OPTIMUM UTILIZATION OF RESOURCES IN CONSTRUCTION INDUSTRY

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1. ABSTRACT

Some degree of waste of material, manpower and equipment is inevitable in the construction process. All estimators allow wastage factor in pricing a bill of quantities. As modern market is facing cut-throat competition in competitive bidding and if the cost of wastage can be curtailed then desirable margin of profit can be achieved.

The aspect is not the whole story though, designer also need to appreciate that they too contribute to construction waste. In this case, the waste is avoidable through design and detailing knowing how much waste can arise. Quality assurance is increasingly wanted or specified by the client and design or manpower waste due to poor project management can be a contributor to the failure of quality.

Construction waste can be divided into five categories:-

- Design waste
- Taking off
- Ordering waste
- Supply waste
- Contract waste

Keeping wastage of the materials, manpower and equipments within the prescribed limit is of paramount importance for achieving the planned profitability level and it gives an insight of the productivity of the construction industry. Study also highlights the failure of QUALITY due to waste in the construction process and therefore, it is desired to quantify wastage and analyze its effect with a view to promote economy in construction.

Keywords- construction Waste management, construction resources, optimum utilization

2. INTRODUCTION

The development of physical infrastructure in the country and, consequently, the construction sector has been in focus during the last decade. The increasing significance of construction activities in the growth of the economy was also evident during the course of implementation of the Twelfth Plan with areas such as transportation, irrigation, housing, urban development, and civil aviation having received greater importance. It is well established that the influence of the construction industry spans across several sub-sectors of the economy as well as the infrastructure development, such as industrial and mining infrastructure, highways, roads, ports, railways, airports, power systems, irrigation and agriculture systems, telecommunication systems, hospitals, schools, townships, offices, houses and other buildings; urban infrastructure, including water supply, sewerage, and drainage, and rural infrastructure. Thus, it becomes the basic input for socio-economic development.

The contribution of construction to the GDP in India increased to 2601.70 INR Billion in the fourth quarter of 2019 from 2448.63 INR Billion in the third quarter of 2019. The increase in the share of construction sector in GDP has primarily been on the account of increased government spending on physical infrastructure in the last few years, with programmes such as National Highway Development Programme (NHDP) and many more. The construction industry is experiencing a great upsurge in the quantum of the work load, and has grown at the rate of over 10% annually during the last five years. Although various steps have been taken to strengthen the construction industry, it is crucial to take necessary measures in order to prepare the industry to meet the challenges of growth.

The importance of construction activity in infrastructure, housing, and other asset-building activities can be seen from the fact that the component of construction comprises nearly 60%–80% of the project cost of certain infrastructure projects such as roads, housing, etc. In projects such as power plants, industrial plants, etc., though the share is lower but it still remains critical. In terms of magnitude, construction activity is second only to agriculture. The construction industry also has major linkages with the building material manufacturing industry including cement and steel, bricks and tiles, sand and aggregates, fixtures and fittings, paints and chemicals, construction equipment, petrol and other petro-products, timber, mineral products, aluminium, glass, and plastics. Construction materials account for nearly two-third of the average construction costs. On the basis of an analysis of the forward and backward linkages of construction, the multiplier effect for construction on the economy is estimated to be significant.

3. CONSTRUCTION IN INDIAN SCENARIO

The Indian construction market is expected to register a CAGR of 6% over the forecast period, 2019 – 2024. Infrastructure sector plays and vital role in the growth and development of the Indian economy. Nearly, 9% of India's GDP is spent on Infrastructure services. It comprises of construction of power, bridges, dams, roads and urban infrastructure development which also forms the base and supporting factor for other services sectors.

Indian companies, both public and private sectors, announced projects worth 1.99 trillion in the quarter ending March 2019, 16% lower than what was announced in the quarter ending December 2018, and 46% lower than the year-ago period.

4. CAUSES OF RESOURCE WASTAGES

Major construction wastes are cause of fault in planning and execution the construction wastes are broadly classified in various categories which are discussed in following topics.

