Effective Utilization of Construction and Demolition Waste :An Approach towards Cleaner Surat



Gaurang Vani

18IF814

EFFECTIVE UTILIZATION OF CONSTRUCTION AND DEMOLITION WASTE

: AN APPROACH TOWARDS CLEANER SURAT

By

Gaurangkumar Dipakchandra Vani
ID No.:18IF814

Institutional Guide
Prof .Jagruti P. Shah
Assistant Professor,
Structural Engineering Department,
B.V.M. Engineering college,
Vallabh Vidyanagar

External Guide
Dr. Nimesh V. Vashi
Founder and Chairman
Enviro Control Associates (I) Pvt. Ltd.,
Surat, Gujarat

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BIRLA VISHVAKARMA MAHAVIDYALAYA
(ENGINEERING COLLEGE)
AN AUTONOMOUS INSTITUTE
VALLABH VIDYANAGAR - 388120
GUJARAT, INDIA

CERTIFICATE

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Date :
Place : BVM Engineering college, Vallabh Vidyanagar

Prof. Jagruti P. Shah Assistant Professor Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat	**Dr. Nimesh V. Vashi** Founder and Chairman Enviro Control Associates (I) Pvt. Ltd., Surat, Gujarat
Dr. Arvind K. Verma Head of Department Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat	**Dr. Indrajit N. Patel** Principal B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat

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(ENGINEERING COLLEGE)
AN AUTONOMOUS INSTITUTE
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GUJARAT, INDIA

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Date :
Place : BVM Engineering college, Vallabh Vidyanagar

Prof. Jagruti P. Shah Assistant Professor Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar.	**Dr. Nimesh V. Vashi** Founder and Chairman Enviro Control Associates (I)Pvt. Ltd., Surat, Gujarat
Dr. Arvind K. Verma Head of Department Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat	**Dr. Indrajit N. Patel** Principal B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat

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AN AUTONOMOUS INSTITUTE
VALLABH VIDYANAGAR - 388120
GUJARAT, INDIA

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Date :
Place : BVM Engineering college, Vallabh Vidyanagar

Prof. Jagruti P. Shah Assistant Professor Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar.	**Dr. Nimesh V. Vashi** Founder and Chairman Enviro Control Associates (I) Pvt. Ltd., Surat, Gujarat
Dr. Arvind K. Verma Head of Department Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat	**Dr. Indrajit N. Patel** Principal B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat

BIRLA VISHVAKARMA MAHAVIDYALAYA
(ENGINEERING COLLEGE)
AN AUTONOMOUS INSTITUTE
VALLABH VIDYANAGAR - 388120
GUJARAT, INDIA

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This is to certify that research work embodied in this dissertation entitled **"Effective Utilization of Construction and Demolition Waste: An Approach towards Cleaner Surat"** was carried out by **18IF814 Gaurangkumar Dipakchandra Vani,** at Birla Vishvakarma Mahavidyalaya (Engineering College) An Autonomous Institution for partial fulfilment of Master of Technology with specialization Infrastructure Engineering & Technology by Gujarat Technological University.

Date :
Place : BVM Engineering college, Vallabh Vidyanagar

Prof. Jagruti P. Shah Assistant Professor Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat	**Dr. Nimesh V. Vashi** Assistant Professor Enviro Control Associates (I) Pvt. Ltd., Surat, Gujarat
Dr. Arvind K. Verma Head of Department Structural Engineering Department, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat	**Dr. Indrajit N. Patel** Principal B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat

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Date:

_____
Gaurangkumar Dipakchandra Vani

_____ _____

Prof. Jagruti P. Shah
Assistant Professor
Structural Engineering Department,
B.V.M. Engineering College,
Vallabh Vidyanagar, Gujarat

Dr. Nimesh V. Vashi
Founder and Chairman
Enviro Control Associates (I) Pvt. Ltd.,
Surat, Gujarat

BIRLA VISHVAKARMA MAHAVIDYALAYA
(ENGINEERING COLLEGE)
AN AUTONOMOUS INSTITUTE
VALLABH VIDYANAGAR - 388120
GUJARAT, INDIA

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Gaurang Vani
Id No: 18IF814

ABSTRACT

The mass production of construction and demolition waste and its deposition are creating serious problems in India. In most of the countries, applicability of construction and demolished wastes are restricted to non-structural concrete, pavements, and backfilling. The recycling and replicability of construction.

The Study is based on the recycling of the rapidly increasing construction and demolition waste. Through this process we want to take a step ahead, the idea of stopping illegal sand mining, earth excavation and ultimately save our mother Earth from destruction. The cost of recycled sand and aggregates is lower than conventional aggregates and sand, resulting in reduction of overall construction cost. Our primary aim is to study about the different properties of construction and demolition waste, perform various tests, so that the recycling processes can be designed accordingly for optimum efficiency.

Based on these test results and projections we will get a rough estimation about the total quantity of recycled aggregate and recycled sand that can be obtained. Further with the help of the obtained recycled material we intend to make various products such as concrete, paver blocks, hollow blocks, kerb stone etc. which will in turn be less costly as well. These recycled materials and products made from it are economical without any considerable change in the strength and durability aspect. Not only the cost effectiveness but it will also be aesthetically pleasing.

Keywords: Construction and Demolition Waste, Waste Recycling, Construction and Demolition Waste Utilization, Construction and Demolition Waste Management

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF CHARTS

LIST OF ABRIVATIONS

MSWM	Municipal Solid Waste Management
CDWM	Construction and Demolition Waste Management
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPCB	Central Pollution Control Board
GOI	Government of India
GOG	Government of Gujarat
SMC	Surat Municipal Corporation
MSW	Municipal Solid Waste
TPD	Tonnes per Day
MT	Metric Tonne
GPCD	Gallon Per Capita Daily
KPI	Key Performance Indicators
PPP	Public Private Partnership
ULB	Urban Local Body
TIFAC	Technology Information Forecasting and Assessment Council

Chapter 1 Introduction

CHAPTER 1

Introduction

1.1 Background

Construction and demolition waste have been defined as “wastage which are arising from construction, renovation, explosion activities, surplus and damaged products and material arising in the course of construction work and on-site work. The primary method is adopted in waste handling is carried through by interviewing professionals like project managers, architects, civil engineers, contractors and government officials like city engineers, solid waste management officials.

The agriculture is the largest industry in India. According to the eleventh five-year plan, construction is the second largest industry after agriculture. India’s most population skilled/semiskilled and significantly labour class unskilled is dependent upon the construction work. Material is a major part of all types constructions projects. The success and failure of every construction project is by and large depending on the material management. In country like India where on one hand side the growth of development and redevelopment project has considerably increased and on the other hand the bad impacts of construction sector on the environment is also amplified.

Today the environmental issues such as flood levels due to the illegal explosion of waste into the rivers, resources are depletion from the earth and illegal explosion of hill slopes are evident in the metro cities. In India infrastructural facilities are increased due to the construction, refurnishing and explosion of buildings, bridges, runways, flyover, roads, factories, industries, hospitals, and other similar formulations. The waste material generally consists of powerless, inactive, and non-biodegradable materials such as

 Plaster Plastics Wood

 Brocken tiles Excavated materials asphalt concrete

 Concrete rubbles Steels, Masonry etc.

Every year in India several metric tons of waste is generated and disposed in landfills and since this waste is not regulated in an effective manner; immense amount of un-disposed waste can be witnessed at several parts of the nation. Therefore, the need for effective waste management and quaint methods to recycle, reuse & reduce has become paramount so that a bright future is assured for the generations to come. Thereby, imparting an important knowledge about the environment & our salvation upon it.

In recent years, initiatives have been taken on a global and national level to regulate waste

management. Regulations have become increasingly rigorous and consequently, options which are rarely used such as minimizing or recycling waste are becoming economically attractive.

In this project to study the paramount importance of effective utilization of Construction and Demolition waste and its management. How C&D waste can be utilized to make finished products such as paver block for pavement works and its practical usage and what methods as well as materials are to be adopted for the same, physical and mechanical aspects of these paver blocks and experiments which are to be conducted prior to utilizing recycled products to ensure its effectiveness.

