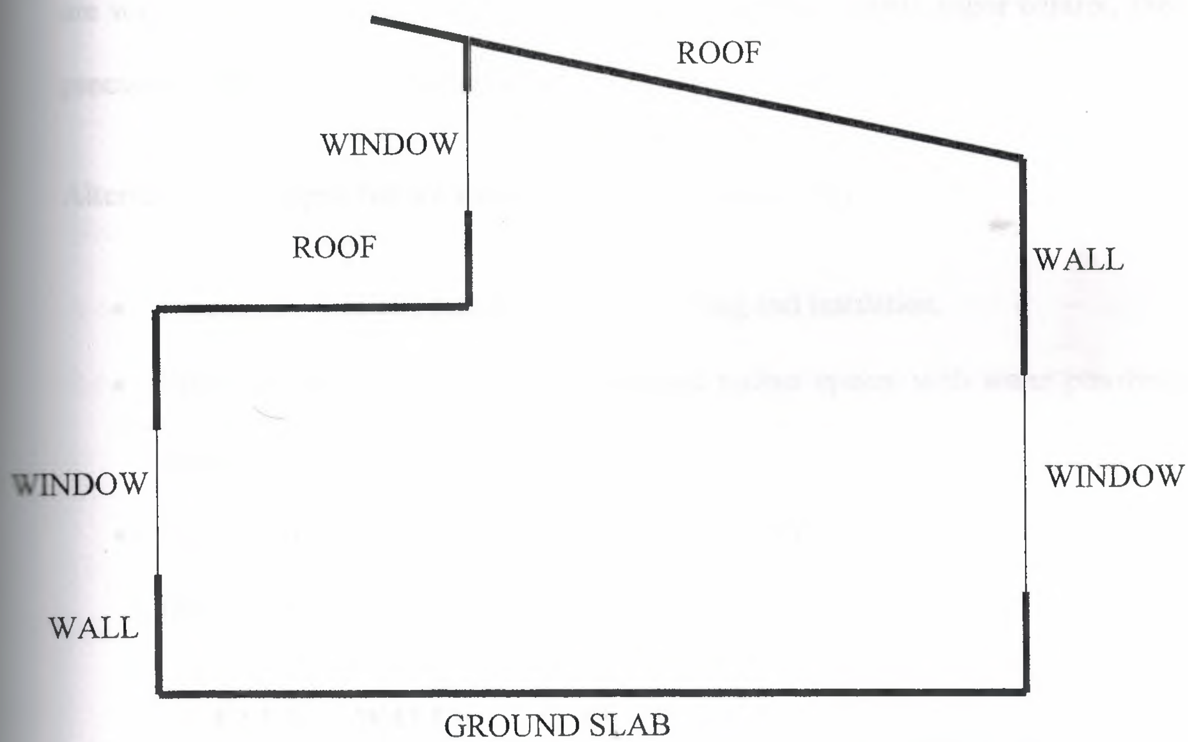


Figure 4.2. Building external envelope

In fact the criteria of each component of external envelope of residential building are selected based on the performance requirement for each one and the result of the surveys conducted with the local architects/engineers users` of them in North Cyprus and the economic abilities. But in this part of VM (Life Cycle costing) we will study the cost of those components all over their life of using.

The components of the external envelope of a building can be classified as roofs, walls, doors, windows, and basement. In the Dormitory example there is no Basement so we will not study the basement related parts here. The components to be studied and some of there alternatives are listed below:

4.2.1.1. ROOFS

The basic forms for a roof are flat, pitched and curved. The performance requirements are water/dust penetration, wind pressure/suction, thermal control, vapor control, fire precaution, durability and maintenance.

Alternative roof types that are considered in this research are;

- Fifteen cm. R.C. flat slab with water proofing and insulation.
- Fifteen cm R.C. slab and tiles on pitched timber system with water proofing and insulation
- Suspended ceiling with tiles on all timber system with water proofing and insulation.

4.2.1.2. WALLS

It's the main member of e external envelope as it forms the thickest layer to protect the internal members of the building and it works as insulation layer for the building. Alternative wall types that are considered in this research are;

- Twenty centimeter hollow local brick wall system
- Lightweight concrete block wall system
- Twenty centimeter lightweight hollow brick made of isolation materials.

4.2.1.3. PLASTERING SYSTEM

It's the layer to cover the wall members to protect them against the weather problems such as rain and heat and it can be in different types or even some buildings may have no plaster. Alternatives to be studied here are

- No plaster
- Traditional cement plaster
- Ready mixed plaster powders

4.2.1.4. PAINTING SYSTEM

When we speak about painting we speak about the outmost coat that covers the external envelope and it's not only the view of the building but its also the shield of the building against all the external affects which damages the buildings external envelope some of which are the rain, snow, hot and cold weathers, dust. etc ....

The three alternatives used here are:

1. Water based with Silicon included ASLAN paint. (QUARZSIL)
2. Water based with %100 pure acrylic included elastic JOTUN paint (JOTASHIELD TEX ULTRA)
3. Water based with sprit under coat %100 pure acrylic straight JOTUN paint (JOTASHIELD SILK + MAGNUM WHITE)

4.2.1.5. DOORS AND WINDOWS

Doors are one of the most heavily used and abused parts of a building. Because they may be subject to frequent movement and heavy wear, their construction and method of assembly must be suitably designed. The joinery sections of external doors need to be robust and sized to ensure that adequate joints can be formed. There are many locations where, rather than timber; metal or glass doors will be adequate. The performance requirements are appearance, durability, strength, weather protection, security and safety.

Windows are a component of the external envelope that performs the complex task of filtering. They have to admit air for ventilation whilst at other times excluding draughts. They admit light but may need to block direct sunlight and provide a view out whilst obstructing views in.

Alternative door types that are considered in this research are:

- All Aluminum sections and single glazing
- All Aluminum sections and double glazing
- All plastic PVC sections and single glazing
- All plastic PVC sections and double glazing
- Hardwood all timber single glazing.
- Hardwood all timber and double glazing.

4.3. APPLICATION

4.3.1. BASICS

Since the users of the construction are human being all alternatives in the external envelope should be put forward to secure healthy, easily used, and economic systems.

A good external envelope system is the one which initial and future costs (i.e. running cost, maintenance, replacement, repairing, etc.), are minimum, and performance, durability and utility are maximum. All of the above mentioned factors might be controlled by a proper application of value management and life cycle cost techniques.

In this study it is analysed by using life cycle cost techniques for n60 years, which is known to be the estimated life of buildings in practice Moreover, the average inflation of American dollar 'E' within 30 years is about 4% per annum and the interest rate of dollar 'I is accepted as %1.2 given by different bank in Turkey Publications.

Then when we calculate the interest rate to use in the future payments we have to use the inflated interest rate which is :

$$i_f = i + f + i \times f \times 100 \qquad (4.1)$$

Where: i is the interest rate = %1.2 and f is the inflation factor = %4

And here it is $i_f = 0.012+0.04+0.012\times0.04\times100 = 0.05248\times100 = \%5.248$

Note: The calculations for the existing system are done according to what has been done in dorm No.8.

4.3.2. ROOF SYSTEMS

The roof system calculation will have many details and elements some of those elements will be done only one time and others renewed continuously. The systems that which be studied are:

a. Alternative1. Fifteen cm. R.C. flat slab with water proofing and insulation.

This is the existing system and its mainly consists of 2 parts the slab of the dorm and all the elements of the staircase including the staircase tour's slap, walls, window and door, stairs and landing concrete and mosaics cover of them. In the existing system the concrete is casted and on the top of it 5cm thick foam with 32mp stress resistance. On the top of that we apply the screed concrete and the water proof on the top and as finish surface we paint it with aluminum paint to protect it from the sunlight. The same thing is applied to the staircase slab but in the calculation the slab will be including the staircase and the slab itself. By the best cost (according to the previous calculations) will be used in the walls, plaster and paint here. The last story ceiling's plaster is calculated as the other alternatives will be including that as the suspended ceiling price includes the preparation for paint.

The advantage of this system is that it can be used for fixing any satellites' receivers, water tanks, etc... and also it's easy to get to the roof and check the problems to maintain if there is any without disturbing any student in the dorm as the roof has a separate entrance.

Table4.1. Unit and total initial cost of the existing roof system components.

Component		Amount units	Unit Price $	Total Price $
Concrete (BS 20)		138 m^3	80	11040
Framework		1109m^2	8	8872
Steel (including w.ship)		14.0 tons	670	9380
Wall (including w.ship)		154 m^2 = 1540	1.7	2618
Plaster (parapet& staircase)	Materials	314	4.6	1444.5
	Workmanship	459	6	2754
Paint (parapet& staircase)		314	5	1570
Stair mosaics		17	90	1530
Heat insulation		800	5.5	4400
The ceiling plaster		826.5	5.2	4297.8
Screed (8cm thick)		800	10.3	8240
Water Proof	Membrane	826.5	6.3	5207
	Aluminum Paint	826.5	2.5	2066.3
Aluminum Door (II glass)		250	1	250
Aluminum Window (II glass)		550	1	550
TOTAL INITIAL COST				64219.4

We have two components only needs renewal and no maintenance in the roof system here which are the wall paint and waterproof aluminum paint. With %30 extra cost and 5 years renewal period for the wall paint and no extra cost and 2 years of renewal for the aluminum paint. The maintenance cost for the door and window is ignored here.

Table4.2 The interest Factors and PW payments for the renewal costs of the existing roof system components.