4.1 Construction Waste

Construction waste can be divided into three major categories: **material, labor, and machinery waste.** However, material wastage is of more concern because most of the raw materials from which construction inputs are derived come from non-renewable resources. Although "waste" is a familiar term in the industry world-wide, it is difficult to compare construction waste figures from different construction sites due to a number of reasons, including the use of varying definitions; and the use of different estimation approaches, by different groups.

Studies at the Building Research Establishment (BRE) in the 1970s established that waste levels were not necessarily related to the type of construction or the building company but to the site and the people engaged in the particular project.

4.1.1 Causes Of Construction Waste Generation

Many factors contribute to construction waste generation at site. Waste may occur due to one or a combination of many causes. Gavilan and Bernold15 organized the sources of construction waste under six categories: (1) design; (2) procurement; (3) handling of materials; (4) operation; (5) residual related; and (6) others. In this research, the factors which cause waste on site were identified after a review of the literature, and placed in four major sources as shown in Table 4.1: (1) design, (2) operational, (3) material handling and, (4)Procurement, mainly for the practical purpose of the survey.

Table 4.1: Sources and Causes of Construction Waste

Design	Operational	Material handling	Procurement
* Lack of attention paid to dimensional coordination of products * Changes made to the design while construction is in progress * Designer's inexperience in method and sequence	*Errors by tradespersons or laborers *Accidents due to negligence *Damage to work done caused by subsequent trades	*Damages during transportation *Inappropriate storage leading to damage or deterioration *Materials supplied in loose form *Use of whatever	*Ordering errors (eg., ordering significantly more or less) *Lack of possibilities to order small quantities *Purchased products that do not comply

of construction * Lack of attention paid to standard sizes available on the market *Designer's unfamiliarity with alternative products * Complexity of detailing in the drawings * Lack of information in the drawings * Errors in contract documents * Incomplete contract documents at commencement of project	*Use of incorrect material, thus requiring replacement *Required quantity uncl ear due to improper planning *Delays in passing of information to the contractor on types and sizes of products to be used *Equipment malfunctioning *Inclement weather	material which are close to working place *Unfriendly attitudes of project team and laborers *Theft	with specification

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The Best Way To Manage Waste Is To Avoid It In The First Place. The Study Revealed That A Substantial Amount Of Building Construction Waste On Site Is Directly Related To Design Errors Or Related Problems On Which The Site Personnel Have Very Little Or No Influence. Design Changes While Construction In Progress, Designer's Inexperience Or Lack Of Data To Evaluate Methods and the sequence of construction at the design stage were ranked as the most significant factors leading to site waste. However, lack of attention paid to modular coordination and lack of knowledge about standard sizes of products on the market were also reported as the next most significant contributors to site waste which are related to the design process. This underlines the urgent need for effective communication and flexible information sharing systems throughout the construction process.

Damages due to subsequent works, errors by tradespersons and improper planning were identified by the responding contractors as the most significant operational contributors to waste generation while inappropriate storage facilities at site and loose forms of material supply to the site were identified as the most significant handling issues.

4.2 Causes Of Labor Wastage

Shortage of labours

Shortage of labor force in construction sector causes great deal of wastage as due to unavailability of one kind of labor the depended labor tasks gets delayed E.g. if the proper number of helpers are not available the task of mason is delayed .

Unqualified work force

Labor having insufficient know how of the task generates time and material wastage with the low grade quality. Usually contractors are employing labors having low rate without inquiring the efficiency.

Low productivity levels

Labors having various variable factors like physical ability, age, gender etc. may gives variable results and outputs labor giving maximum productivity should be employed in order to optimize the productivity

Recess time

It is observed that labor productivity graph follows a cup shape trajectory or gets a dip around the break time this time should be checked with strict time follow ups and supervision.

Overtime

Any labor has fixed efficiency beyond that efficiency labors give lesser productivity and compromised quality at higher rates. So sufficient rest and time should be given to labors and over time should be avoided.

Personal conflicts

Conflicts between labour and supervisor or internal labour conflicts due to various reasons like payment problems, sanitation or housing problems etc. may generates decrease in output.

Provision of improper/ insufficient tools

Proper tools in adequate numbers should be allotted to obtain proper output and significant material wastage can be avoided as proper equipments gives better speed and reduce material wastage.