Table 1 C&D Waste Generation in Select Indian Cities

City	Population (census 2011)	Daily CDW generation (tonnes/day)	Annual CDW generation (million tonnes/annum)
Mumbai	12442373	2500	0.75
Delhi	16787941	4600	1.38

Bengaluru	8443675	875	0.26
Chennai	6500000	2500	0.75
Kolkata	4496694	1600	0.48
Jaipur	3471847	200	0.06
Patna	2514590	250	0.08
Ahmedabad	6063047	700	0.21
Bhopal	1917051	50	0.02
Coimbatore	2618940	92	0.03
Surat	4400000	330	0.09

1.2 Historical Background of Construction Waste Management

Recycling of demolition waste was first carried out after the Second World War in Germany to tackle the problem of disposing large amount of demolition waste caused by the war and simultaneously generate raw material for reconstruction. Considerable research has been carried out in U.S.A, Japan, U.K, France, Germany, Denmark and in other developed countries for recycling concrete, masonry, bricks, bituminous and other constituents of waste from Construction Industry.

In India Central Building Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi have done studies to assess and demonstrated possibility of using construction waste to substitute new materials of recycling.

According to Technology Information, Forecasting and Assessment Council (**TIFAC**), study, 70% of the construction industry is not aware of recycling techniques and concludes the need for quality standards for recycled aggregate materials and recycled aggregate concrete to help setting targets for quality products and assure the user of a minimum quality requirement, thus encouraging him to use it.

The C&D rules considers the historical perspective of the problems of C&D waste disposal and methods deployed to manage them, both locally and globally.

Indian Scenario of C&D Waste Processing

In India, it is quite common to see huge piles of C&D waste, stacked alongside of major roads resulting in traffic jams, congestion, and disruption & chocking of drains. Around 30% of the total municipal solid waste generated in the country comprises of C&D waste.

TIFAC has conducted a techno-market survey on 'Utilization of Waste from Construction Industry' targeting housing/building and road segment. The total quantum of waste from construction industry is estimated to be 12 to 15 million tons per annum out of which 7-8 million tons are concrete and brick waste.

As per the Central Public Health & Environmental Engineering Organization (CPHEEO), the Indian Real Estate Industry alone is facing a shortage of aggregates to the extent of 55,000 million cum. In addition, 750 million cum of aggregates would be required to achieve the targets of road construction sector, which will lead to tremendous pressure on natural resources.

The C&D Waste generated in each city would reflect different characteristics based on each city’s growth pattern and lifestyle. While retrievable items such as bricks, wood, metal, titles are recycled, the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India.

Figure 1 Dumping of C&D Waste in Public Places

1.3 Motivation and Gap Analysis of Study

India is a developing country and the backbone for a developing country is its infrastructure. Of the infrastructure, residential units for all economic class of people are a must. Shortage of urban housing in India is estimated to be 24.71 million for 66.3 million households at the end of the 10th Five Year Plan. There is a huge shortage for homes in the lower income segment. The fig. 2 below gives the details of the status of housing in INDIA.

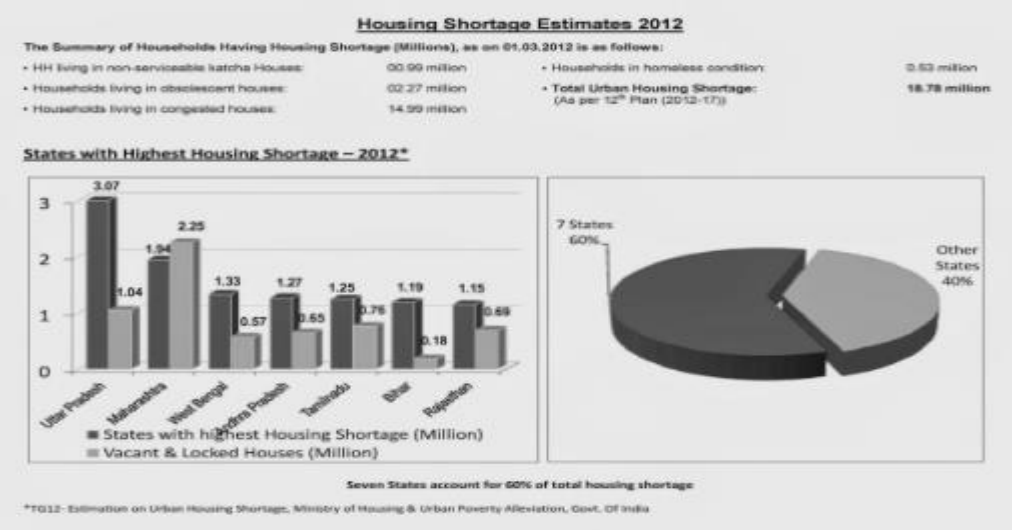

Figure 2 Housing shortage estimates 2012(Courtesy: Estimation on urban housing shortage, Ministry of housing and urban poverty, Govt. of India)

The main reasons for rise in shortage in affordable housing on the supply side are lack of availability of urban land, rising construction costs due to shortage of building materials. Thus, this project aims maximum utilization of C&D waste derived recycled aggregate in manufacturing of finished products. with an aim to reduce the cost of construction for a finish items during project. The second major problem faced by the society is increase in cost of virgin materials as they are derived from natural sources and generating of waste materials. Both these activities cause threat to the environment. Thus, understanding both these issues, of providing a descent dwelling to the low- and medium-income group society and reducing the construction cost by utilizing waste materials was the main idea behind this project.

1.4 Need of Study

C&D waste management in urban areas is a key issue in developing countries due to the lack of proper waste management facilities and services, very less attention had been paid towards CDWM in urban areas. It has been seen that major amount of solid waste is dumped though open dumping near water bodies and in vacant lands which is completely unscientifically way to dispose MSW, which will creates adverse effects to the water body and water is being polluted and certainly it will also impacts on human health.

1.5 Research Aim

The Aim to "Designing Reality Oriented Cost Estimate Model for Transport Infrastructure Projects".

1.6 Objectives of the Research

The followings are the objectives to achieve the above aim of the study.

[1] To study existing scenario of C&D Waste
[2] To study of existing practice done for managing Construction and Demolition Waste
[3] To study durability properties and application of C&D Waste material
[4] To perform different applications of product design from C&D Waste
[5] To Comparison Cost of Recycled products with available market products

1.7 Scope of the study

To This study will mainly cover the utilisation of construction and demolition waste generated from new construction, demolition, and renovation in building practices with a focus in Indian context for the Surat Municipal Corporation limit, Surat City.

1.8 Methodology

For with success achieving the on top of research objectives needs a strategy from that to conduct the study. The methodology provides a basis for the research method. during this

approach, the research is conducted in an exceedingly logical and precise manner. Methodology structure provides need study of literature and systematic work process structure behind the information collection, analysis, and results mentioned underneath the tasks lined during this Report as illustrate in Chart 1 (below) with the terminal effect of modal development with a neural network approach effectively to cost estimate of road construction cost.