Year	Interest Factor	Aluminum Paint Renewal	Aluminum Paint Renewal (PW)	Parapet and staircase	Parapet and staircase pint (PW)		Future Payments
0	0.0000	2066.3	0.0	0.0	0.0	F1	0.0
2	0.9028	2066.3	1865.4	0.0	0.0	F2	2288.9
4	0.8150	2066.3	1684.0	0.0	0.0	F3	2535.4
5	0.7743	0.0	0.0	1570.0	1580.4	F4	2027.5
6	0.7357	2066.3	1520.2	0.0	0.0	F5	2808.5
8	0.6642	2066.3	1372.4	0.0	0.0	F6	3111.0
10	0.5996	2066.3	1239.0	1570.0	1223.8	F7	6064.5
12	0.5413	2066.3	1118.5	0.0	0.0	F8	3817.3
14	0.4887	2066.3	1009.7	0.0	0.0	F9	4228.5
15	0.4643	0.0	0.0	1570.0	947.6	F10	3381.5
16	0.4411	2066.3	911.5	0.0	0.0	F11	4684.0
18	0.3982	2066.3	822.9	0.0	0.0	F12	5188.5
20	0.3595	2066.3	742.9	1570.0	733.8	F13	10114.3
22	0.3246	2066.3	670.6	0.0	0.0	F14	6366.5
24	0.2930	2066.3	605.4	0.0	0.0	F15	7052.2
25	0.2784	0.0	0.0	1570.0	568.2	F16	5639.6
26	0.2645	2066.3	546.6	0.0	0.0	F17	7811.8
28	0.2388	2066.3	493.4	0.0	0.0	F18	8653.3
30	0.2156	2066.3	445.4	1570.0	440.0	F19	16868.5
32	0.1946	2066.3	402.1	0.0	0.0	F20	10617.9
34	0.1757	2066.3	363.0	0.0	0.0	F21	11761.5
35	0.1669	0.0	0.0	1570.0	340.7	F22	9405.6
36	0.1586	2066.3	327.7	0.0	0.0	F23	13028.4
38	0.1432	2066.3	295.8	0.0	0.0	F24	14431.8
40	0.1293	2066.3	267.1	1570.0	263.8	F25	28132.9
42	0.1167	2066.3	241.1	0.0	0.0	F26	17708.2
44	0.1053	2066.3	217.7	0.0	0.0	F27	19615.7
45	0.1001	0.0	0.0	1570.0	204.3	F28	15686.4
46	0.0951	2066.3	196.5	0.0	0.0	F29	21728.5
48	0.0858	2066.3	177.4	0.0	0.0	F30	24069.0
50	0.0775	2066.3	160.1	1570.0	158.2	F31	46919.4
52	0.0700	2066.3	144.6	0.0	0.0	F32	29533.4
54	0.0632	2066.3	130.5	0.0	0.0	F33	32714.6
55	0.0600	0.0	0.0	1570.0	122.5	F34	26161.4
56	0.0570	2066.3	117.8	0.0	0.0	F35	36238.4
58	0.0515	2066.3	106.4	0.0	0.0	F36	40141.8
Sum			**18195.7**		**6583.2**		

Any PW of future payment is calculated as follows:

$P\ (PW) = F \times (1/\ (1+ if)^{n})$

where :

F: is the future payment.

if : is the inflated interest rate which is equal to 1.05248 here .

n : is the number of years that the future payment to be done in.

The total PW of renewal cost for the aluminum paint = \$ 18195.7

The total PW of renewal cost for the parapet and staircase paint = \$ 6583.2

Total PW cost of the roof system = 64219.4+18195.7 + 6583.2 = \$ 88998.3

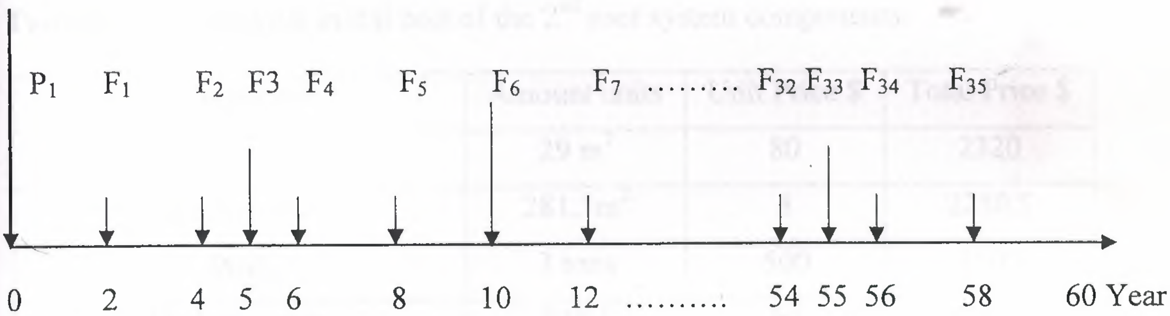


Figure 4.3: Cash flow for 1st roof system alternative.

P1 = Initial cost F1,2, 3....35 = maintenance and renewal costs

b. Suspended ceiling with tiles on all timber system with water proofing and insulation.

In this system the beams of the last story are applied only and then a pitched timber system with booth heat and water insulation in it. Then a suspended ceiling is fixed below the timber system between the beams and the finish plaster coat is applied. Both timber system and suspended ceiling life is assumed to be 60 years and maintenance cost of %2 and %5 of the initial cost respectively.

The water proof used here is a breathing type to prevent the decay of the suspended ceiling or the chipboard because of the moisture comes from the rooms. There is no slab concrete or staircase room. The only concrete to be calculated is the beams' concrete. The price for the timber system including the water proof and heat insulation is \$55 /m^2. And maintenance is %1 from the total initial cost each 5 years.

The advantages of this type of ceiling is the easy and cheap maintenance of any problems and the light weight of the suspended ceiling on the building itself but the problems are the weak fire protection and the ease of corruption due to different usage factors.

Table4.3 Unit and total initial cost of the 2nd roof system components.

Component	Amount units	Unit Price \$	Total Price \$
Concrete (BS 20)	29 m^3	80	2320
Formwork	281.3m^2	8	2250.5
Steel	3 tons	500	1500
Timber system	948.5	60	56910
Suspended ceiling	338.8	22.5	7623
TOTAL INITIAL COST			70603.5
Total renewal cost (PW)			2983.3
Total Cost (PW)			73586.8

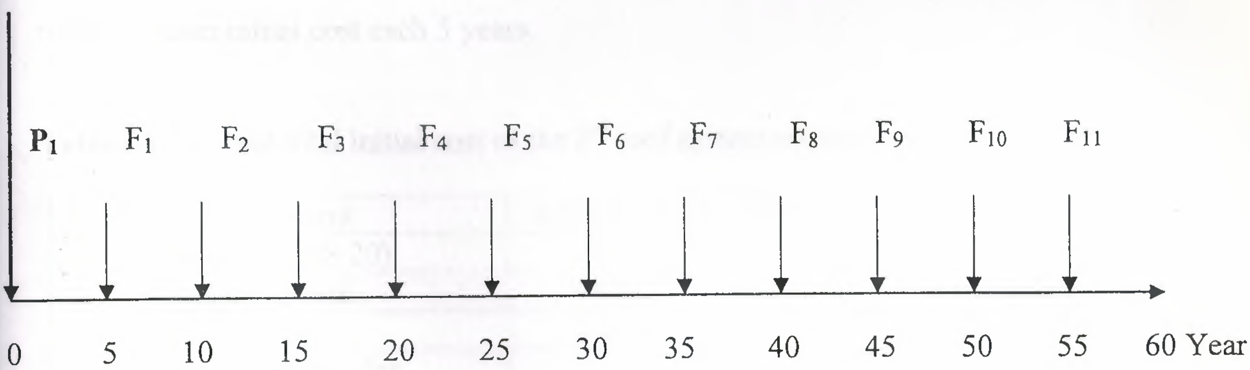


Figure 4.4. Cash flow for 2nd roof system alternative.

P1 = $ 70603.5 F1 = $911.8 F2 = $1177.5

3 = $1520.7 F4 = $1963.8 F5 = $2536.1

F6 = $ 3275.2 F7 = $ 4229.7 F8 = $ 5462.4

F9 = $7054.2 F10 = $9110.0 F11 = $11764.9

P1 = Initial cost F 1,2, 3....11 = maintenance costs

The economic analysis resulted in Total Present value cost P = $ 73586.8

Any Future cost of payment done today is calculated By:

$$F = P\times (1+ if)^{n} \qquad (4.3)$$

where :

F: is the future payment.

if : is the inflated interest rate which is equal to 1.05248 here .

n : is the number of years that the future payment to be done in.

c. Fifteen cm R.C. slab and tiles on pitched timber system with water proofing and insulation.

This system is a composite between the two other systems as it has tamper system on the top but also it has a concrete slab on the bottom. According to different experts like Mison Timber Ltd manager, the East Mediterranean University's technical services directorate office and the quantity surveying office of Korman Construction Ltd the only maintenance cost is for the timber system which about %0.5 from the timber system initial cost each 5 years.

Table4.4 Unit and total initial cost of the 3rd roof system components.

Component	Amount units	Unit Price $	Total Price $
Concrete (BS 20)	126m^3	80	7200
Framework	984m^2	8	5240
Steel	10tons	670	6700
The ceiling plaster	5.2	394	2048
Timber system	948.5	55	47425
TOTAL INITIAL COST			**78868.3**

Total renewal cost (PW) = **$1666.285**

Total Cost (PW) = **$80534.58**

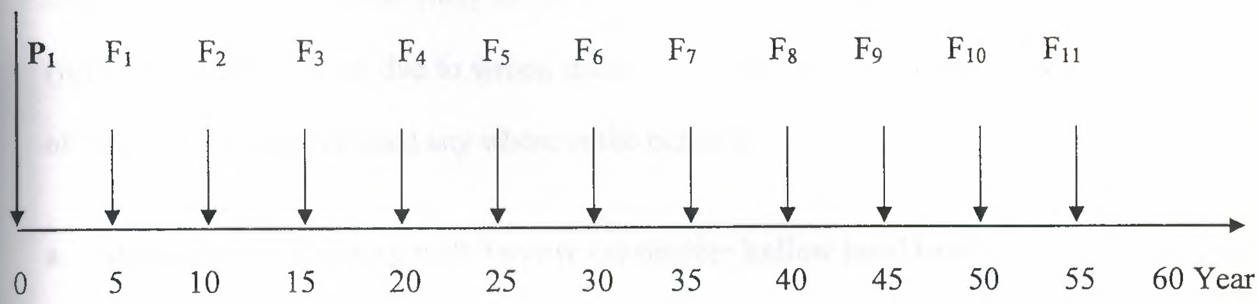


Figure 4.5. Cash flow for 2nd roof system alternative.

P1 = $ 78868.3	F1 = $509.3	F2 = $657.7
3 = $849.4	F4 = $1096.9	F5 = $1416.5
F6 = $ 1829.3	F7 = $ 2362.4	F8 = $ 3050.9
F9 = $3940.0	F10 = $5088.2	F11 = $6571.0
P1 = Initial cost	F 1,2, 3….11 = maintenance costs	

The economic analysis resulted in Total Present value cost P = $ 73586.8

Table: 4.5 The Summary of the data calculated for the roof system alternatives

Life Cycle Costing Present Worth (PW) Computation Description: Roof System	Alternative 1 15 cm. R.C. flat slab with screed & insulation			Alternative 2 Suspended ceiling with timber seystem on top			Alternative 3 15 cm. R.C. flat slab with timber seystem on top		
	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $
Initial Cost			64219.4			70603.5			78868.3
maintenance Cost (PW)			24778.9			2983.3			1666.29
Total Cost (PW)			88998.3			73586.8			80534.6
Total Cost (AE)			4898.25043			4050.039			4432.43
Total Cost Saving according to Alt1(PW)						15411.5			8463.72

Annual Equivalent payments is found by dividing the Total PW on the factor for 60 years and interest rate of 0.05248 which is 18.17

4.3.3. WALLS

In the TRNC there many different types of walls in the construction market but the most used types are he one study in the alternative here. There about %5 from each type of bricks are loosed due to wrong usage or dimension loss that some remaining of the cut bricks cant be used any where in the building.

a. Alternative 1: Existing wall Twenty centimeter hollow local brick.

