

# Resource Optimization for Sustainable Construction: A State of Art

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**Abstract:** The estimated cost of construction material on any construction project is about 40-60% of the total construction project cost in which approximately construction material's waste contributes 30-35% of the material cost, which in result leads to project cost overrun and loss of materials. Lesser studies have been done for the construction material waste reduction or optimization directly at the time of its use on site. The basic aim of this study is to describe the methods by which the construction material as a resource can be used sustainably reducing the wastages and prevention at site during construction. The study discloses that selection of less experienced working method and the poor quality of materials to be used on site also results in material wastage during sudden design stage. The major beginning of material wastages during construction stage are improper uses of material as well as labors. Similarly, while procurement, wastages are caused during loading, unloading and transportation processes and unavailability to order small quantities of material. Also, lack of knowledge and improper security for materials procured causes the same even before its use on site. Thus, the study can be used further in co-ordination of optimization techniques on site to reduce the wastages and cost of materials during construction.

**Keywords:** Resource management; construction management; construction material; resource wastage; optimization.

## I. INTRODUCTION

There are few things certain in life such as death, transition and waste. Either of the three can't be avoided from happening but, we can make our lives better with a proper management of the same [1]. Population eruption, along with demand of improving life style of results in increasing demand of infrastructure for basic needs such as housing, transportation, business and education etc. Since, the time of Industrial revolution, the globe has noticed a compelling development in advancement of technology, population and growth. Thus, the use of resource is also increasing simultaneously. In other words, the technological advancements achieved, resulting in excessive use and extraction of any kind of resources and directly or indirectly has a hand in global warming related issues like ozone depletion, thinning of the ice layers on the poles, flooding etc. Sustainability is affected by such activities which also, puts a question for the availability of resources for the future generations [2]. Therefore, we as engineers should find solutions for the optimum utilization and waste reduction techniques of the resources. The resource planning and management is one of the most important ingredients for competitiveness and profitability in today's construction industry. Initially, which was done with making models base on Critical Path Method time analysis, which could be used for estimating multi-project resource planning and sharing [3].

## II. WASTAGE OF CONSTRUCTION MATERIALS

Loss of material during usage or decay of unused or unattended material on construction site can be stated as construction material wastage. It is something that never gives a process of increase in value to the work of construction at any phase. The dominant crisis in our construction sector is the material waste with its evident associations. Knowing that construction industry is the second largest industry in India being a rapidly developing nation has reported to generate waste beyond bearing and manageable quantities.

Each year, India produces 24 million tonnes (2010) of construction and demolition waste which is increasing every year [4]. Globally, the production of building material waste estimates to 2 to 3 billion tonnes every year, of which 30-40% is only concrete [4].

As we all know, let it be any type of construction project the material cost associated with it is no where less than 40-60% of total project cost, which is a very high capital investment alone. The wastage is estimated to be approximately 30-40% of the total amount of materials at different stages of construction [5]. In Table. 1. we get a brief idea about the different stages of construction projects as gathered from literatures.



TABLE. 1. SOURCE OF MATERIAL WASTAGE IN DIFFERENT STAGES OF CONSTRUCTION [5].

Sr. No.	Design Stage	Operational Stage	Procurement Stage	Material Handling Stage
1.	Design change while construction	Damages to work done due to subsequent trades	Lack of possibility to order small quantity	Material supplied loose
2.	Inexperience of methods	Errors by trade men or laborers	Order errors (too much or too little)	Inappropriate storage
3.	Lack of attention to dimensions	Required quantity unclear due to improper planning	Purchase not comply with specification	Damages while transporting
4.	Lack of knowledge about standard size	Re-working due to incorrect materials/Labour	-	Theft
5.	Complexity of detailing	Delay in passing information to the contractor	-	Unfriendly attitudes of project team and laborer
6.	Lack of information in drawings	Accident due to negligence	-	Use of materials close to workplace
7.	Selection of low quality products	Inclement Weather	-	-
8.	Inconclusive contract Documentation	Malfunctioning of equipment	-	-
9.	Errors in contract document	-	-	-



If these wastages on construction sites are neglected, it may lead to project cost overrun and time overruns unnecessarily. Therefore, need to increase the material wastage management activities at site is to obtain more benefits in less time with minimum cost of constructions.