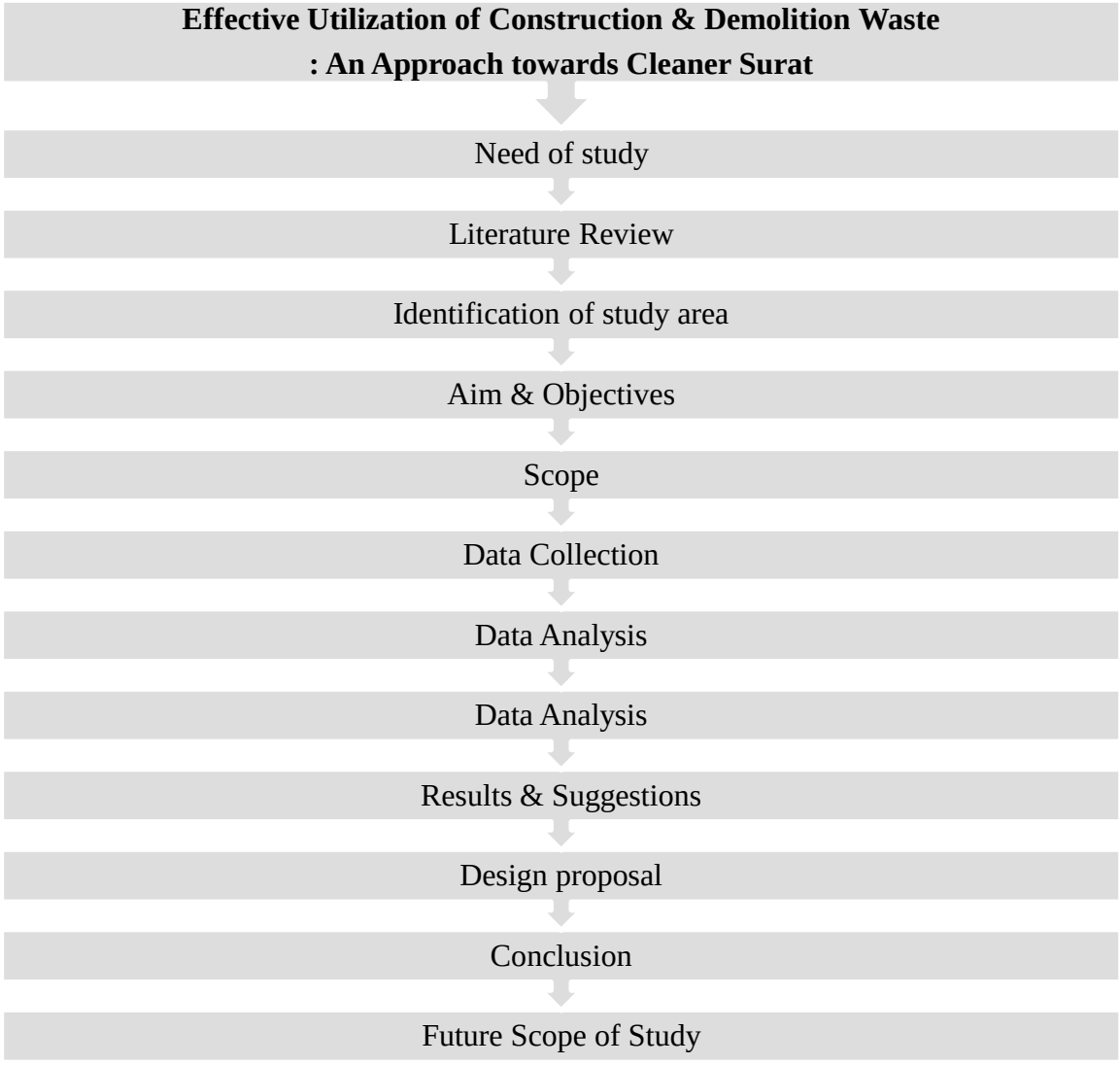

Chart 1 Research Methodology

1.9 Chapters Contents

This research included six chapters explained as follow:

Chapter (1) :	This chapter gives the general background, historical background, Indian scenario, motivation and gap analysis of study introduction, and research Aim with research methodology to achieve objective.
Chapter (2) :	This chapter formed with a detailed systematic literature review of research paper, definition and concept , government and private institution report and guidelines on utilization of construction and demolition waste, construction and demolition waste management and recycling methods with critical literature review and major finding.
Chapter (3) :	This chapter discussion about study area and its waste characteristic
Chapter (4) :	This chapter contains about data collection throughout the study period and its systematic analysis.
Chapter (5) :	This chapter contains experimental planning and testing for which product making using construction and demolition waste recycled aggregates for checking various tests on it.
Chapter (6) :	This chapter about experimental results and discussion of this Study.
Chapter (7) :	Finally, this chapter outlines conclusions and recommendations of this Study. It also includes the future scope.

Chapter 2 Literature Review

CHAPTER 2

Literature Review

2.1 Introduction of Literature

The literature review occupies searching, assembly and taking notes from the literature related to construction and demolition waste management, construction, and demolition waste utilization methods for its recycling. Also, construction and demolition waste generation worldwide and in India. The firstly discovers the source through searching with the keyword like a construction and demolition waste, C&D waste management, construction and demolition waste recycling, utilization of C&D Waste, recycled aggregates, properties of recycled aggregate, recycled aggregate in concrete, paver block manufacturing by using C&D Waste in search engine to identify significant important literature for research. The Google, goggle scholar and yahoo search engines are used, Over 55 literatures identified and surveyed. The literature consists of government reports, private institution reports, construction and demolition waste rule and guidelines, journal articles and papers & conference proceedings the proportion is shown in Chart 2.1 (below).

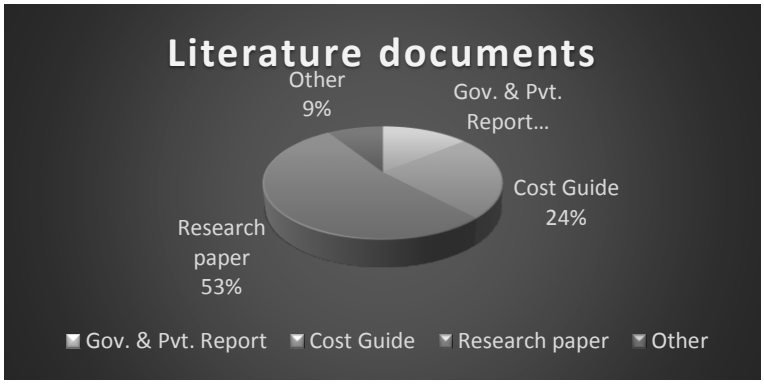

Chart 2.1 Literature Review Proportion

The literature review clarifies the base of this research and targeted to study and get ideas for effective utilization of construction and demolition waste and its various application

including 3R principles for developing and managing different methodology and strategies for utilization of construction and demolition waste for recycling process for reuse.

2.2 Definition / Concepts

Construction waste is defined as clean, heterogenous building materials which are produced from the various construction activities. Construction, renovation, and demolition activities lead to the formation of waste.

Construction and demolition waste are generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway, remodelling etc. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A part of this waste comes to the municipal stream.

2.3 Composition of C&D Waste

The composition of C & D waste can vary depending on age of building being demolished / renovated or the type of buildings being constructed. As mentioned earlier, C & D waste generation figures for any region varies as it depends largely on the type and nature of construction / demolition project activities which may be regional / site / project specific.
The typical composition of Indian C & D waste:
The major constituents are concrete, soil, bricks, wood, asphalt, and metal. Brick & masonry, soil, sand & gravel account for over of total waste.
Typical Composition of C&D Waste as shown in Table 2.1(below).

Table 2.1 Typical Composition of C&D Waste

Material	Composition
Soil, Sand & Gravel	36 %
Brick & Masonry	31 %
Concrete	23 %
Metals	5 %
Bitumen	2 %
Wood	2 %
Others	1 %

2.4 Summary of Literature

Following section gives the detailed summary of literature preferred for construction and demolition waste and its method of recycling process for reduce, recycle and reuse principles for which it can be effectively utilize for various construction activities with cost optimization and strategies developing for construction and demolition waste management, in this research see Table 2.2(below).

Table 2.2 Summary of Literature

Sr. No.	Title	Author	Year
1.	Construction and Demolition Waste Management – A Review	P. Markandeya Raju	2015
2.	Study on Durability properties of Recycled Aggregate Concrete incorporate with Silica Flume and Mineral Quartz	Anand K. Darji, Dr. Indrajit N Patel, Mrs. Jagruti Shah	2015
3.	Construction and Demolition Waste Management in India	Harish.P.Gayakwad, Neha.B.Sahane	2015
4.	Municipal solid waste management manual (CPHEEO)	GOI	2014

5.	Management of Construction Waste in India: A Case of Green Technology	Nitish Bagdi, Vipin Aggarwal and Neetu Sherwal	2013
6.	Construction and Demolition waste – An Overview of Construction Industry in India	Rohan S. Shetty	2013
7.	Construction waste management in India: an exploratory study	Mohammed Arif, Deepthi Bendi, Tahsin Toma-Sabbagh	2012
8.	Management of Construction and Demolition Waste	Anantha Rama and Lokeshwari M	2010
9.	Preliminary study for the management of construction and demolition waste	B. kourampanis, A. Papadopoulos, M. Stylianou and M. Loizidou	2008

10.	Use of recycled aggregates in moulded concrete bricks and blocks	Chi Sun Poon, S.C.Kou, Lik Lam.	2008
11.	Use of construction and demolition waste as fine aggregates in manufacturing concrete paver blocks.	A.A.T.Darshika and K.M.L.A Udamulla.	2006
12.	A study on the strength properties of paver blocks made from unconventional materials.	M.C.Nataraja and Lelin Das.	2006
13.	Use of construction renovation and demolition waste in partial replacement of coarse aggregate in M20 concrete	N.Sai Trinath Kumar and Chava Siva	2005
14.	Utilization of waste material in concrete paver blocks.	Vishal kumar and Dr. A.K. Mishra.	2005
15.	Replacement of fine aggregate by using recyclable materials in paving blocks	Shyam prakash kognati,kommineni hemanthraja, satish sajja	2004

16.	Development of sustainable construction material using construction and demolition waste.	V A Dakwale and R V Ralegoankar.	2003
17.	Manufacture of paver block using partial replacement of construction and demolition waste	Dinesh W. Gawatre, Rohit S. Chhajed, Prashik B. Panpatil, Shubhum S. Desarda, Chetan S. Waghchure, Nikhil S. Agarwal.	2001
18.	Experimental Investigation on effect of demolished aggregate in Paving Block	Mr. Shivkumar Hallale, Mr. Rohit M. Shinde, Ms. Vaishnavi Battul, Ms. Tejashree Gulve	2014
19.	Analysis of Construction and Demolition Waste for Infrastructure Projects	Zenith Shah	2015
20.	Structural Design of Interlocking Concrete Paving Block Paving Block	E.Palanikumar, Pothuganti Uday Kumar	2016

2.5 Critical Literature Review

The critical literature review provides data of construction and demolition waste management practices and management all over the country and worldwide, C&D Waste problem statements and its effective management for reduce, recycling and reuse with 3R principles.