The bricks used are the most used type of bricks in TRNC and in Turkey even that many alternatives started to be used within the last 10 years. The life of the walls is estimated to be 60 years which is the estimated life of the building which means we don't need to renew the walls during the building life. The repairs cost is calculated in the painting cost.

Twenty centimeter hollow local brick (10x20x30)

Total area of build wall is = 135.4+505.8+153.3 = 794.44 m^2

Number of bricks used =794.44/ (0.3x0.1) = 26481 Units

Amount of loss during the work = %5 *26481=1324 Units

Total Amount = 27805 units

Mortar Materials:

6 trucks of sand

150 bags of cement

Table 4.6 Materials, workmanship and total initial cost of the existing Wall system

Component	Amount	Unit Price $	Total price $
bricks (10x20x30)	27805	0.38	10566
Sand for mortar (truck)	6	346	2076
Cement (Bags)	150	6.2	9030
Workmanship	26481	0.27	7150
Total Initial Cost			**28822**

b. Alternative 2: Twenty centimeter lightweight hollow brick made of isolation materials (BIMS)

This type of block is newly used in TRNC but it occupied a wide range in the market in short time. The Bims are blocks with light weight, with insulation property, and good plaster sticker. According to the BLOCK BIMS publications the blocks has different shapes and thicknesses for different construction proposes its unit weight is 400-600 kg/m^3 the one which will be used is 20x20x40 (including the thickness of the mortar). The life of the walls is estimated to be 60 years which is the estimated life of the building which means we don't need to renew the walls during the building life and as it's not the out most coat of the building it has repairing costs .

Total area of build wall is = 135.4+505.8+153.3 = 794.44 m^2

Number of blocks used =794.44/ (0.2x0.4) = 9931Units

Amount of loss during the work = %5 x 8611 = 497 Units

Total Amount = 10428 units.

Table 4.7 Materials, workmanship and total initial cost of the 3rd alternative Wall system

Component	Amount	Unit Price	Total price
bricks (20x20x40)	10428	$ 1.2	$ 12514
Sand for mortar (truck)	4	$ 346	$ 1384
Cement (Bags)	120	$ 6.2	$ 744
Workmanship	9931	$ 0.5	$ 4966
Total Initial Cost			**$ 19608**

c. Alternative 3: Lightweight concrete block wall system YTONG blocks

The used blokes have a trade name which YTONG and it is blocks are made of light concrete (1/6 of the concrete and 1/3 of the normal bricks) which is full of pores which results in isolation property of those blocks beside those properties the YTONG is easy to be used and its being friend of the environment as the buildings that use YTONG will need less energy than traditional bricks. And it's available with many different sizes and shapes. The life of the walls is estimated to be 60 years which is the estimated life of the building which means we don't need to renew the walls during the building life and as it's not the out most coat of the building it has repairing costs .

YTONG blocks (20x25x60)

Total area of build wall is = 135.4+505.8+153.3 = 794.44 m^2

Number of blocks used = 794.44/ (0.25x0.6) = 5297 Units

Amount of loss during the work = %5 x5297 = 265 Units

Total Amount = 5562 units.

As the YTONG is sold in m^3 then the total volume of the amount is:

5562 x0.2x0.25x0.6 =166.86 m3

Glue material: special glue bags 1 for each 50 blocks

Table 4.8 Materials, workmanship and total initial cost of the 2nd alternative Wall system

Component	Amount (Units)	Unit Price	Total price
YTONG blocks (20x25x60)	5562	$ 3.57	$ 19856
Glue	5297 /50 = 106	$ 11	1166
Workmanship	5297	$ 0.9	$ 4767
Total Initial Cost			**$ 25789**

Table: 4.9 The Summary of the data calculated for the external wall alternatives

Life Cycle Costing Analysis Present Worth (PW) Computation Description: External Wall System	Alternative 1 bricks (10x20x30) Local bricks			Alternative 2 bricks (20x20x40) Blok BIMS			Alternative 3 (20x25x60) YTONG blocks		
	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $
bricks (10x20x30)	27805	0,38	10566						
Sand for mortar (truck)	6	346	2076						
Cement (Bags)	150	6,20	930						
Workmanship	26481	0,27	7150						
Total Initial Cost			28822						
bricks (20x20x40)				10428	1,2	12514			
Sand for mortar (truck)				4	346,0	1384			
Cement (Bags)				120	6,2	744			
Workmanship				9931	0,5	4966			
Total Initial Cost						19608			
YTONG blocks (20x25x60)							5562	3,57	19856
Glue							106	11,0	1166
Workmanship							5297	0,9	4767
Total Initial Cost									25789
Total life Cost PW		28822			19608				25789
Total life saving (Comp. To Alt.1)					9214				3033

4.3.4. PLASTERING SYSTEM

Note that

- During the measurement of the workmanship we don't discount the empty places like windows and doors from the external plastered areas.
- The corners of the columns where we need extra workmanship the corner length is paid by meter square for each meter length.

a. Alternative 1: in the existing system there is no plaster on the bricks.

b. Alternative2: Traditional 3 coats of cement based plaster.

This type of plaster is the most famous type of plaster and very hard one to protect the external walls of the building and the life of the plaster is estimated to be 60 years which is the estimated life of the building which means we don't need to renew the walls during the building life and its repairing are included in the painting repairing costs.

Table4.10 Materials, workmanship and total initial cost of the 2nd alternative of external plastering system

Component		Amount m^2	Unit Price $	Total price $
Materials	Ground floor	374.3	4.3	1609.5
	1st,2nd,and 3rd	= 366 x3 =1098	4.3	4722
	terrace wall	314	4.3	1350
Workmanship	Ground floor	608	7.0	4256
	1st,2nd,and 3rd	608x3 = 1824	7.0	12768
	terrace wall	459.5	7.0	3216.5
Total Initial Cost				**27922**

c. Alternative3: Ready mixed cement based machine plaster.

This type of plaster is the only plaster material which mixed in the industry and according to Ahmet Özerman Ltd. (ASLAN) paint and construction materials industry this material is better than the hand made traditional plaster because its easier to apply, faster because its applied by machine, and its more homogeneous as its mixed in the factory.

Table4.11 Materials, workmanship total initial cost of the 3rd alternative of external plastering system

Component		Amount m^2	Unit Price $	Total price $
Materials	Ground floor	374.3	4.6	1723
	1st,2nd,and 3rd	= 366 x3 =1098	4.6	5051
	terrace wall	314	4.6	1444.5
Workmanship	Ground floor	608	6.0	3648
	1st,2nd,and 3rd	608x3 = 1824	6.0	10944
	terrace wall	459.5	6.0	2757
Total Initial Cost				**25565**

Table: 4.12 The Summary of the data calculated for the Plaster alternatives

Present Worth (PW) Computatio Description: External Plaster System	Traditional 3 coats of cement based plaster			Ready mixed cement based machine plaster		
	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $
Total Materials	1786	4.3	7679.8	1786	4.6	8215.6
Total Workmanship	2891.5	7	20240.5	2891.5	6	17349
Total Initial Cost			**27920.3**			**25564.6**
Repairment Cost (PW)			0			0
Total Cost (PW)			27920.3			25564.6
Total Cost (AE)			1536.666			1407.014

4.3.5. PAINTING SYSTEM

There are many types of painting materials but here we will study four types which are the applied one and another 3 types in different qualities and costs. Painting measurement method is done by calculating only the places where the painting is applied.

And it's important to know that the quality and life of paint depends in many factors like the under coat of the painting materials, the materials used to plaster the walls or if it's plastered or not, weather conditions … etc.

Note: the painting workmanship is calculated exactly as material calculation from the area point of view which means there is no extra workmanship like plaster.

Total painting area:

Ground floor = 374.5m^2

1^{st}, 2^{nd}, and 3^{rd} floors = 366m^2 x 3 =1098 m^2

Roof parapet and staircase room = 314.5m^2

Total painting area = 1787 m^2

a. Alternative1 Water based with Silicon included ASLAN paint. (QUARZSIL)

A silicon based paint with grains included which can be applied to all external wall types. This paint is produced in North Cyprus. Because of the silicone additive inside it prevents rain water to be sucked into the plaster and to the wall and according to the company catalogs this paint because of the high amount of acrylics included in it , it can protect the building against rain, heat and all external bad affect. And this paint can give the building a decorative view

Before painting the walls they should be smoothen by a material called Yapser5 and Yapser10 and then painted with an undercoat called SILIKOMATLI and then 2 layers of paint from this material. And 1 liter of paint paints 1.5 to 2 m^2 of wall.

The prices of this paint is given by the Producing Company is $5.0/m^2 including workmanship.

From the expert point of view this paint is to be renewed every 5 years and %30 extra cost for taking of old paint and maintain the cracks if there any.

Table 4.13 Unit and total initial cost of the 1st alternative of external painting system.

Component	Amount m^2	Unit Price $	Total price $
Ground Floor	374.5	5	1872.5
1st, 2nd, 3rd floor	1098	5	5490
Terrace parapet	314.5	5	1572.5
Total Initial Cost	**1787**	**5**	**8935**

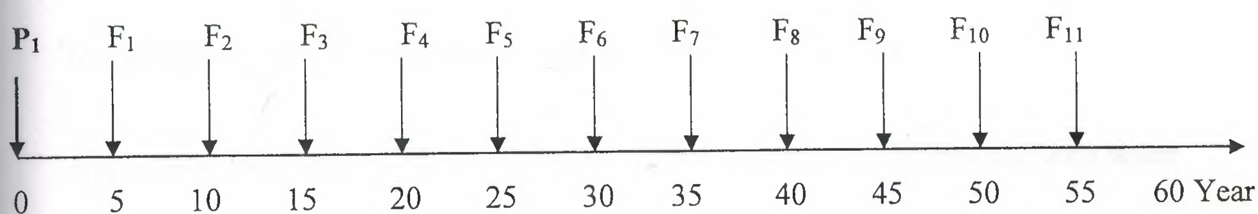


Figure 4.6. Cash flow for 1st paint alternative.

P1 = $ 8935	F1 = $15000.55	F2 = $19372.09
F3 = $ 25017.6	F4 = $32308.36	F5 = $41723.83
F6 = $53883.21	F7 = $69586.14	F8 = $ 89865.29
F9 = $116054.3	F10 = $149875.4	F11 = $193552.9

P1 = Initial cost F2, 3....12 = maintenance and renewal costs

The Total Renewal Cost = $37465.64

The economic analysis resulted in Total Present value cost P = $ 46400.64

b. Alternative2 Water based with %100 pure acrylic included elastic JOTUN paint (JOTASHIELD TEX ULTRA)

It's a water based %100 pure acrylic included paint , according to the published catalogs from JOTUN its said that this paint because of the special binding additive it can stretch and hide cracks up to 14mm and it protects the walls against all the harmful external elements specially the ones results in di-oxide carbon which prevents the concrete corrosion. Silicone don't allow the water to in or out from the paint and after a period the evaporation comes from inside the building doesn't have any exit which breaks the bond between the wall and the paint. But this paint is a breathing paint which allows the evaporated water or moisture comes from the inside to exit to the out side. It has a performance of providing the costumer with 225 colors and gives the guarantee not to have any fade for at least 6 years. And the paint is to be renewed each 10 years. %40 extra cost for taking of old paint and maintain the cracks if there any. One more advantage of this paint is the finish surface of it which looks like an orange bark texture which helps to cover the wall surface waves.