4.3 Causes Of Material Wastage

Material waste has been recognized as a major problem in the construction industry that has important implications both for the efficiency industry and for the environmental impact of construction projects. Moreover, waste measurement plays an important role in the management of production systems since it is an effective way to assess their performance, allowing areas of potential improvement to be pointed out.

- Changes in design after work has started
- Lack of liaison
- Use of unsuitable plants, equipments and tools
- Bad layout and working method
- Unnecessary movements
- Bad sequencing
- Delay in providing working drawings
- Unsuitable work packages

CEMENT	SAND	STEEL	BRICKS	SHUTTERING
- Excess mortar/ Concrete preparation -Left over material -Loss in transport and during application -Contractor's negligence -Overstocking -High buffer stock	-Excess mortar/ Concrete preparation -Left over material -Silt content -Transport condition	-Improper cutting of steel -Non utilization of cut pieces -Theft -Design changes -Improper storage -High buffer stock	-Poor quality -Improper handling -Losses in transport and application -Use of semi-skilled masons for carrying out brickwork	-Improper placing and removing -Handling the shuttering very roughly without proper care -Stocking the shuttering in the open and exposing it to different weather conditions -Non utilization of cut pieces

4.4 Causes Of Equipment Wastage

Equipments breakdown

This happens due to irregular maintenance of equipments. Thus many equipment experiences time to time breakdown which not only inflicts the time duration but also increases time to time procurement of spare parts.

Shortage of equipments

This happens due to improper planning due to which right numbers of require machinery are not procured hence the same machinery is utilised 24/7 gradually causing breakdowns.

Low level of equipment technology

Low level equipment not only gets inefficient but requires more maintenance and more numbers to do a piece of job. The introduction of new mechanized equipment in construction has had a profound effect on the cost and productivity of construction as well as the methods used for construction itself. An exciting example of innovation in this regard is the introduction of computer microprocessors on tools and equipment. As a result, the performance and activity of equipment can be continually monitored and adjusted for improvement. In many cases, automation of at least part of the construction process is possible and desirable.

Lack of skilled operators

Lack of skilled operators is also one of the important factors considering the causes of wastages. Unskilled operators required training and assistance they are not aware with new technologies and cannot handle the equipment with care causing breakdowns.

5. CONSTRUCTION RESOURCES AND COST

Construction resources and its cost awareness is one of the major aspects in taking resource optimization process various components / resources and their percentage weightage is shown in following points

5.1 Construction Cost Break-Up

Table 5.1 Entire Project Cost Break up is as follows

Material	35%
labour	30%
Equipments	15%
Profit	10%
Indirect Cost	05%
Over head	05%

Source: Data collected from Gala Swing (Gala Builders Pvt.Ltd.)

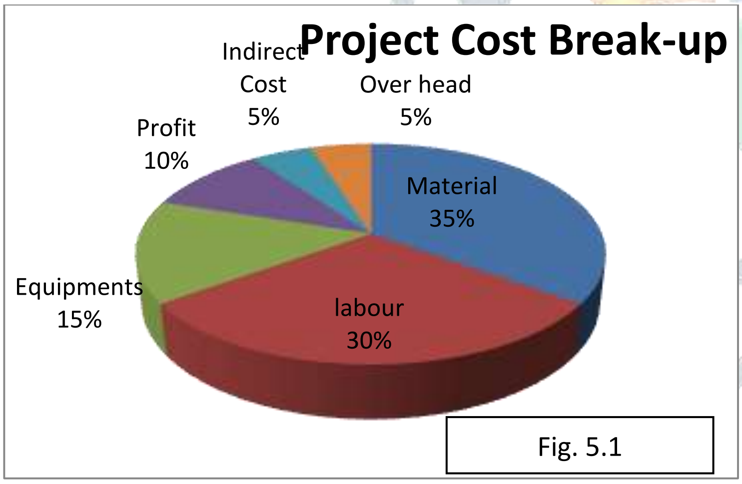


Fig. 5.1

Source: Data collected from Gala Swing (Gala Builders Pvt.Ltd.)

5.2 Labour Resource And Cost

Labour being consisting of about 20 to 30 percentage of total construction cost its analysis and productivity check must be done which is as shown in various figures and graphs shown below.