[1] Title: Legal aspects which implement good practice measures in the management of construction and demolition waste

Author: Mercedes del Río Merino, Justo García Navarro, Paola Villoria Saez

Type of article & year of publication: Accepted manuscript (2011)

This research article reviews that to enhance C&D waste management systems through the development of preventive measures during the construction process. These measures concern all the agents intervening in the construction process as only the personal implication of all of them can ensure an efficient management of the C&D waste generated.

The social demand towards greater respect for the environment is a high and general outcry. Therefore, the construction industry needs to reduce the impact it produces. Proper waste management is not enough; we must take a further step in environmental management, where new measures need to be introduced for the prevention at source, such as good practices to promote recycling. Following the amendment of the legal frame applicable to Construction and Demolition Waste (C&D waste), important developments have been incorporated in European and International laws, aiming to promote the culture of reusing and recycling. This change of mindset, that is progressively taking place in society, is allowing for the consideration of C&D waste no longer as an unusable waste, but as a reusable material.

On other hand, a model based on preventive measures achieves organizational cohesion between the different stages of the construction process, as well as promoting the conservation of raw materials through the use and waste minimization. All of these to achieve a C&D waste management system, whose primary goal is zero waste generation.

In this study authors conclude various things that Construction and demolition waste is a major component of the solid waste stream. Each year 40.000.000 tons of C&D waste are generated in Spain. This waste should be recognized as a valuable resource since large quantities of it could either be recycled or reused. Until recently, C&D waste has been overlooked in the efforts to reduce waste dumped in landfills, with the emphasis being placed on domestic recycling.

This study has been undertaken to identify key issues that will help in the development of management strategies to improve C&D waste minimization. Nevertheless, the speed and degree to which this inclusion should be carried out is determined by the eco-nomic viability of the process.

Public administrations are dedicating great efforts to improve the legislation of C&D waste and this article includes the last measures being achieved in this area. In addition, as it has been shown, only with the implication of all the agents and local administrations and with a strong enforcement and severe tracking of the proposed measures, an efficient management of the waste can be reached.

Many aspects of the construction waste management should be considered, both in the design stage and in the proper construction stage as well as in the demolition or re-construction phase. All the agents intervening in the construction process should be involved and concerned with these issues.

It is a fact that a good management is the one considering all the aspects of the construction activity and, in such a way, management of C&D waste can be improved and could be more adequately used. Finally, these aspects should be included in a Good Practice Manual where the waste management follows the principles of the waste hierarchy. Good practices involve going beyond the current baseline performance of the construction industry, which has historically focused on meeting its legal obligations only.

[2] Title: Construction and Demolition Waste Management in Turkey: A Review

Author: Hakan Arslan, Nilay Coşgun and Burcu Salgın

Journal: Intech Open Journal

Year of Publication: 2012

This Research paper study examines that recent construction and demolition waste management practices have incorporated with updated technologies to tackle modern challenges in the field of municipal solid waste management. This article has briefly described latest construction and demolition waste management technologies and parameters, which should be keep in consideration while choosing the technology for implementation. The article is especially useful, as it explored the latest, efficient, and environmentally sound technologies in the sector of municipal solid waste.

The aim of this article is to compile technologies recently introduced in the MSWM sector. CDWM is a network of storage-to-dispose activities. Developing countries should shift to the latest CDWM technologies to avoid environmental contamination and human health risks due to poor waste management by implementing 3R principles. The researcher covered these latest and innovative technologies briefly.

Recently developed countries have implemented the visionary concept of zero waste which is encouraging latest technologies of CDWM. While on the other hand in most developing countries waste management is a matter of least concern, which is causing severe environmental and health issues in those countries. The sustainable management of construction and demolition waste can reduce the short and long term environmental and human health hazards. Proper implementation of latest technologies in the sector of MSW management can play an especially important role in providing pollution free and sustainable environment.

Authors also concludes that a Construction and Demolition Waste Management (CDWM) plan should be created in every stage of the building production processes in order to take the necessary precautions to minimize the negative effects of construction wastes on the environment and human health. A CDWM System can be created through the integration of waste management plans with construction production within lifecycle process in every stage. By creating a CDWM System as part of the construction lifecycle, solutions at the national, local, institutional, and individual scale will become clearer. The stakeholder's role in each process can be summarized as; -

Legal Base for Waste Management Hierarchy: Laws and regulations should be made at a national scale; effective monitoring and control should be introduced; a measurement and verification system should be developed to establish the potential of C&D wastes;

integration potentials of C&DWM system and present implementations in Turkey should be determined; incentive policies should be developed, Regulations should be introduced to reduce the negative environmental effects of obtaining and using raw materials, their transportation and processing. Minimizing the raw material use will contribute to lower the global warming impacts through the production of these materials and their transportation to the construction site. National, regional, and local standards and codes should be established for recycled and salvaged materials.

Central and Local Government Initiatives and Role Distribution: Although the legal base will identify the role of government bodies it is important to implement and clarify the roles of the local and central government. Waste management need a governmental level approach for determining national goals but apart from that it is based on the local governments (municipalities) capacity and capability to manage the process. Decisions taken at local level should be implemented effectively, a database should be created to determine the potential of C&D wastes, and effective supervision and instruction should be implemented.

Sustainable Construction and Demolition Waste Management Systems: Recycling systems should be developed and supported at the national scale. The use of recycled and/or salvaged materials should be encouraged. Tax reductions should be used as a mechanism to encourage the use of recycled and salvaged materials. Reasonable price policies should be implemented for C&D wastes and classified waste materials should be charged with lower prices than the unclassified ones.

Institutional and Individual Action Plans: At an institutional scale, especially in construction/demolition organizations (including local recyclers and haulers), functional waste management departments should be created, wastes should be classified and properly disposed of, and effective supervision and instruction should then be developed. At an individual scale, waste management plans should first involve reducing the waste with source control optimization.

Clarifying Contractors/ Builders Responsibilities: Contractors' responsibilities for wastes should be clearly determined in pre-construction phase in contracts and supervised /controlled during construction. Contracts should require contractor’s responsibility to

follow the waste management plan at least results with 50% recycle and salvage option during construction for sustainable building(s) goals.

Educational and Research Activities: Interdisciplinary training programs should be developed and encouraged to raise awareness of construction waste management at a national scale for all the construction sector bodies. Research and development studies should be supported by the energy and construction related governmental organizations at a national scale to revise and sustain the existing waste management strategies.

[3] Title: Construction waste management in India

Author: Job Thomas, Wilson P. M.

Journal: American Journal of Engineering Research

Year of Publication: 2013

This study enlightens the importance of reduce, reuse, and recycle (3R) concept for managing the construction waste in India. The management of construction waste is important today. The scarcity in the availability of aggregate to produce concrete is one of the important problems facing by the construction industry. Appropriate use of the construction waste is a solution to the fast degradation of virgin raw materials in the construction industry.

Waste Generation in Construction Industry

All over the world, the growth of construction industry is enormous in the past decade. The pace of generation of C&D waste is also significant. In general, there are two sources for generation of waste materials, namely, bulk generators and retail or small generators. The classification of sources is given in Fig 3. The infrastructure development sector and real estate sector are the bulk generators of waste.