Application: the walls to be cleaned with a glass paper and to be painted with water based alkali resistance primer and then 2 layers of JOTASHIELD TEX-ULTRA .

The material cost for all the components is \$5.31/m2 and workmanship of \$3.0/m2

Table4.14 Unit and total initial cost of the 2nd alternative of external painting system.

Component	Amount m^2	Unit Price \$	Total price \$
Ground Floor	374.5	8.3	3108.35
1st, 2nd, 3rd floor	1098	8.3	9113.4
Terrace parapet	314.5	8.3	2610.35
Total Initial Cost	**1787**	**8.3**	**14832.1**

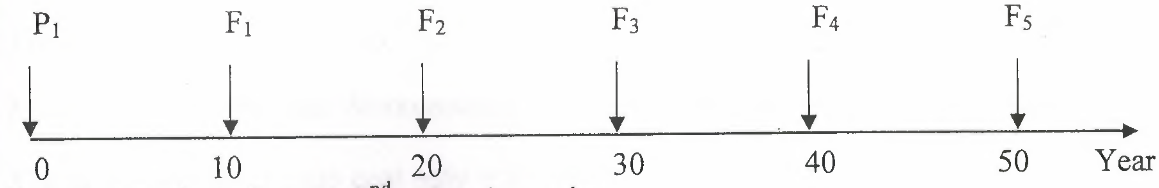


Figure 4.7. Cash flow for 2nd paint alternative.

P1 = $ 14832.1	F1 = $34631.1	F2 = $57757.02
F3 = $96325.95	F4 = $160650.4	F5 = $267929.4

P1 = Initial cost F1,2, 3….5 = maintenance and renewal costs

The total PW of renewal and maintenance cost is = $28685.6

Total Present value cost P = $28685.6+14832.1 = $ 43517.7

c. Alternative3 Water based with %100 pure acrylic included on the top of sprit coat. (JOTASHIELD SILK & MAGNUM)

This paint is consisted of two main layers and an undercoat between them the under layer is a hard material like a thin white plaster but with rough surface (MAGNUM)on the top of a water based alkali resistant primer and then water based %100 pure acrylic included top coat silk paint and with. The rough surface it cover a high percentage of the waves in the walls plaster. The MAGNUM layer if applied well it renewal period is 10 years with %40 extra cost for taking of old paint and maintain the cracks if there any and the top coat renewal is 5 years and %20 of the top coat initial cost extra cost for taking of old paint and maintain the cracks if there any.

Then we have two lines of renewal cost in the flow chart one for all the paint and another only for the top coat as follows.

The initial cost is:

Material = \$3.96 /m^2 and Workmanship = \$3.76/m^2 → total initial cost = \$ 7.72/m^2

The initial cost for the top coat only = \$3.7/m^2

Table4.15 Unit and total initial cost of the 2nd alternative of external painting system.

Component	Amount m^2	Unit Price All paint\$	Unit Price Top coat\$	Total price All paint\$	Total price Topcoat\$
Ground Floor	374.5	7.72	3.7	2891.14	1385.65
1st, 2nd, 3rd floor	1098	7.72	3.7	8476.56	4062.6
Terrace parapet	314.5	7.72	3.7	2427.94	1163.65
Total Initial Cost	**1787**	**7.72**	**3.7**	**13795.64**	**6611.9**

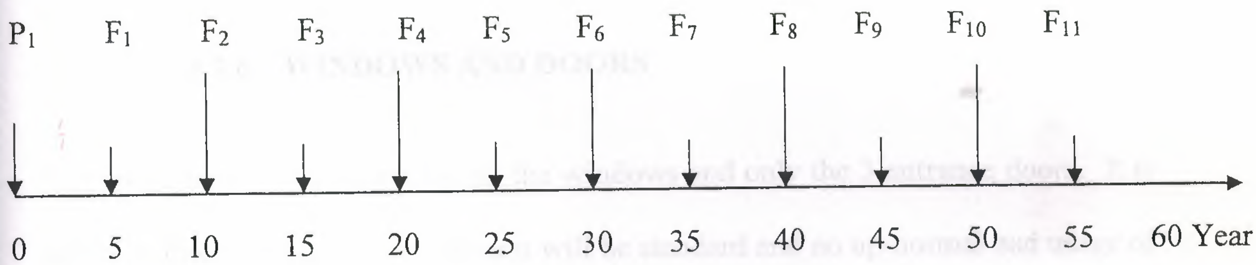


Figure 4.8. Cash flow for 3rd paint alternative.

P1 = \$ 13795.64   F1 = \$10246.53   F2 = \$32211.31

F3 = \$17088.95   F4 = \$53721.35   F5 = \$28500.59

F6 = \$ 89595.34   F7 = \$ 47532.68   F8 = \$ 149425.2

F9 = \$79274.01   F10 = \$249208.3   F11 = \$132211.5

Total Present value cost P = 47924.03+13795.64= \$ 61719.67

Table4.16 Summary of the economy analysis of the 3 painting alternatives .

Present Worth (PW) Computation Description: Painting System	(QUARZSIL).			(JOTASHIELD TEX ULTRA)			(JOTASHIELD SILK & MAGNUM)		
	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $	Amount (Unit)	Unit Price $	Tot. Price $
Initial Cost	1787	5	8935	1787	5	8935	1787	5	13795.6
Renewal Cost (PW)			40347.6			34582.7			47924
Total Cost (PW)			49282.6			43517.7			61719.7
Total Cost (AE)			2712.40			2395.11			3396.9
Total Cost Saving PW according to Alt1						5764.92			-12437

4.3.6. WINDOWS AND DOORS

The calculation is done here for all the windows and only the 3 entrance doors. It is assumed that the usage of the element will be standard and no up-normal bad usage of them like fights is taken into consideration. Each system is calculated according to 1 glassed and double glassed. The three alternatives used here are:

a. Alternative1. All Aluminum sections single and double glazing

The existing windows and doors are all are white aluminum sections with double glazing which one of the old type of windows doors systems which widely used in the TRNC for a long time. And the maintenance cost is about %1 each 5 years.

Table4.17 Unit and total initial cost of the 1st alternative of windows system

Type	Dimension	Unit	Unit Price$ Single glazing	Unit Price$ Double glazing	Total Price $ Single glazing	Total Price $ double glazing
P1	345x160	6.0	508	640.3	3047.0	3841.92
P2	300x160	61.0	442	556.8	26937.6	33964.8
P3	297.5x160	12.0	438	552.2	5255.0	6625.92
P4	295x160	15.0	434	547.5	6513.6	8212.8
P5	350x130	4.0	419	527.8	1674.4	2111.2
P5'	297.5x130	4.0	356	448.6	1423.2	1794.52
P6	345x130	8.0	413	520.3	3301.0	4162.08
TP1	350x50	4.0	161	203.0	644.0	812
TP2	347.5x50	8.0	160	201.6	1278.8	1612.4
TP3	345x50	2.0	159	200.1	317.4	400.2
TP4	300x50	1.0	138	174.0	138.0	174
k1	295x220	1.0	634	800.0	634.5	800
k5	150x220	2.0	357	450.0	713.8	900
Total Initial Cost					**51878.4**	**65411.84**

I. Single Glazing

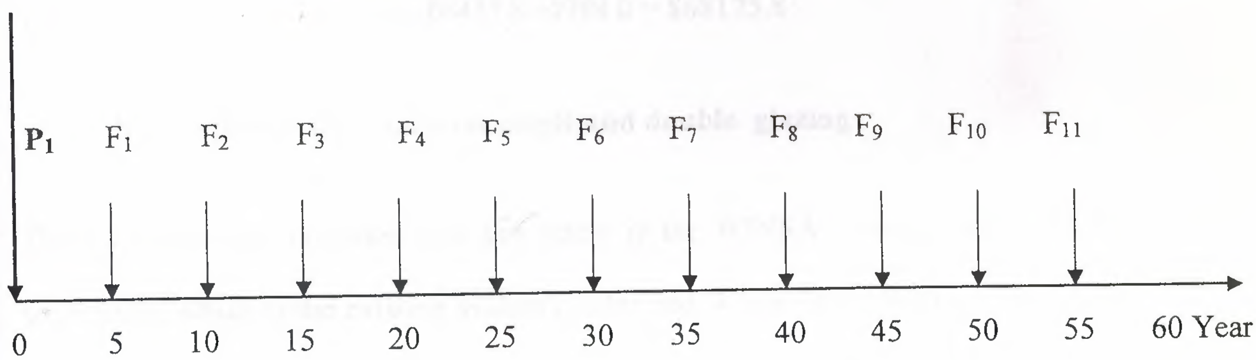


Figure 4.9. Cash flow for single glazing aluminum windows and doors.

P1 = $ 51878.4 F1 = $670.0 F2 = $865.2

F3 = $1117.4 F4 = $1443.0 F5 = $1863.5

F6 = $ 2406.6 F7 = $ 3107.9 F8 = $ 4013.7

F9 = $5183.3 F10 = $6693.9 F11 = $8644.7

Total Maintenance cost (PW) =2192.1

Total Cost (PW) = 51878.4 + 2192.1= $54070.5

II. Double glazing

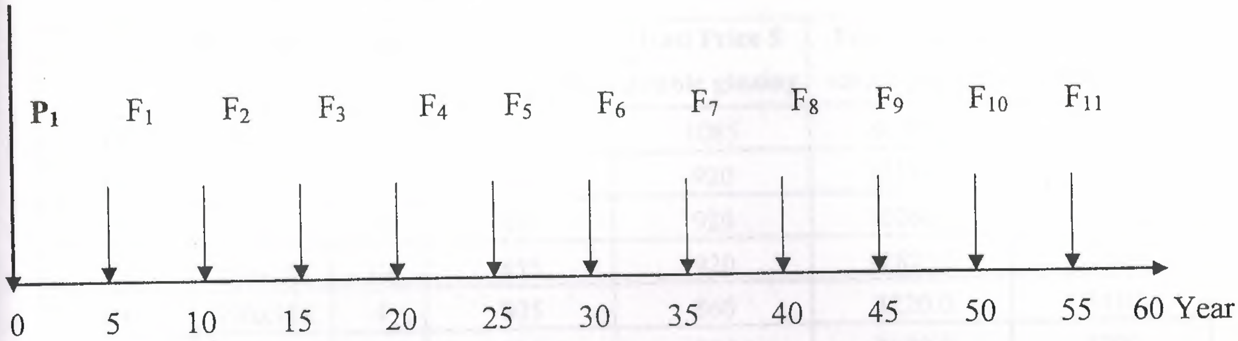


Figure 4.10. Cash flow for double glazing aluminum windows and doors.