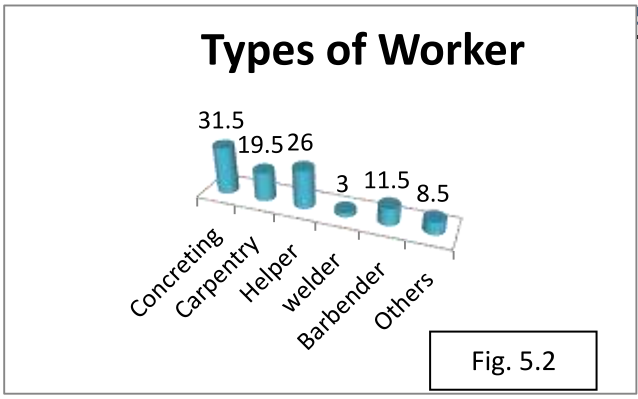


Fig. 5.2

Source: Data collected from Gala Swing (Gala Builders Pvt.Ltd.)

Table5.2 Construction Worker	Daily Wages	
	RURAL	***Urban***
Carpenter 1st class	387.50	406.50
Carpenter 2nd class	382.00	397.50
Mason 1st class	387.50	406.50
Mazdoor 1st class	287.50	295.00
JCB Operator	407.50	426.50

Source: Data collected from Govt. of Tamilnadu, Minimum wages notification

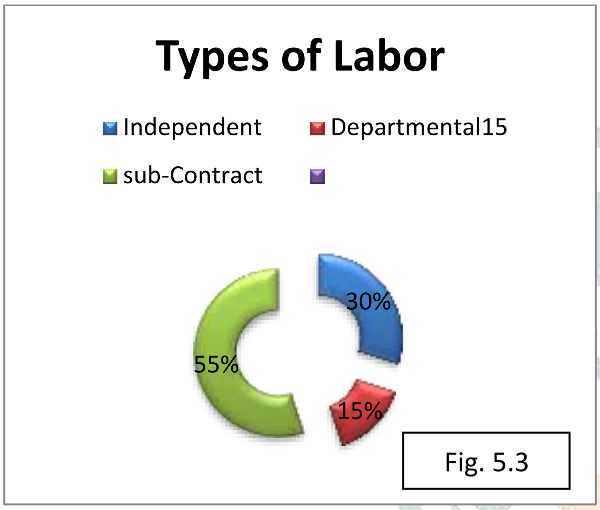


Fig. 5.3

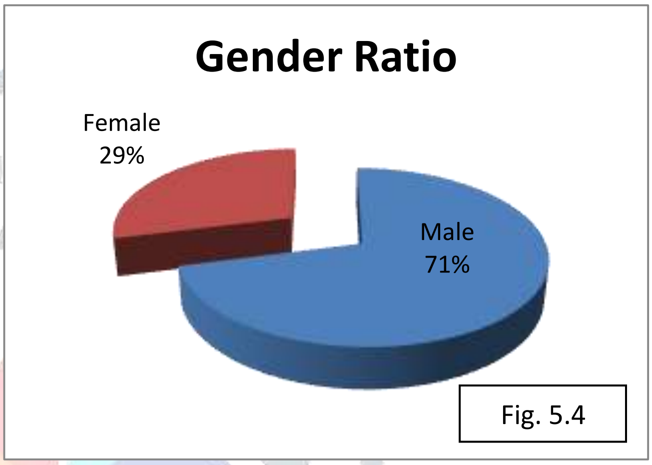


Fig. 5.4

Source: Data collected from Gala Swing (Gala Builders Pvt.Ltd.) Source: Data collected from Gala Swing (Gala Builders Pvt.Ltd.)