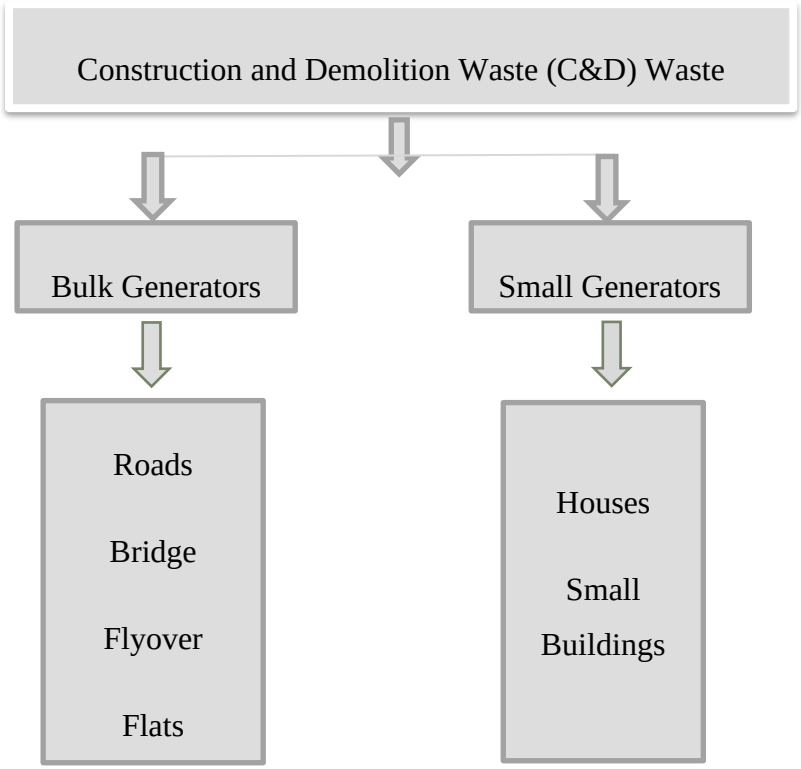

Figure 3 Sources of C&D waste generators

Construction and repair of roads, bridges, flyovers etc. are classified under infrastructure development sector. Real estate sector consists of housing, industrial, and commercial building construction, demolition of unauthorized structures etc. Small commercial enterprises and individual house building teams are considered as retail or small generators. The contributors of C&D waste in a project are given in Fig 4. The project activities are to be planned at every stage by every personnel, who are involved, to minimize the overall waste generation.

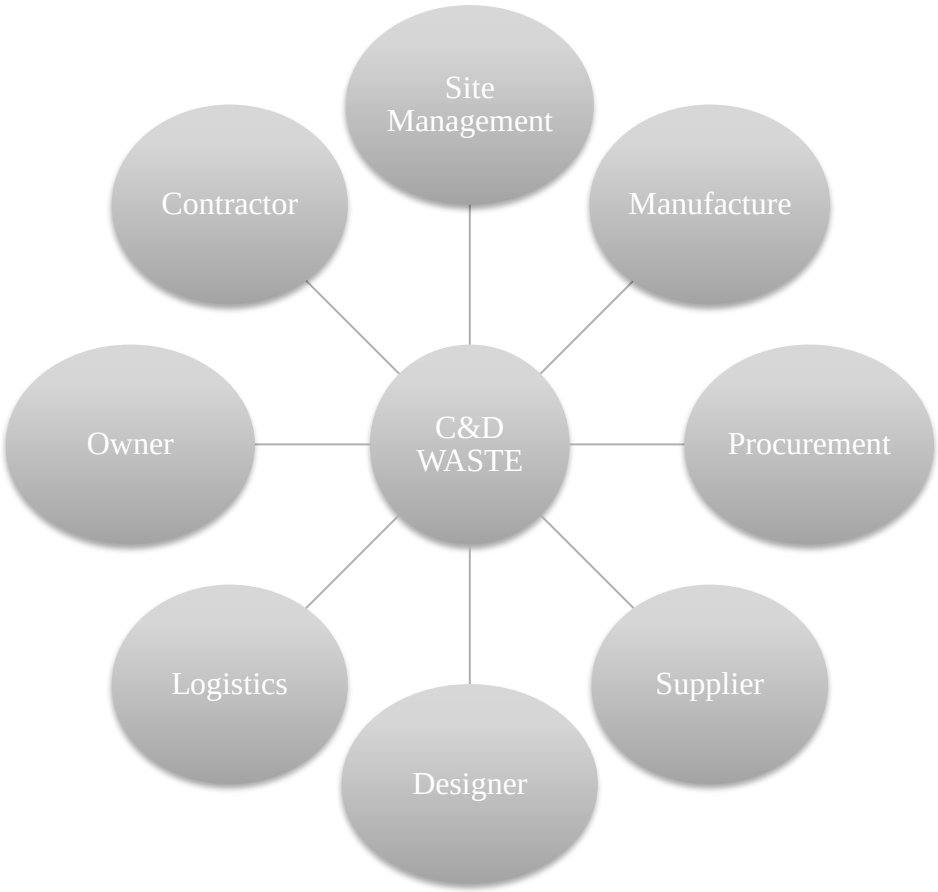

Figure 4. Contributors of C& D waste in a project

From the cost analysis of various modes of expenses in Indian construction industry, it has been seen that the component of material cost comprises nearly 40 to 60 per cent of the project cost. The material waste generation in construction industry is huge in monetary terms. Thus, cost saving potential for India is expected to be millions of dollars by adopting suitable measures for waste management. This is particularly essential for a development that responds to the challenges of environmental sustainability, low carbon emission and minimal resource depletion. The total quantum of C&D waste generated in India is estimated to 11.4 to 14.69 million tonnes per annum (TIFAC, 2000). The distribution of various components of C&D waste in India. The concrete, brick and masonry together constitute more than 50 percent of the total C&D waste. This shows the importance of developing C&D waste management plan for these components.

[4] Title: Integrated Solid Waste Management based on 3R Approach

Author: Mushtaq Ahmed Memon

Journal: Journal of Material Cycles and Waste Management

Year of Publication: 2010

This paper discusses the concept of integrated solid waste management aimed to reduce the risks to the public health and later environmental aspect was also become an important focus of SWM. One the one hand, 3R (Reduce, Reuse, Recycle) helps to minimize the amount of waste from generation to disposal; thus, manages the waste more effectively and minimizes public health and environmental risks associated with it. On the other hand, resource recovery is maximized at all the stages of CDWM.

Integrated solid waste management refers to the strategic approach to sustainable management of solid waste covering all sources and all aspects, covering in an integrated manner generation, segregation, transfer, sorting, treatment, recovery and disposal, with a focus on maximizing resource efficiency. Integrated solid waste management (ISWM) and 3R (reduction, reuse, and recycling) have become common terminology for solid waste management policy makers and practitioners. However, ISMW is synonymous with traditional municipal solid waste management (MSWM) in many countries. In some countries, ISWM is understood to be an integrated approach for managing municipal waste to optimize the efficiency of the services and to achieve objectives of 3R approach.

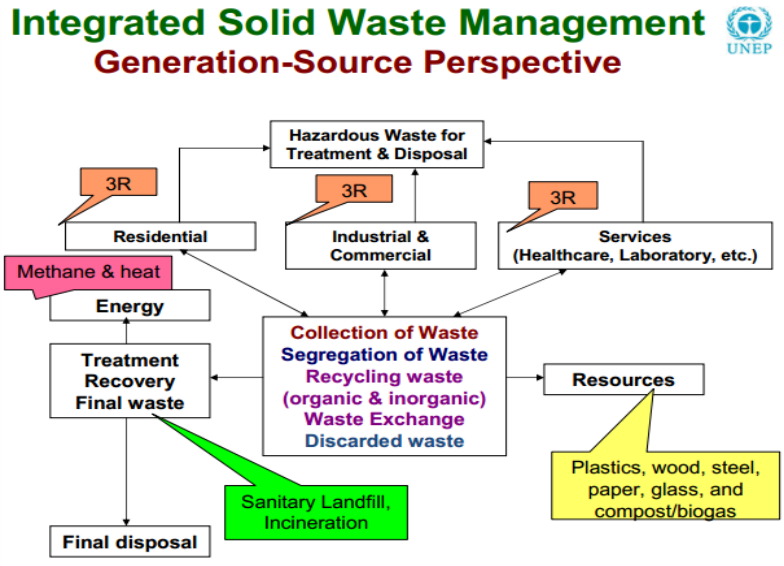

Figure 5 Concept of Integrated Solid Waste Management based on 3R Approach

The 3R-based concept of ISWM and the process of implementing ISWM in towns and cities. The 3R-based ISWM system clearly improves resource efficiency as all waste sources are managed under an integrated waste management system. For the management of special waste, such as hazardous waste, this is crucial. If separate sectors are managed, it would be a costly business. It could therefore be efficient and effective to put joint efforts under ISWM. For cities, this is a major challenge. In addition, resource recovery from one sector, such as the commercial sector, may not be significant in attracting investment in eco-industries or converting waste into a resource. Addressing all ISWM sectors could therefore be a remarkably effective tool for managing their waste efficiently. Implementation of ISWM is straight forward as local capacity building, supported by national and international initiatives, can lead to undertake all the actions locally, including waste characterization and quantification, assessment of current waste management system, targets for ISWM, identification of stakeholders' issues of concern, development of ISWM Plan and implementation strategy for ISWM.