P1 = $ 65411.8	F1 = $844.8	F2 = $1090.8
F3 = $1408.9	F4 = $1819.4	F5 = $2349.7
F6 = $ 3034.4	F7 = $ 3918.7	F8 = $ 5060.7
F9 = $6535.5	F10 = $8440.1	F11 = $10899.8

Total Maintenance cost (PW) =2764.0

Total Cost (PW) = 65411.8 +2764.0 = $68175.8

b. All plastic PVC sections single and double glazing

The PVC windows considered in this study is the WINSA products and used the white color which is the existing system's color and Winsa panorama type except the bath windows which Winsa Ultra type. The price includes the fixing and life long maintenance if any problem happened due to normal usage which is not expected according to the experts and the producer company.

Table4.18 Unit and total initial cost of the PVC single and double glazing window

Type	Dimintion cm	Unit	Unit Price $ single glazing	Unit Price $ double glazing	Total Price $ single glazing	Total Price $ double glazing
P1	345x160	6	1020	1085	6120.0	6510
P2	300x160	61	855	920	52155.0	56120
P3	297.5x160	12	855	920	10260.0	11040
P4	295x160	15	855	920	12825.0	13800
P5	350x130	4	805	860	3220.0	3440
P5'	297.5x130	4	775	825	3100.0	3300
P6	345x130	8	785	840	6280.0	6720
TP1	350x50	4	375	425	1500.0	1700
TP2	347.5x50	8	375	425	3000.0	3400
TP3	345x50	2	375	425	750.0	850
TP4	300x50	1	335	375	335.0	375
k1	295x220	1	1600	1650	1600.0	1650
k5	150x220	2	1000	1050	2000.0	2100
Total Initial Cost					**103145.0**	**111005**

The only cost is the initial cost:

Single glazing : $103145.0

Double glazing : $111005.0

c. Alternative3. Hardwood all timber single or double glazing.

The wooden windows are oldest types used in TRNC and may be all over the world and for more than 30 years the other types started to be used but now a days it's the fashion is going back to wooden doors and windows specially in the villa type houses and in the summer houses because of there aesthetics views and shapes. Even so it's well known that the standard wooden types of windows and doors are creating many problems to owners they need continuous maintenance and paint. According to different experts like Mison Timber Ltd manager, the East Mediterranean University's technical services directorate office and the quantity surveying office of Korman Construction Ltd it needs paint each 4 years and about %10 of the initial cost as maintenance costs those costs are the same for both single or double glazed. The assumed life for the windows especially in such a place like dorms is about 20 years. The paint cost is \$65 for each window and \$100 for each door.

Table4.19 Unit and total initial cost of the PVC single and double glazing window

Type	Dimintion cm	Unit	Unit Price \$ single glazing	Unit Price \$ double glazing	Total Price \$ single glazing	Total Price \$ double glazing
P1	345x160	6	783	904	4697.4	5425.2
P2	300x160	61	682	787	41577.6	48019.2
P3	297.5x160	12	676	781	8111.0	9367.68
P4	295x160	15	670	774	10053.6	11611.2
P5	350x130	4	646	746	2584.4	2984.8
P5'	297.5x130	4	549	634	2196.7	2537.08
P6	345x130	8	637	736	5095.0	5884.32
TP1	350x50	4	249	287	994.0	1148
TP2	347.5x50	8	247	285	1973.8	2279.6
TP3	345x50	2	245	283	489.9	565.8
TP4	300x50	1	213	246	213.0	246
k1	295x220	1	1050	1150	1050.0	1150
k5	150x220	2	650	710	1300.0	1420
Total Initial Cost					**80336.5**	**92638.9**

Maintenance cost: %1x 48259.5 = 4826 each 4 years.

Paint cost = 125 windows x 65 + 3 doors x 100 = \$ 8425 each 4 years.

I. Single glazing

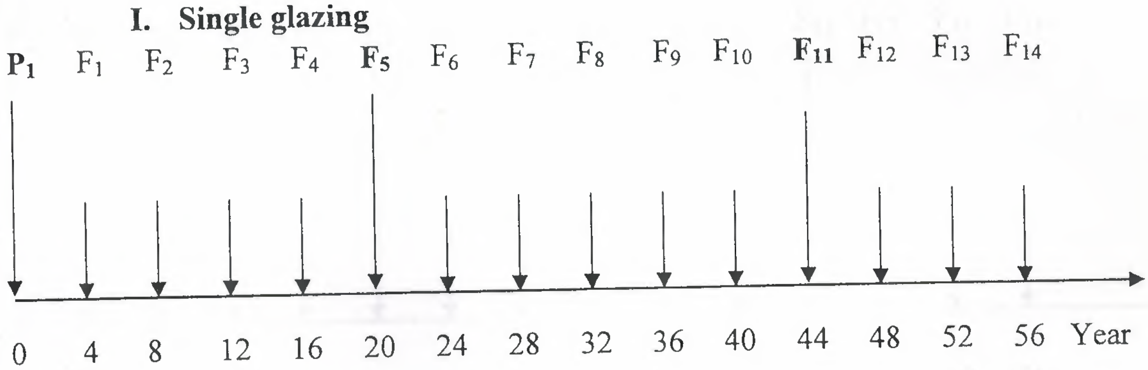


Figure 4.11. Cash flow for single glazing wooden windows and doors.

P1 = $ 80336.5 F1 = $21704.8 F2 = $26632.5

F3 = $32678.9 F4 = $40098.0 F5 = $223454.9

F6 = $60371.6 F7 = $74077.9 F8 = $90895.8

F9 = $111531.9 F10 = $621537.0 F11 = $16923.0

F12 = $206064.6 F13 = $252825.5 F14 = $310224.6

P1 = Initial cost F5, 11 renewal cost F1,2,…..14 maintenance and renewal costs

Total maintenance cost (PW) = $ 25999.7

Total renewal cost (PW) = $ 23588.0

Total paint cost (PW) = $ 39300.6

Total initial cost =$ 55736.3

II. Double glazing

Maintenance cost: %1x 55736 = 5573.6 each 4 years.

Paint cost = 125 windows x 65 + 3 doors x 100 = $ 8425 each 4 years.

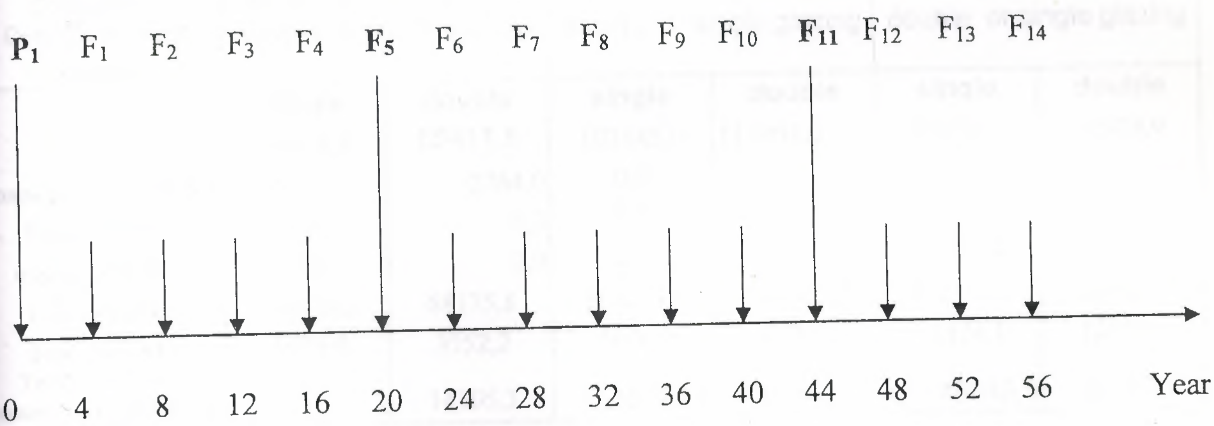


Figure 4.12 Cash flow for double glazing wooden windows and doors.

P1 = $ 92638.9 F1 = $21704.8 F2 = $26632.5

F3 = $32678.9 F4 = $40098.0 F5 = $257673.9

F6 = $60371.6 F7 = $74077.9 F8 = $90895.8

F9 = $111531.9 F10 = $716716.6 F11 = $16923.0

F12 = $206064.6 F13 = $252825.5 F14 = $310224.6

P1 = Initial cost F5, 11 renewal cost F1,2,.....14 maintenance and renewal costs

Total maintenance cost (PW) = $ 43213.9

Total renewal cost (PW) = $ 45279.5

Total paint cost (PW) = $ 39300.6

Total initial cost =$ 92638.9

Total cost PW = 220432.9

Table: 4.20 The Summary of the data calculated for the windows and doors alternatives

Life Cycle Costing	Alternative 1		Alternative 2		Alternative 3	
Present Worth (PW) Computation Description: Roof System	all aluminume section double or single glazing		All plastic PVC section double or single glazing		all timber section double or single glazing	
	single	**double**	**single**	**double**	**single**	**double**
Initial Cost	51878,4	65411,8	103145,0	111005,0	80336,5	92638,9
maintenance Cost (PW)	2192,1	2764,0	0,0	0,0	43213,9	43213,9
Paint Cost (PW)	0,0	0,0	0,0	0,0	39300,6	39300,6
renewal cost (PW)	0,0	0,0	0,0	0,0	39266,4	45279,5
Total Cost (PW)	54070,5	68175,8	103145,0	111005,0	202117,4	220432,9
Total Cost (AE)	2975,9	3752,2	5676,9	6109,4	11124,1	12132,1
Total Cost Saving according to Alt1(PW)		14105,3	49074,5	56934,5	148046,9	166362,4

4.4.DISCUSSION AND CONCLUSION

The result of each system shows that each alternative has different total cost in present worth but each alternative has its own properties. Some of the existing parts of the external envelope are better from the economic life cost point of view and some of the offered alternatives are better in the next section those differences will be studied.

A. ROOF SYSTEM

The 2nd alternative – Suspended ceiling with timber system on top- is the best choice according to the economic analysis as it saves \$15411.5 in present worth with respect to the existing system and some other benefits of this system is the ease of fixing lights and central air-condition units if needed avoiding cracking and destroying the concrete ceiling .

B. WALL SYSTEM

The best wall system is the 2nd alternative which is made of light weight insulation material and also its cheaper than the existing system and the other YTONG block system. And it saves \$9214 in present worth. And it needs no future maintenance or replacement.

C. PLASTERING SYSTEM

In fact the best from the first look is the No expenditures on plaster which is the existing system but if we look from other views we may change our minds as no plaster results in high percentage of decay in the bricks in the walls and also increases the energy consumption specially in such buildings. So if plaster is to be applied the ready mixed cement passed ASLAN plaster is a better choice as it saves $2355.7 in present worth.