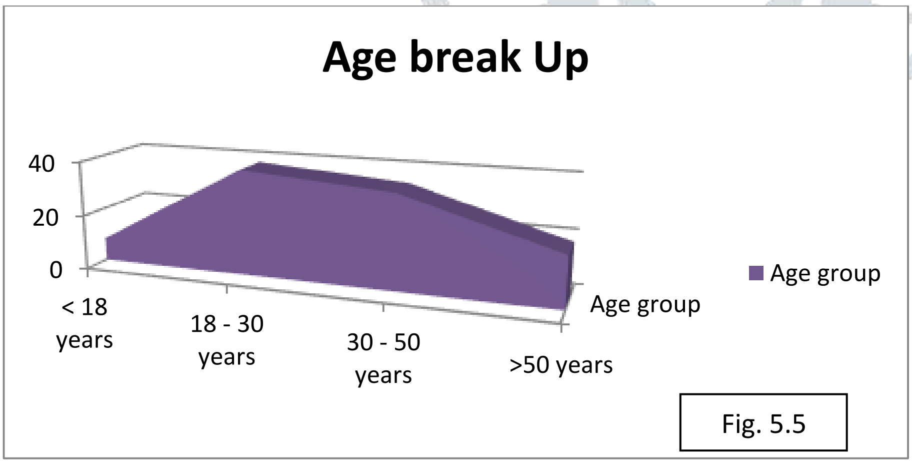


Fig. 5.5

Source: Data collected from Gala Swing (Gala Builders Pvt.Ltd.)

5.3 Material Resource And Cost

Materials use and materials reuse, reduction and recycling -- begins in the planning stages of a project. It starts with the architect, proceeds through the engineer, the estimator, the purchaser, the construction manager and finally the contractors. Materials cost control and, therefore, profitability starts with a plan. Once the material is on site and especially once its been cut, it is too late to plan but for its fate. But with carefully scrutinized operational procedures and construction practices, a plan can be developed and implemented to save significant costs in materials.

5.3.1 Cost of Waste

The cost of waste is more than simply the cost of getting it to a landfill and dumping it. The cost of waste really is:

Original cost of material + Delivery cost + Handling cost + Management cost + Cleanup cost + Waste hauling cost + Tipping fee = Total cost of construction waste.

Many usable or reusable pieces of material can be seen in construction trash containers. Examples include lighting ballasts, electrical switches and other hardware and fasteners; pails of roof penetration sealant with material in them; and various lengths of piping and conduit.

This is the typical materials and waste management method:

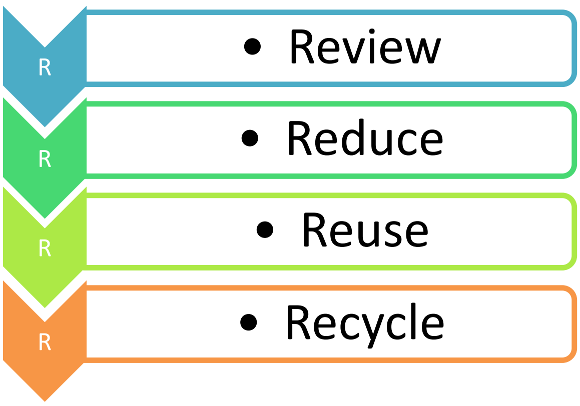
once a piece of material or hardware is left on the floor or on the ground it is picked up and deposited in the trash container.

Materials Management

Materials management is a process: It is how a building is designed and how materials are estimated. It is how materials are acquired and even how the packaging is specified. It is how the delivery schedule is designed. It is how contractors plan materials use and how they manage previously used materials and cuts. It is how waste is managed for use elsewhere or recycling rather than being discarded in a landfill. It is a culture: It is how the customer expects the contractor and contractor its subcontractors and the subcontractors its workers -- to care for and properly manage the materials provided.

The Plan

The Plan should consider the "four R's":



REVIEW: Reconsider your design philosophies and practices. Review your company's policies regarding estimating and purchasing and your site construction practices. And review the sources of those policies and re they valid in today's economy or procedures: ecology?

REDUCE: Reduce quantities purchased as well as waste. A way of looking at the estimator's and purchaser's "fudge factor" is that they are actually specifying the waste amounts. More care taken on the jobsite and different cleanup practices could dramatically reduce waste. You could probably create a substantial list of waste-reducing practices.

REUSE: Form lumber is used more than once, but generally for another concrete form. Have you ever thought of using it for blocking? Used plastic film can be stored and used to cover exposed work in case of inclement weather.