National Specialist Contractors Council (UK)- says that the 10% of construction material ordered on site is never used and directly goes to the construction wastage lists. This review would like to emphasize on the use of optimization tools such as Genetic algorithm (GA) to optimize such kind of wastages from planning and designing stage up till the construction completion stage.

### III. RESOURCE OPTIMIZATION

Many authors have developed optimization-based simulation models, which are integrated with commonly used project management software [6] in which the bestow approach determines the least cost and most productive amount of resources that achieve the highest benefit by cost ratio. Hegazy (1999) [7], solved the resource levelling problems using Genetic algorithm (GA) in initial stages of resource optimization. Major advantage of the procedure was its simple applicability within commercial project management software systems to improve their performance. Many case examples are also solved to illustrate the performance and effectiveness of the resource allocation model [8]. As the resource management is necessary in today's construction industry. Kandil, et al., (2006) [9] emphasis upon the automated system for the resource optimization using Spreadsheet software, database application and project planning Software.

Optimizing resource utilization can lead to significant reduction in the duration and cost of repetitive construction projects such as highways, high-rise buildings and housing projects. Rayes, et al., (2001) [10], developed model that utilizes dynamic programming formulation and incorporates a scheduling algorithm and an interruption algorithm so as to automate the generation of interruptions during scheduling.

### IV. GENETIC ALGORITHM

It is an established fact that, Genetic Algorithms (GA) is a very adept way in seeking answers to a problem. GA has been favorably and profitably adopted to get solutions for the problems faced by the researchers in engineering as well as in science [11-12] such as optimization, machine learning, automatic programming, transportation problems, adaptive control etc. It is a system of accomplishing a code on computer for optimized result of a problem which is basically stimulated with an organic form of system also known as natural genetics. These are inspired by the theory of evolution by Darwin.

To get an optimal solution in openly available set of solutions it does a random yet a directed search. Usually, it requires a likeness in course of action to encrypt a doable solution to a problem which needs optimization. And, this operation is performed in chains called genes or chromosomes. Every individual section represents a gene (chromosome) or a solution than the other available solutions in the whole set of solutions.

The solution of the optimization problem is decided by the GA depending upon the fitness of each and every gene which is derived by judging its accomplishment with respect to an objective function [7]. As we all know survival of the fittest is the law of nature and in the same way the genes with better fitness exchange their information and population evolves over time to generate offspring continuously in large numbers until and unless an optimum gene is obtained. With every generation of offspring generated the fitness of each is generated too which helps the algorithm decide the fittest of them to continue in the process.

The working principal of Genetic algorithm technique for any optimization problem consists of the following five distinct steps:

- (1). To generate a structure of gene.
- (2). The judgement criteria for gene is to be made which is also known as objective function.
- (3). An initial population of gene is to be created.
- (4). Offspring reproduction criteria to be set.
- (5). Finally, this procedure needs to be made on a coding platform based on computer language.