D. PAINT SYSTEM

The 2nd alternative (JOTASHIELD TEX ULTRA) paint system is the best choice from all views as it saves $5764.9 in present worth and it's a breathing paint type which allows the moisture comes from the inside of the building to exit without causing any damage to the paint or the bricks .

E. WINDOW AND DOOR SYSTEM

The economic analysis shows that the single glazed aluminum sections are the best choice as it's cheaper than all other alternatives as it saves $ 14105.3 from the closest alternative to it in PW which is the double glazed aluminum sections and save $166362.4 from the most expensive alternative in PW which is the double glazed wooden sections.

Its an important point to see that the wooden sections with single or double glazing is too much expensive than all other choices even the PVC types especially in the usage cost of them which is high due to paint and maintenance costs and also its short life of usage is another important factor for that expensive life cycle cost.

- **Summary of the Results**

From all systems' alternatives we can make a composite system consists of some existing alternatives and offered ones to gain the best external envelope which can be defined as the external envelope that gives the suitable performance to the users with the best price. And in the diagram below all the results are shown in graphical way that we can understand the difference clearly.

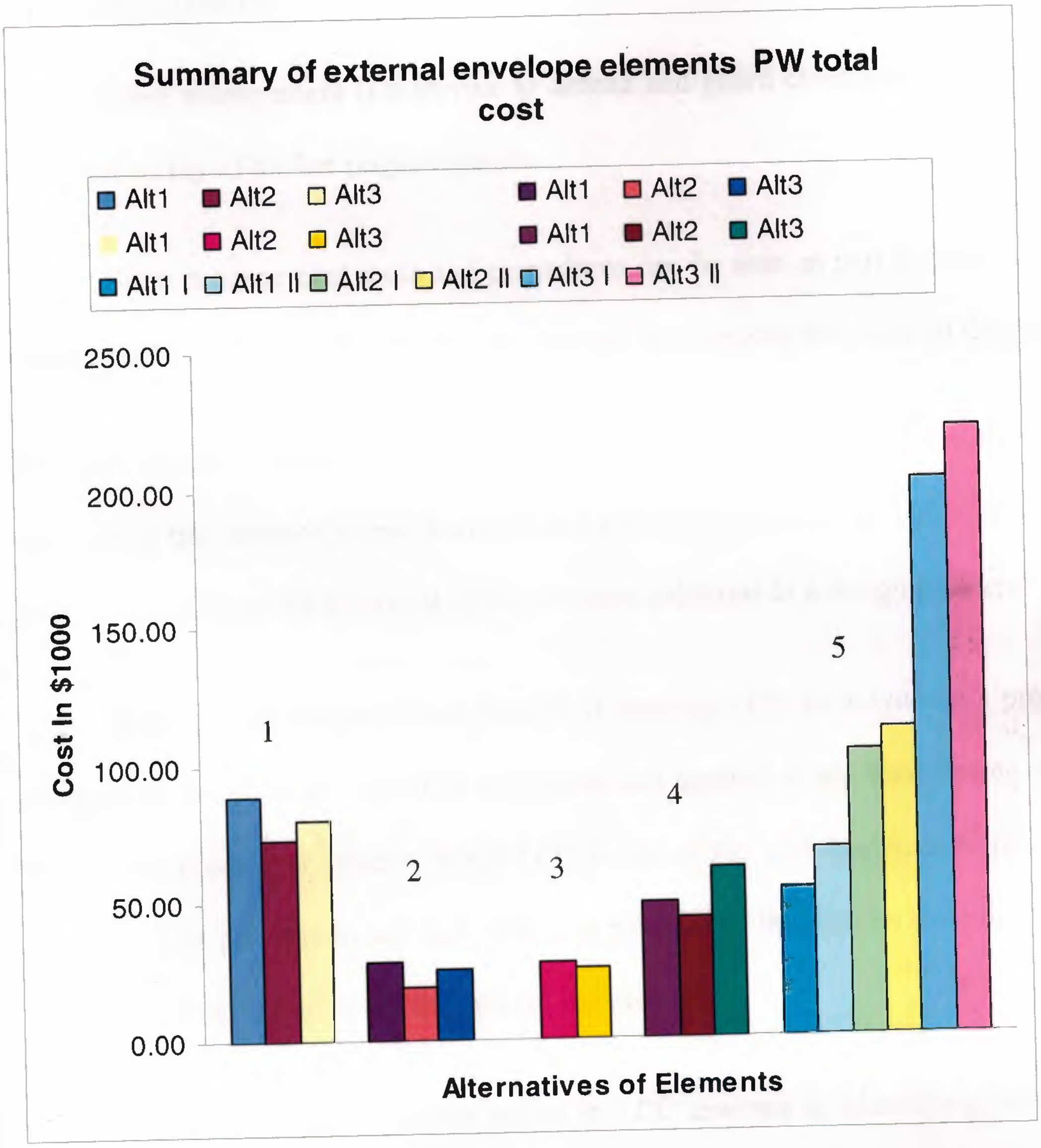


Figure 4.13 graphical summary of all the economic study of the external envelope.

1. The Roof system
2. The Wall system
3. The Plaster system
4. The Paint system
5. The windows and doors system

CHAPTER FIVE

CONCLUSION

5.1. CONCLUSION

Value management is a service to defend and guard client/end user from low value and utility of his/her project/system.

Value management tools and procedures can be seen as part of early strategic management inputs in developing the project and maximizing the value of the system.

Life cycle cost is a technique for economic evaluation which accounts for all relevant cost during the investor's time horizon, and adjusting for the time value of' money, and also to compare the total cost of two or more solutions to a design problem.

Even though the maximum benefit of exerting LCC technique on a project is obtained at design stage, it can be employed and applied at any time during the life span of the product or system. While LCC is one of the VM fundamental principles, therefore, it is possible to say that 'VM is a philosophy that can be used in a project from concept up to end of the life span of the product.

One of the most important points in LCC analysis is, identifying the feature cost.

The study of external envelope system started by first key element of VM, which is the Functional Analysis (FA). The function of each part is examined to identify the main objectives of the system (by 4 regulation of FA. 1-Verb/noun definition. 2-Function definition/technical solution. 3- Primary! secondary function. 4- Cost/worth (value)).

Under group creativity work (second key element of VM) some times the existing alternatives, resulted better solution and performance with respect to the offered systems and some time the opposite was true. The direct interview and cooperation with dorm builders, construction companies' technical managers, and expertise is a multi-disciplined Team work, which is, the third key element of VM. The required level of quality and utility at least cost, is the fundamental point to approach maximum value. The comparison of offered alternatives versus existing system gives the clue about the value/performance of the systems (Value=worth/cost), and this is the benefit of application the fourth key element (value criteria) of vm. The gathered and linking the first four elements (mentioned above) under a planned program is the fifth key element of value management (Job plan), and this is the vital root of value management. All matters above shows that the study was under the VM framework, and examined the ability of vm by applying on NEU Dormitory's external envelope.

In economy analysis it considered the; life, depreciation, maintenance period and rate, inflation, replacement, salvage value and system service. All of these factors are considered under the LCC framework.

As a result of the application of LCC on the dormitory external envelope we reach that in the roof system the 2nd alternative – Suspended ceiling with timber system on top- is the best choice according to the economic analysis as it saves $15411.5 in present worth with respect to the existing system.

And the offered walls alternatives we will have a save of about %32 of the total cost of the walls if we use the Block BIMS system, which costs $9214 in present worth less than the existing wall system. And an additional benefit of this the BIMS blocks is the insulation property which does not exist in the existing walls. And the same thing can be done for the painting system if we use the 2nd alternative which is JOTASHILELD TEX ULTRA instead of the existing system more than %10 of the paint cost is saved which is about $5764.9 in present worth and extra benefits like the good look of the texture, the ability to have breathing cover to the external walls, and the ability to cover up to 14mm cracks in the wall.

If we look at the plaster systems we find the existing choice which is no plaster applied is the cheapest but if we try to compare the other alternatives we will find that the ready mixed plaster (ASLAN MIX) is $2355.7 in present worth and extra benefits like extra insulation and fast application.

Another important part of the external envelope is the windows systems. Its clear that the existing system – double glazed aluminum sections- is the closest alternative to the best alternative which is the single glazed aluminum sections and it's a good choice with respect to the remaining alternatives but the first alternative saves $14105.3 from double glazed aluminum sections and save $166362.4 from duble glazed wooden sections.

The results of Lcc application shows that, if we can save such amount of money, and gain value just small parts of the system, there exist many waste and necessaries costs which results in lowering the value of the rest of the housing project.

The total save of the offered alternatives with respect to the excising systems is $44495.7 disclosing the energy conservation and heat transfer saves.

It is not necessary to increase or gain value by cost reduction or elimination of necessaries cost, but, the utility and worth increment can also increase value (e.g. a close cost of two different systems may increase utility or worth) like the single and double glazed windows system providing less energy consumption may give better results.

Value management is the science of selection and appointment (person or material).

The price of houses on offer, includes the 'initial cost' plus 'profit' (without informing the customer about; life, performance, repair, replacement, running cost, etc) and this is the value that convince and deceive the customer. This is because of customer careless and ignorance, beside the seller's abuse and misuse of the customer.

At the end, the author believes that; VM is a necessity for a project, not a luxury.

1. REFERENCES

1. Halil Şevket NEAP 1999 "Integration of Expert System With Value Managment In construction for selection of External envelope of residential building in Cyprus" East Mediterranean University North Cyprus
2. Mc. Craly "Life Cycle Costing" 1st edition Oct. 1985 UK.
3. AJORLO , Gholam Ali "Life Cycle Costing for Housing Project" Master Thesis 1995 East Mediterranean University North Cyprus
4. Allan Ashworth " Cost Studies of Buildings " 3rd edition, 1999 Longman.
5. Miami University , Building construction Standards "Life Cycle Cost Analysis" 1st Edition 2004
6. Rpger Flangman , George Norman, J. David Furbur, "Life Cycle Costing for Construction" C1981-3, UK.
7. Leland T.Blank , Anthony J. Tarquim " Engineering Economy" 4th Edition. 1995
8. Ralph Morton & David Jaggar " 1st edition Design and Economics of Buildings" 1995 Clays Ltd. St Ives Pls UK.
9. H. Paul Barringer , " Alife Cycle Costing Summery" P.E. Barringer & associates Inc. Humble 1995 Texas USA
10. George sockariah & Osama Alkayyali " Value Management and Constructability studies with microcomputers " P207-219 S.D Green. Volume 3. UK.
11. Jhon Kelly and steven Male , Value managment in design and construction (The Economic Managment of projects) E&FN spon, 1993 UK.
12. Abdulrezak Mohamed, Tahir Celik: Knowledge based-system for alternative design, cost estimating and scheduling. Knowl.-Based Syst. 15(3): 177-188 (2002)

13. Halil Shevket Neap, Tahir Celik: A knowledge-based system for determination of marginal value of building projects. Expert Syst. Appl. 21(3): 119-129 (2001)

14. Del Isola A.J., Kirk Stephen J.K "Life Cycle Costing for design professional" Mc Graw-hill book comp 1997 USA.

15. Alaska Department of education and early development "Life cycle cost and analaysis hand book" 1st edition 1999.

16. R. L. Miller and David Vanhoose Modern Money and Banking , 2004 3rd Edition

APPENDICES

APPEDIX A : QUESTIONNAIRE FOR THE SURVEYS WITH DESIGNERS/ ENGINEERS/ EXPERTS

QUESTIONNAIRE FORM

Name

Profession;

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1. Professional experience in residential buildings
    a. 1 year
    b. 3 years
    c. 5 years
    d. 10 years and over

2. Types of experience:
    a. Design (office works)
    b. Construction
    c. Supervision / Controlling

3. Could you please specify more than three design alternatives that you use or recommend in practice for each of the following components of external envelope of residential buildings.

a) ROOFS

a.
b.
c.
d.
e.
f.

b) WALLS

a.
b.
c.
d.
e.
f.

c) DOORS

a.
b.
c.
d.
e.
f.

d) Windows

a.

b.

c.

d.

e.

f.

e) Ground Cover

a.

b.

c.

d.

e.

f.