2.5.1 Present Practices of C&D Waste Disposal

The common treatment methods of C&D waste are given in Fig 7. Among the various approaches, the manual separation is highly labour oriented, and the mechanical separation requires costly installations. The present waste handling practices adopted by the construction industry in India at different levels are:

- Items recovered during construction /demolition is sold in the market at a discount rate.
- The feasibility of recycling is not even considered seriously in most cases. Items that cannot be re-used are used for filling the land.
- Landfill tax is not imposed by the municipality.
- The waste is disposed without segregation.
- No penal action is taken against violators.

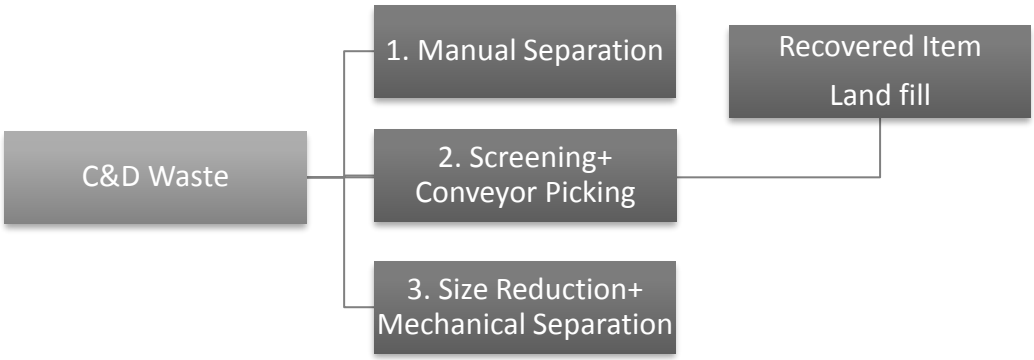

Figure 6 C&D Waste Treatment Method

The C&D waste management methods proposed by TIFAC (2000) are not practically implemented in most of the construction sites. This shows that the industry is not aware about the possibilities of cost savings from proper handling of C&D waste. In fact, higher construction productivity, save in time and cost can be achieved by proper implantation of C&D waste management system.

The '3R' Concept

Until last two decades, landfill was considered as the cheapest and convenient method of C&D waste disposal. But land filling is undesirable due to environmental and ecosystem hazards. Now most of the landfills are at the verge of arriving at its full capacity. Hence, more valuable lands may have to be employed in the future, which increase cost for C&D waste disposal.

Summary

The exploitation of potential resources from construction and demolition (C&D) wastes is yet another opportunity and future profession in the construction industry in India. Waste minimization and waste management programs are in its infancy in India. It is possible to minimize the volume of C&D waste generated by identifying the potential waste early in the

design. But even with proper resource-efficient design and by adopting proper construction and deconstruction procedure, some waste may essentially be generated in every project.

2.5.2 Hierarchy in waste management

According to United Nations Environment Programme (UNEP), waste management includes both the components of prevention and disposal of waste.

The waste management hierarchy can be traced back to the 1970s, when the environment movement started to criticize the practice of disposal-based waste management.

It argued 'waste' that is made up of different materials should be treated differently as suggested:

a. Reduce its production

b. Explore its reuse and recycle potential

c. Final disposal

The same is echoed in India's waste management handling Rules either directly or indirectly and it includes C & D wastes.

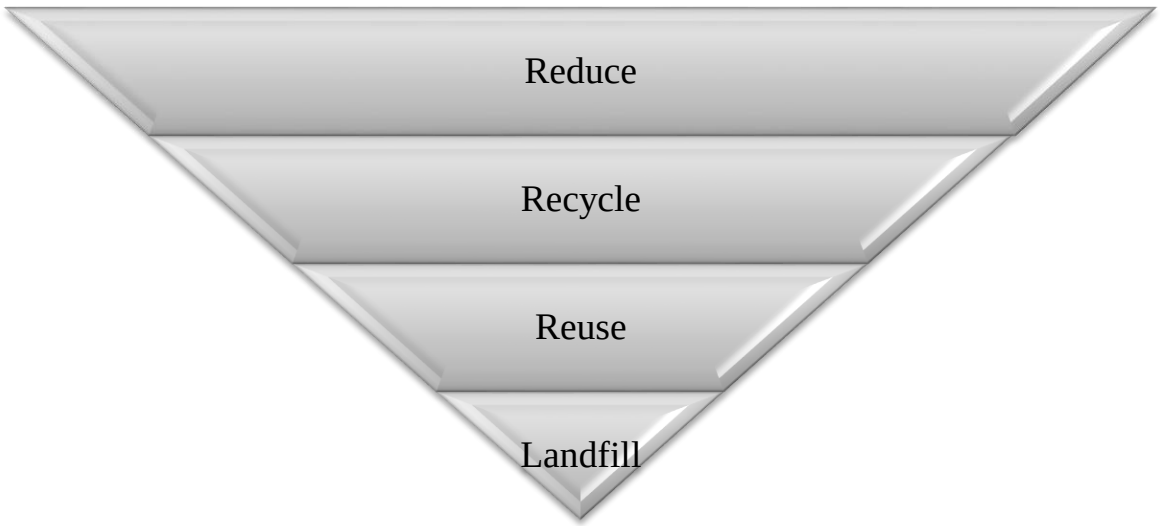

Figure 7 Sustainable C&D Waste Management Hierarchy

2.5.3 Effects of C&D Waste

Construction activities occur to build/rebuild new structures or old structures. Demolition activities are growing due to old structures needing restructuring or replacement with time

to make way for vertical structures or flats in line with growing needs of the society. All such activities generate C&D waste. Disposal of such debris in a safe environment is a big challenge for the builders, developers, and owners. When on one hand the disposal of debris is a challenge, then, on the other hand, there is an acute shortage of naturally available aggregates for the construction of buildings. Reduction of this demand is possible only with the reusing or recycling of waste generated from the construction activities.

Construction, renovation, and demolition projects create environmental and economic problems in addition to waste. These include depletion of already diminishing natural resources, air and water pollution from waste that is improperly disposed of, and, for many state and local governments, pressure on premium landfill space and taxpayer money. As virgin materials become scarcer and more costly, some increased recycling of construction, renovation, and demolition waste has occurred, but most of these materials continue to be discarded. Moreover, many types of construction materials and demolition waste contain persistent, bio-accumulative toxins (PBTs) and other hazardous substances. Typically, demolition activity is undertaken by specialized demolition contractors who bring their own equipment and personnel and transport the residual waste. The property owners

The deterministic cost estimating method is not flexible in estimating. There for their result have some variations. Probability estimating method identifying the cost factor, limit range and associated probability distribution of the element. With simulation process like Monte Carlo, oracle, three-point estimate and triangulation method. Probability distribution running large iteration of different combination for each probability of cost associated with the overall project. The property owners pay fee to the demolition contractors, which is decided based on the recoverable value of recycled materials – steel, wood, glass, pipes etc. by demolition contractors. The environmental impacts of unmanaged C&D waste are evident. Waste to resource approach towards recycling C&D waste brings great benefit. Environment and Social Impacts of Unmanaged C&D Waste include:

 Impose strain on landfill needs.

 Hazardous portion of waste, such as asbestos, could lead to potential harm to the environment and public health issues.

 Illegal dumping affecting the bio-habitat of dump area and creates potential public health issues such as mosquito breeding.

 Potential high value of recycled material not tapped and gets buried in landfills or illegal dumps leading to economic loss.

 Increasing quantity of C&D Waste leads to un-sustainable situation.

 Reliance on mines and natural sources for building material leads to escalating price, un-sustainable supply, and high transportation costs.

To address the problems of resource depletion, increasing demand for building materials, societal awareness on pollution effects (dust, pollution due to traffic congestion owing to roadside disposal) of C&D these rules were framed.