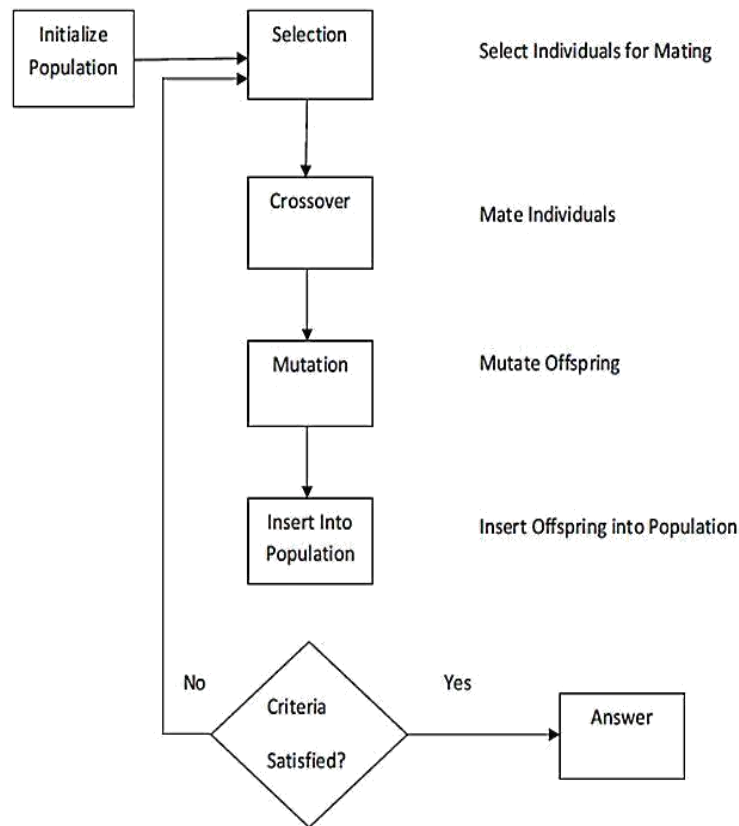


Fig. 1. Fundamental Mechanism of Simple Genetic Algorithm [10]

## V. SIGNIFICANCE OF STUDY

This study focuses to obtain sustainable construction as its goal in India, for which the optimization of resource material can be done at many different stages of construction process itself. The initial demand is to study for the sources of these wastages. Secondly, there is need to find the challenges related in construction market and construction industry in India to tackle them for the subsequent reduction in the wastage.

Study also helps understanding that the way any particular construction activity is carried out at site has a direct association with the amount and volume of material resource waste produced. And, if the material to be used is already procured on the basis of the design received from the design team leads to the changes in design during construction process will definitely lead to material wastage as it cannot be resold at any profits or returned to the suppliers at any time as there are limitations in the supply chain management. Any design changes after construction too leads to sectional demolition wastage and other capital invested for that particular section's construction. At procurement stage there are many associated material wastages too, for e.g. unable to order small quantities, damages to the materials during the loading, unloading and during transportation.

Also, lack of knowledge to recycle is one of the obstacles for the construction which lead to delay in project progress. The success of the project depends upon the efficient management of material resource taking in mind the consideration of the high proportion of material resources in the total construction project cost. During handling stages of the material resource during construction is most crucial part of the material wastage management. As the handling of some materials such as cement: needs to be kept in close shed or room and avoiding moisture contact to reduce the quality of cement, excessive time of storage for the cement also leads to its quality reduction. Similarly, steel is one of such material which needs at most care during handballing period as it starts to rust if it comes in contact of the water or moisture. Both of the above needs to be stored in dry storage area to reduce its wastage during handballing periods.

Garba et al., (2016) [5], suggests to recycle and reuse the materials in places where it can be utilized during the construction process to avoid as much of material wastage can be avoided rather than its disposal.

Thus, an optimization tool is required to find the possible and feasible optimal solutions for the optimization problem with us. For this work Genetic algorithm is the one of the best selection of all as it has proved itself in between the researchers in solving such optimization problems. GA has a unique and very similar way to reach the optimal solution,



as it works similar to the way nature does. The fitness associated with every possible solution also called as a gene in the gene population. This fitness defines if the gene is fit for the further process of cross mutation by exchanging its information with the other gene to produce next level offspring associated with their fitness levels. Thus, this further proceeds level by level to reach its optimal solution at the end.

## VI. SUMMARY AND DISCUSSIONS

This study is the done to bring us on a successful conclusion that the wastage with respect to construction activities are coming out and needs to increase the attention towards its management as well need to sustainably develop our nation and let the resources be available for the future generations. This can be done initially by the Indian government authorities by strengthening the policies and laws made for the construction waste management process. This will help the nation to make the construction related authorities seriously think upon the wastage management and thus, will also force them to reduce the material resource wastage, recycle and reuse the reusable waste produced during construction to increase the sustainability in their construction.

This study is limited to the study of material resource wastage and to study if the process of optimization can be applied to it. Make choice of the optimization tool to help the study further optimize the material resources.

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