4. In selecting a design alternative for the external envelope which of the following way(s) do you usually take?

a) Decide by yourself

b) Select by yourself and ask to the client for comment/approval

c) Select more than one alternative and refer to the client

d) Discuss first with the client and select one that is most favored to the client

e) Let client to select and decide on the alternative

f) (Any other way)

5. How do you classify the respond of clients for the construction of external envelope of residential building?

a) Satisfied with the selections

b) Complaints during construction and usually change the selected details

c) Dissatisfied with selections

d) (Any other respond)

6. How can clients get a good value for invested money for external envelope of residential building?

a) By letting designers to decide on the selection of design alternatives

b) By knowing and realizing the performance of design alternatives before selecting design alternatives

c) By close consultation with the designers/engineers for the selection of design alternatives

d) (Any other way)

7. Do you consider clients capable of analyzing design alternatives proposed by designer/engineer?

a) Capable

b) Having little knowledge and experience for analyzing

c) Not capable

d) (Any other comment)

APPEDIX B : QUESTIONNAIRE FOR THE SURVEYS WITH DESIGNERS/ ENGINEERS/ EXPERTS FOR THE GROUND COVER

QUESTIONNAIRE FORM

Name:

Profession:

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1. The criteria given below are for each alternative of the ground cover of residential buildings. Please give importance weights of the criteria (in other words, how important is the criteria for importance of the criteria for the ground cover), out of 100.

Criteria of ground cover	Importance weight Out of 100
Image ad Aesthetics	
Color Rendition	
Floor heating	
Obsolescence Avoidance	
Operational Effectiveness	
Durability	
Future Extendibility	

2. Considering that, each design alternative can have different degree of utility (Performance)against different criteria, could you please assign, out of 100, utilities for the following external envelope alternatives against criteria. Criteria of ground cover

❖ Utility rating out of 100

Carpet on screed	
Criteria of ground cover	Importance weight Out of 100
Image ad Aesthetics	
Color Rendition	
Floor heating	
Obsolescence Avoidance	
Operational Effectiveness	
Durability	
Future Extendibility	

❖ Utility rating out of 100

Laminant parquet on screed	
Criteria of ground cover	Importance weight Out of 100
Image ad Aesthetics	
Color Rendition	
Floor heating	
Obsolescence Avoidance	
Operational Effectiveness	
Durability	
Future Extendibility	

❖ Utility rating out of 100

Ceramics on screed	
Criteria of ground cover	Importance weight Out of 100
Image ad Aesthetics	
Color Rendition	
Floor heating	
Obsolescence Avoidance	
Operational Effectiveness	
Durability	
Future Extendibility	

❖ Utility rating out of 100

Mosaics on Mortar	
Criteria of ground cover	Importance weight Out of 100
Image ad Aesthetics	
Color Rendition	
Floor heating	
Obsolescence Avoidance	
Operational Effectiveness	
Durability	
Future Extendibility	

APPEDIX C : QUESTIONNAIRE FOR THE SURVEYS WITH MANAGERS / EXPERTS FOR THE PRICES

QUESTIONNAIRE FORM

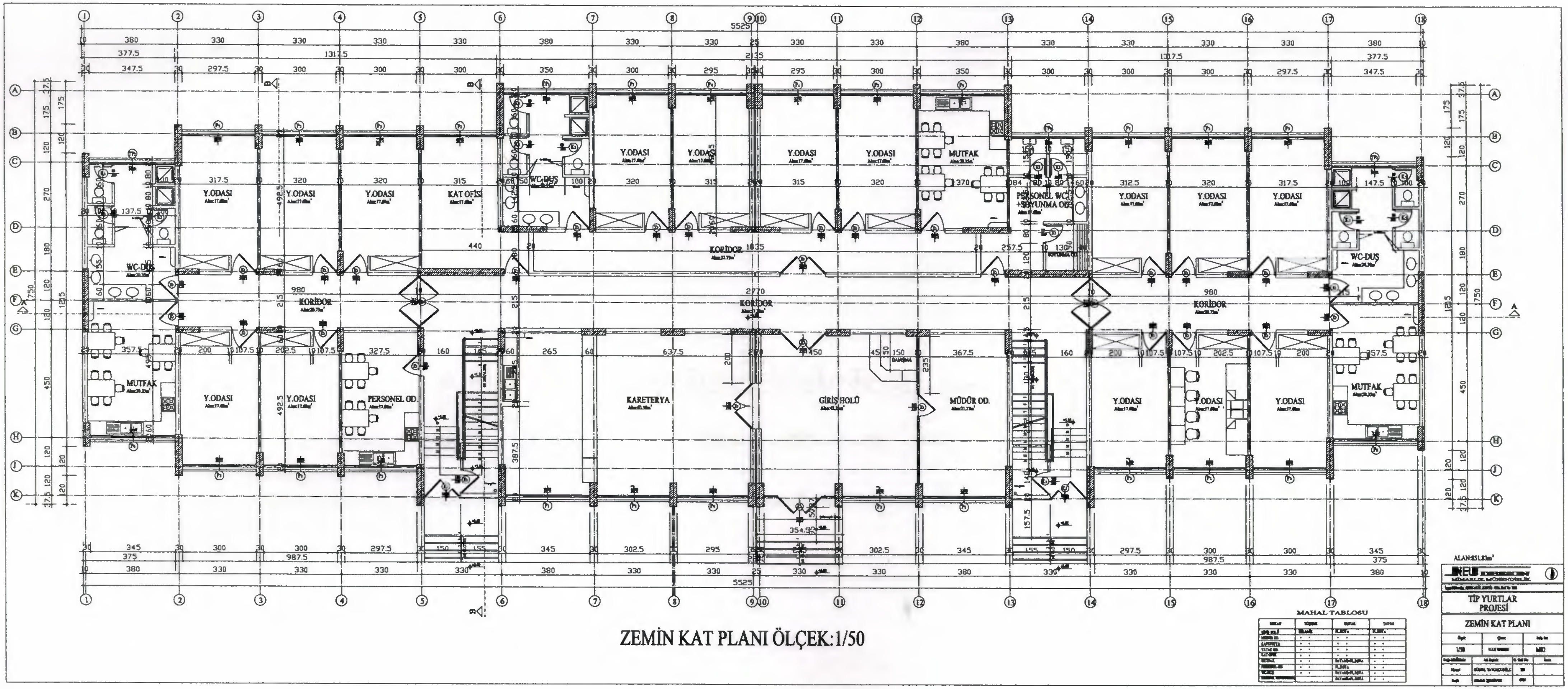
Name:

Profession:

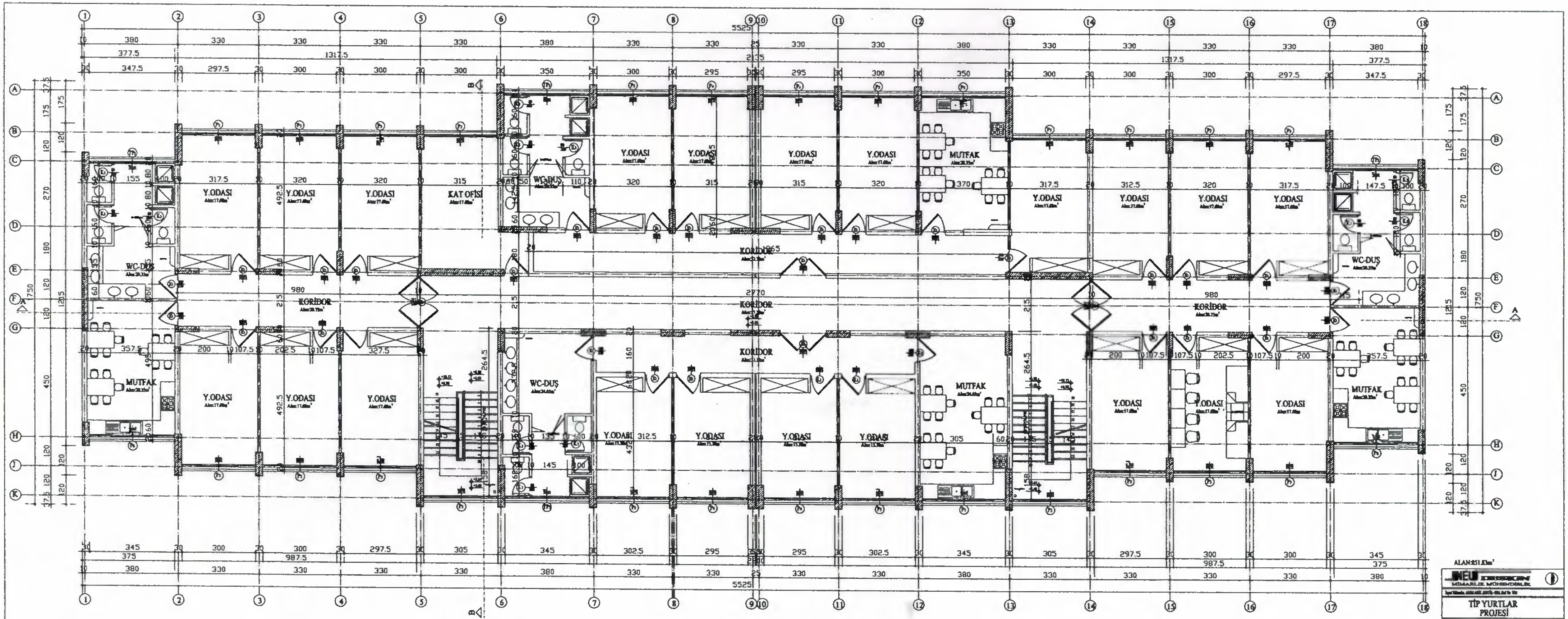
Design alternative	Material cost	Workmanship
	$ per square meter	
ROOFS		
a. concrete (BS20)		
b. steel		
c. framework		
d. heat insulation		
e. Screed		
f. Water proof (membrane)		
g. Aluminum paint for the water proof		
h. Suspended ceiling		
i. Timber system		