2.6 Conclusion

Based on the critical literature review several points can be preliminarily concluded:

1) For site factor, five factors were identified from the previous work as: Theft, vandalism, damage of materials on site, unnecessary inventories in site, rework, Improper cutting of materials.
2) For Environmental factor, four factors identified: Waste disposal, weather conditions, improper land filling and act of god.
3) For economical factor, five factors identified: separation of sources, transportation cost, and cost of waste disposal, labour of waste disposal, labour of waste disposal, labour cost, and recycling cost.
4) For technical factor, eight factors identified: Lack of supervision, poor storage facilities on sites, error in design, design changes, human error, lack of communication on sites, lack of waste management, and ineffective method of work

Chapter 3 A Case Study of Surat City

CHAPTER 3

A Case Study of Surat City

3.1 Introduction

Surat is a city located on the western part of India in the state of Gujarat. It is 2nd largest city of Gujarat in terms of Area and Population. India's 8th most populous city. It is the 73rd largest urban area in the world.

Diamond city Surat's population grew from 2.8 million in 2001 to 4.5 million in 2011 — a phenomenal rise of 58.68%.

Surat ranks 4th fastest growing city in a global study of fastest developing cities conducted by The City Mayors Foundation, an international think tank on urban affairs. In fact, it is the fastest growing Indian city in terms of economic prosperity.

Surat gained fame and recognition for being the '3rd Cleanest City' in India in 2011, awarded by INTACH. In 2013 Surat was conferred with two awards 'Best Urban City of India' and 'Best City to Live in India' constituted by Annual Survey of India's City-Systems (ASICS). UK-based charity, The Ecological Sequestration Trust (TEST) in 2013, has selected Surat as one of the three cities in the world, to be developed as 'Global Eco-cities'.

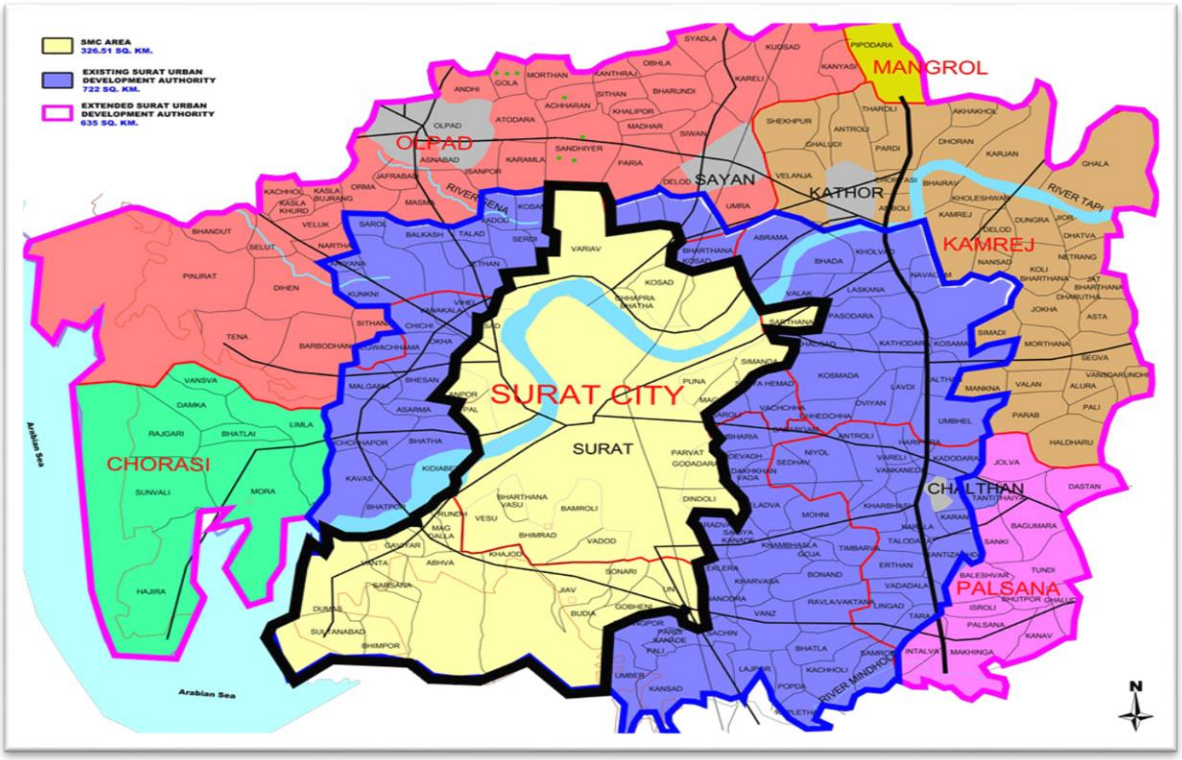

Figure 8 Map of Surat City- SMC Limit

(Map Source: Surat Municipal Corporation website)

3.1.1 Demographics of Surat City

Table 3 Demographics of Surat City

Total Area	326.515 Sq.km
Total Population	44,66,826
Population density	13,680 persons / Sq.km
Sex Ratio	756/1000 MALE
Literacy Rate	87.89 %
No. of Zone	8

(Source: Census data of India 2011)

3.1.2 Economy Profile of Surat City

Table 4 Economical Profile of Surat City

Indicator	City (Municipal Corporation)
Per Capita Income (Rs.) at 2004-05 constant price	*NA
Urban Poverty Ratio (% of urban population)	5.61
Unemployment Rate, 2011-12	0.29
Work Participation Rate, 2011-12	42.20
Work Status, 2011-12(%)	
Self-employed	37.10
Regular/wage salaried employees	57.05
Casual labour	5.85
Sectoral Distribution of Workers, 2011-12(%)	
Primary	0.28
Secondary	66.10
Tertiary	33.63
Workers Classified by Major Occupation, 2011-12 (%)	
Legislators, senior officials, and managers	27.93
Professional	1.79
Technicians and associate professionals	6.05

Skilled agricultural and fishery workers	0.00
Plant and machine operators and assemblers	34.46
Major Industries	Machinery Machine tools and its parts Textiles Chemicals and petrochemicals products Diamond
No. of sanctioned SEZ	1

(Source: * Directorate of Economics and Statistics of respective State Governments and for all India-Central Statistics Office)

3.2 Overview of Construction and Demolition Waste in Surat

Although the demolition activities in Surat are not tracked, the construction permits throw some light onto the quantum of demolition activities. As per the data shared by Environment Cell, SMC, about 5700 permits were issued for construction of buildings in 2014-15; approximately 50 % of which were reconstructions projects with associated demolition activities. In addition, 40-45 permits were issued for major renovation while minor renovations are done without even applying for permits.

As per the new set of building by- for the walled city laws are anticipated, SMC proposes to change vacant plots of government and buildings which are old into parking spaces. This will lead to demolition of buildings, generating large quantities of Constructional and demolished waste. On an average SMC there is estimation approximately 330 tons that of waste of constructional and demolishing is created per day in Surat city.

However, the actual generation is likely to be higher as the data received by Environment Cell, SMC does not cover generation from demolition carried out without permits. The demolition is carried out through mechanical processes and the valuable materials are segregated onsite and sold off for in the secondary market. The Major amount of Construction and Demolition Waste are later transported and collected by private company which is assigned and contracted for recycling of C&D waste and used for recycling process at site designated by SMC.

As per estimates more than 40.75 million tons of C&D waste is generated in India per year out of which 330 tonnes per day generated from Surat City. Construction and demolition waste are constituting 15 – 20 % of total waste collection from Surat City as per the graph below. There is approximately 330 ton/day of construction and demolition waste is generated in Surat which is shown in figure 9. as below:

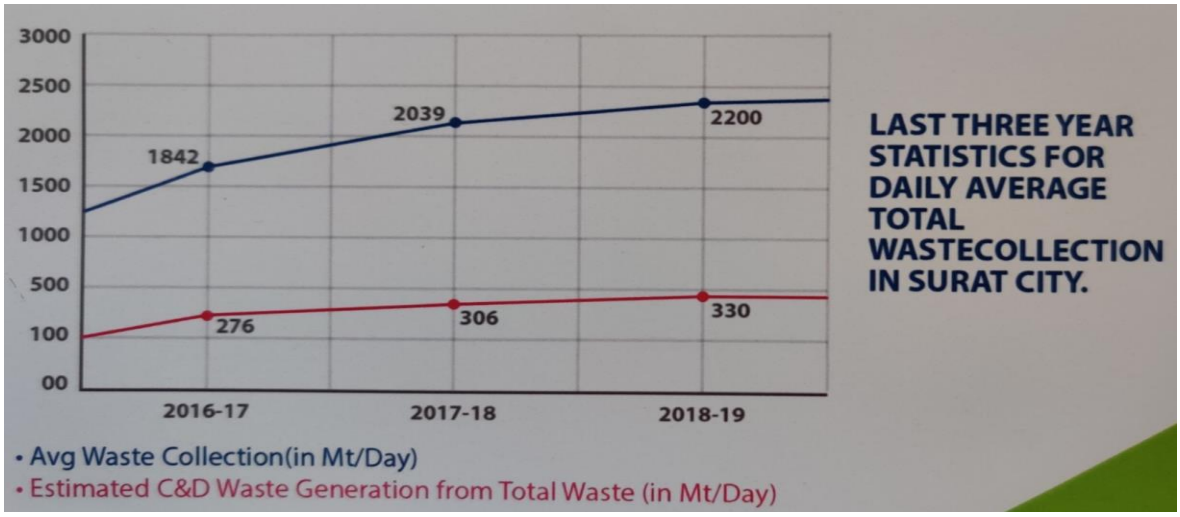

Figure 9 C&D Waste Generation in Surat

The model of Constructional and demolished waste management in Surat is based on Public Private Participation (PPP).