RECYCLE: Plan the recycling of your construction waste before the project starts at the site. Once the project is underway, treat the waste recycling as rigorously as you would the quality of your construction

5.3.2 The Concept Of Designing Out Waste

Waste minimization is any technique that either avoids, eliminates or reduces waste at its source. Many different terms are used to describe the various waste minimization techniques, the focus however, with this research is on ‘source reduction’ techniques opposed to ‘release reduction’ techniques. Release reductions often involve activities dealing with pollution after its generation. Designing out waste at the earliest stages of the construction process offers the greatest opportunities for waste minimization. The best management approach to waste, particularly hazardous waste, is to manage the process so that there is no waste to manage. This is obviously very difficult, but the concept of Designing out Waste begins with the question ‘can the amount of waste being produced be minimized, if not eliminated?

Total Estimated Material:-

= theoretical quantity of material X {(100+std. wastage %) /100} Table 5.3 To find out Material variance:-

Table 5.3 Sample To Find Out Variance:-

S. No.	Material	Estimated Consumption	Actual Consumption	Variance	% Variance
1.	Cement	-	-	-	-
2.	steel	-	-	-	-

Table 5.4 Sample To Find Out Cost Impact:-

S. No.	Material	Wastage	Cost Impact
1.	Cement	X Bags	-

2.	steel	X MT	-

WCI (Waste Control Indices) = Actual consumption / estimated consumption

5.3.3 Equipment Resource And Cost

The selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus the job-site productivity of a project.

Equipment management is an important element in project planning and control. Equipments represent a major expense in construction, so minimizing *procurement* or *purchase* costs presents important opportunities for reducing costs. First, if materials are purchased early, capital may be tied up and interest charges incurred on the excess *inventory* of materials. Even worse, materials may deteriorate during storage or be stolen unless special care is taken. For example, electrical equipment often must be stored in waterproof locations. Second, delays and extra expenses may be incurred if materials required for particular activities are not available. Accordingly, insuring a timely flow of material is an important concern of project managers.

Excavation and Loading

One family of construction machines used for excavation is broadly classified as a *crane-shovel* as indicated by the variety of machines. The crane-shovel consists of three major components:

- A carrier or mounting which provides mobility and stability for the machine.
- A revolving deck or turntable which contains the power and control units.
- A front end attachment which serves the special functions in an operation.

Compaction and Grading

The function of compaction equipment is to produce higher density in soil mechanically. The basic forces used in compaction are static weight, kneading, impact and vibration. The degree of compaction that may be achieved depends on the properties of soil, its moisture content, the thickness of the soil layer for compaction and the method of compaction. Some major types of compaction equipment includes rollers with different operating characteristics.

Drilling and Blasting

Rock excavation is an audacious task requiring special equipment and methods. The degree of difficulty depends on physical characteristics of the rock type to be excavated, such as grain size, planes of weakness, weathering, brittleness and hardness. The task of rock excavation includes loosening, loading, hauling and compacting. The loosening operation is specialized for rock excavation and is performed by drilling, blasting or ripping.

Lifting and Erecting

Derricks are commonly used to lift equipment of materials in industrial or building construction. A derrick consists of a vertical mast and an inclined boom sprouting from the foot of the mast. The mast is held in position by guys or stiff legs connected to a base while a topping lift links the top of the mast and the top of the inclined boom. A hook in the road line hanging from the top of the inclined boom is used to lift loads. Guy derricks may easily be moved from one floor to the next in a building under construction while stiff leg derricks may be mounted on tracks for movement within a work area.

Tower cranes are used to lift loads to great heights and to facilitate the erection of steel building frames. Horizon boom type tower cranes are most common in high-rise building construction. Inclined boom type tower cranes are also used for erecting steel structures.

Mixing and Paving

Basic types of equipment for paving include machines for dispensing concrete and bituminous materials for pavement surfaces. Concrete mixers may also be used to mix portland cement, sand, gravel and water in batches for other types of construction other than paving.

Steps to find out equipment cost:

- Step 1. Transactions associated with bringing the machine into your fleet.
- Step 2. Transactions associated with keeping the machine in your fleet.
- Step 3. The costs you generate once you turn the key and put the machine to work.
- Step 4. Determine the total "cash out."
- Step 5. Estimate the "cash in.“
- Step 6. Transactions associated with selling the machine.
- Step 7. Calculate the final "cash position” and understand the results.