Design alternative	Material cost	Workmanship
WALLS		
a. 20cm local clay bricks		
b. 20cm BIMS blocks		
c. 20cm YTONG blocks		
d. 50 kg cement bags		
e. 25 kg glue bags		
f. Sand in truck		
DOORS		
a. Aluminum section single glazing		
b. Aluminum section double glazing		
c. PVC section single glazing		
d. PVC section double glazing		
e. Timber section single glazing		
f. Timber section double glazing		
WINDOWS		
a. Aluminum section single glazing		
b. Aluminum section double glazing		
c. PVC section single glazing		
d. PVC section double glazing		
e. Timber section single glazing		
f. Timber section double glazing		

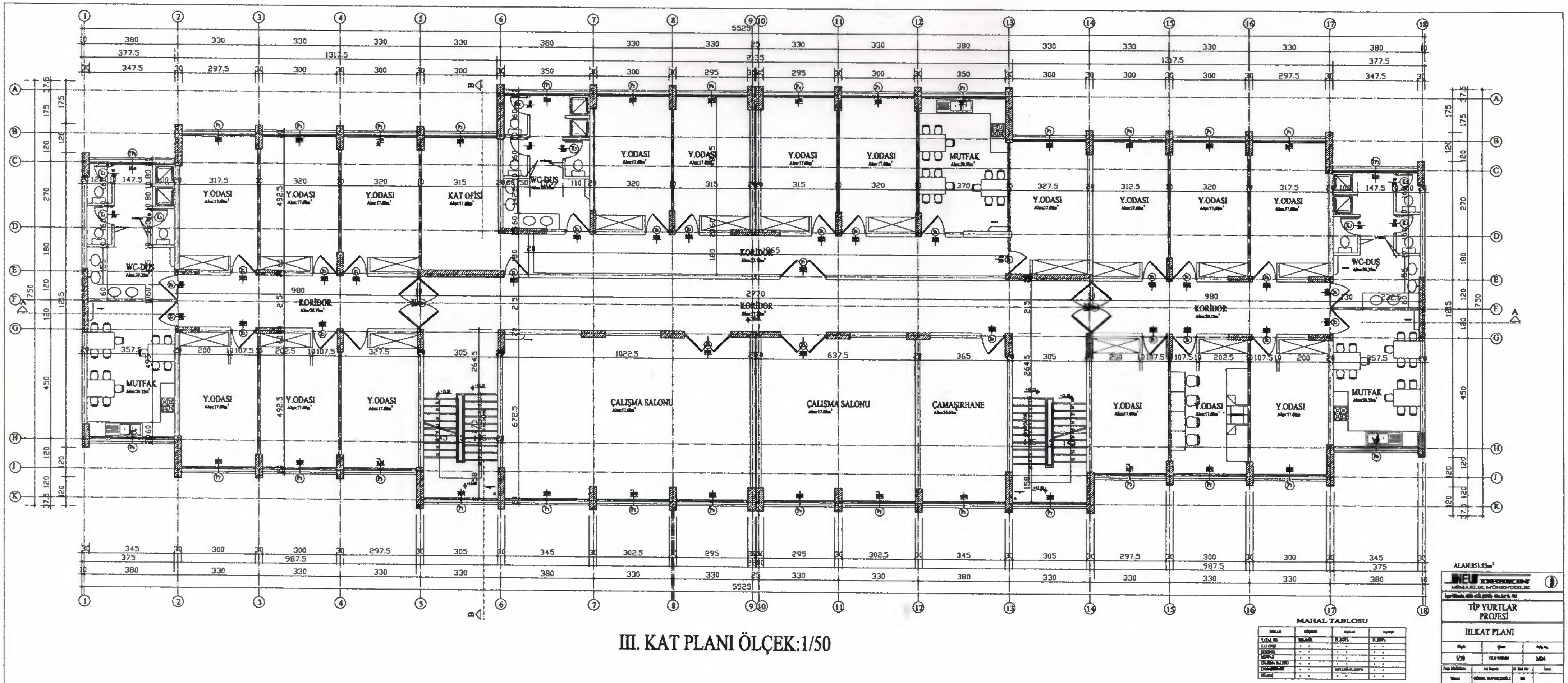
PLASTER a. Cement in 50kg bags b. Fine aggregates in truck c. Sand (sari kum) in truck d. Ready mixed cement based plaster (ASLAN Siva Mix)		



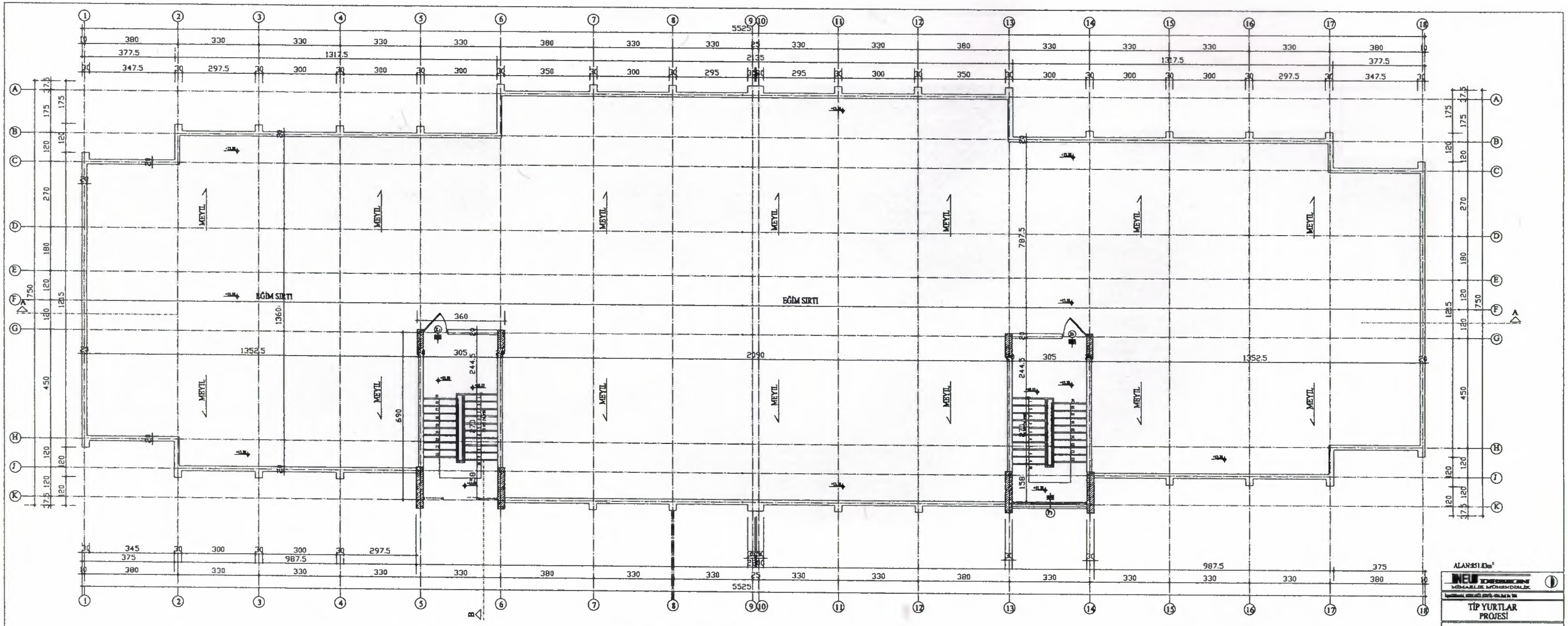
ZEMİN KAT PLANI ÖLÇEK:1/50



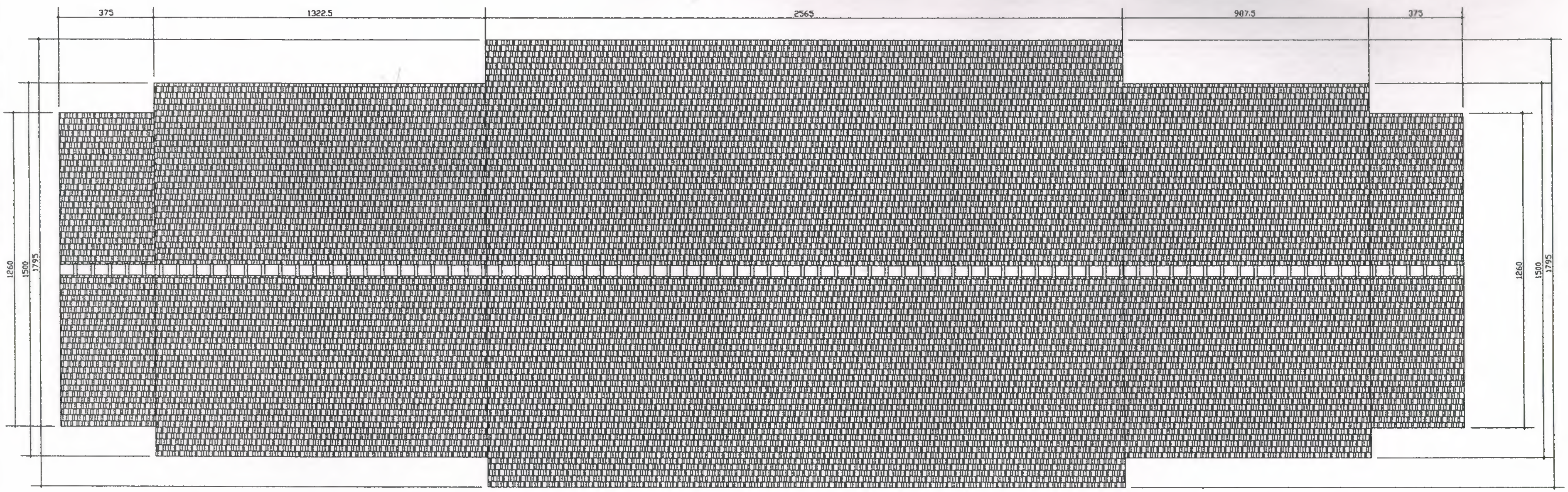
TİP KAT PLANI ÖLÇEK:1/50



III. KAT PLANI ÖLÇEK:1/50



ÇATI PLANI ÖLÇEK:1/50



KİREMİT ÇATI PLANI ÖLÇEK:1/50

ALAN:851.83m²

TİP YURTLAR PROJESİ

ÇATI PLANI

1/50		M85