Establishing the lifecycle cost of construction involves five basic steps:

- Determine the equipment's net acquisition cost, factoring in incentives and any other options or variables.
- Establish the equipment's estimated depreciation rate (more on this later).
- Identify other fixed costs, such as interest, insurance, etc.
- Calculate the estimated lifetime operating expense.
- Add the estimated lifetime holding and operating costs to arrive at the estimated lifecycle cost.

The chart and the methodology used clearly show the delicate balance between "cash in" and "cash out" in the later stages of the machines life. It is easy to see how the repair and rebuild cost estimates used to calculate the assumed rate can be replaced with the actual costs experienced and used as the basis for repair limits that control expenditure and achieve break-even cost recoveries within the target rate over the full lifecycle of the machine.

Table 5.5 Equipment Cost Analysis

Sr.No	Item	Calculation	Value	Units	Notes
1	Expected life		5	yrs	Look to your records Check carefully on annual utilization as this is very important
2	Expected utilization		1800	hrs per yr	
3	Age when sold		9000	hours	
4	Purchase price		Rs. 1,90,000.00		
5	Estimated residual value		Rs. 52,000.00		Look at auction results when estimating residual value
6	Depreciation	(4-5)/1	Rs. 27,600	per year	
7	**Rate to cover depreciation**	6/2			
8	Basis for annual interest	AAV	Rs. 1,34,800		Based on average annual value and required interest rate - See November 2003 article for details
9	Annual interest rate		Rs. 6	% per year	
10	Annual interest cost	8x9	Rs. 8,088	per year	
11	**Rate to cover interest**	10/2			
12	Annual cost of insurance, licenses and property tax		Rs. 5,600	per year	Frequently estimated as a % of AAV
13	**Rate to cover other owning**	12/2			
14	**TOTAL OWNING COST**	7+11+13			
15	Fuel cost		Rs. 1	per gal	You should know this
16	Fuel factor		Rs. 2		This factor covers the cost of dispensing fuel and the cost of daily oil and lubrication
17	Fuel consumption		Rs. 4	gal per hour	Look to your records
18	**Rate to cover fuel**	15x16x17			
19	Wear parts		Rs. 2,600	per set	Look to your records

20	Factor on cost		Rs. 1	hours	Covers the cost of installation and routine welding etc
21	Expected life		Rs. 500		Look to your records
22	**Rate to cover wear parts**	19x20/21			
23	Tires		Rs. 9,500	per set	Look to your records
24	Factor on cost		Rs. 1	hours	Covers the cost of fitting and routine maintenance
25	Expected life		Rs. 4,000		Look to your records
26	**Rate to cover tires/tracks**	23x24/25			
27	Cost of a PM service		Rs. 900		The average cost of labor and supplies for a PM service
28	PM service interval		Rs. 250		Fixed
29	**Rate to cover PM**	27/28			
30	Lifetime expected repair costs		Rs. 85,000		This is the big one. Look to your records and see what similar machines have cost at this age.
31	**Rate to cover repairs**	30/3			
32	**TOTAL OPERATING COST**	18+22+26+29+31			
33	**TOTAL OWNING AND OPERATING COST**	14+32			

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6. CONCLUSION & FURTHER SCOPE

This study examines the site engineer's (we can also name him as a waste control Engineer) responsibilities in achieving maximum project waste reduction. It suggests criteria for a waste reduction program and possible areas of an organization where such a program could extract significant savings. It should be noted that the waste reduction program criteria put forth here are only suggestions. Waste reduction programs take on many different forms, and are based on many different philosophies. Yet each is as vigorous and effective as the next. As long as paper management attitudes and employees involvement are present, the form of the program is of secondary importance to its substance.

This study is subjected to various limitations like location Type and Nature of the project and the derived variances can only be referred to the similar situation. An imperial formula can be developed by that the quantity of wastage and its variable can be found for any nature, type or quantum of project.

Also this project is not exhaustive for every resource in construction management resources like money, and good will cannot be quantified but wastage of above mentioned resources can lead to decline of the intangible resource and can impact in negative manner a study can be held on impact of waste management on good will of company can be done.

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