Currently the ground scenario is that Constructional and demolished waste is actively dumped in 10 designated dumping sites as large amount of Constructional and demolished waste is created in the vicinity of these sites as. Collection of Construction and Demolition Waste is fully operational by the private company. Transport of waste is done by trucks owned by company.

3.2.1 C&D Waste Management in Surat

The model of C&D waste management in Surat is based on Public Private Participation (PPP). Surat Green Precast Pvt. Ltd (SGPPL) is managing and processing all C&D waste in the city. SGPPL charges SMC ₹ 160/ton for less than 5 ton and ₹ 333/ton tipping fee to pick up waste from any of the 10 designated dumping sites from over the 8 administrative zones in the city.

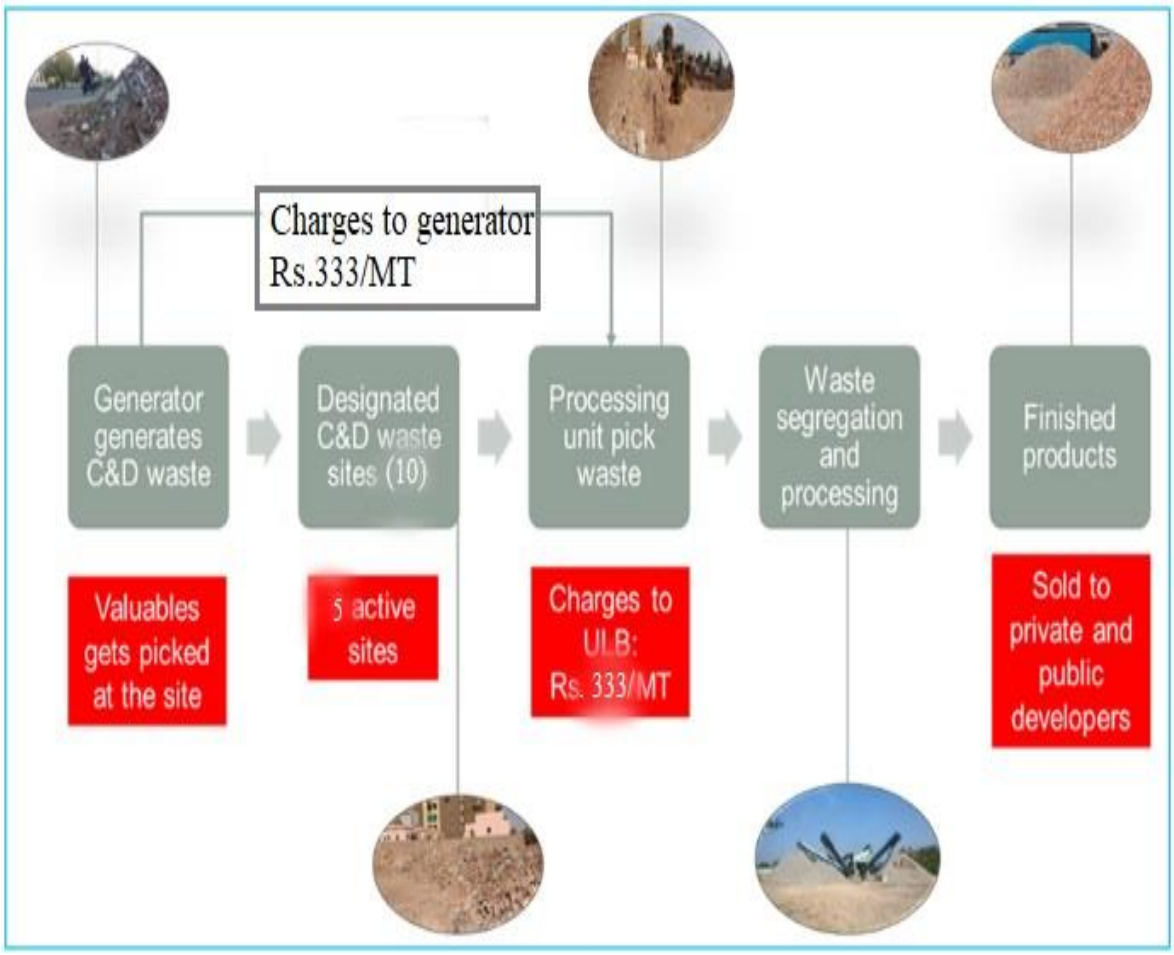

Chart 2. C&D Waste Management Practice in Surat

SGPPL is responsible for transporting the C&D waste from the collection points to the processing facility, whereas the generator is supposed to dump the C&D waste at any of the 10 designated dumping locations.

Collection and transportation of C&D waste from different unauthorised locations to the designated collection points is also carried out by SGPPL and it charges the SMC for

collection and transportation of C&D Waste from the collected designed centres to the recycling management facility.

There are total 10 designed dumping sites in over the 8 administrative zones in the city. SMC-Designed C&D Waste Collection Centres is shown in Table 6. below:

Table 5. SMC-Designed C&D Waste Collection Centres

Sr. No	Name of Zone	Collection Centre
1	Central	Rudrapura Technical Vahan Depo
2	East-A	TP 16, Kapodara, FP 14
3	East-B	TP 22,FP 66, Sarthana (Valak)
4	West	44 Jahangirabad FP 47 District Centre
5	North	Kosad C&D Waste Plant
6	South	TP 1, FP F 122, Beside Sosiyo Circle
7	South West	1) NR. DGVCL Office, Aventis farm 2) Uttar Gujarat Vahan Depo
8	South East	1) TP 61 FP61 Man Society Road, Godadra 2) Near Ashtik Party Plot, Parvat Patiya

(Source: Environment Cell, Surat Municipal Corporation)

3.3 Recycling Unit for Processing and Utilization of Construction and Demolition Waste

In Surat, currently material streams in C&D waste of immediate market value like metals, wood frames, etc. are recovered for the secondary market (usually by the informal sector), while the rest of debris and constructional and demolished waste is left behind which into collection from the designed collection centres in the city from all 8 administrative zones located in the city. While a small fraction of this debris is used for backfilling and as daily landfill cover, most of it is not utilised which cannot be take into the consideration of recycling process for C&D waste management facility. Surat has successfully set up C&D waste processing facilities that are manufacturing a wide range of recycled products from the construction and demolition waste materials. As required for city under the new Rules and Regulation, such processing units has been established of 300 TPD/day capacity for recycling and management facility in the city.The entire process for handling of collected C&D waste in the city of Surat is allocated the work by SMC to Surat Green Precast Private Limited (SGPPL).

SGPPL has successfully commenced the plant since February 2019. SGPPL capital investment for this project is more than 12 Crore.

Table 6. C&D Waste Recycling Unit in Surat

Sr. No.	Name of Company	Daily Treatment of Final Product	Work given in the year	Agreement Period	Land Acquired	Project Capital Cost (Indian Rupees)	Operational Since
1	Surat Green Precast Private Limited (SGPPL)	300 TPD Recyclable products like Sand, Aggregates, etc.)	2016	20 years	3 acres	12 crores	February 2019

3.4 Technology for Processing of C&D Waste

In Surat, mostly C&D waste debris basically consists of debris of concrete, mortar, bricks and tiles, the processing usually just involves crushing, downsizing the material, washing and sieving it into uniform size aggregate particles, that can substitute primary aggregates in the construction market. The processing method is remarkably like a stone crushing process and uses the same machinery and equipment used in the stone crushing industry.

The basic steps and simplified flow chart for processing C&D waste are depicted in Figures.10 & 11.

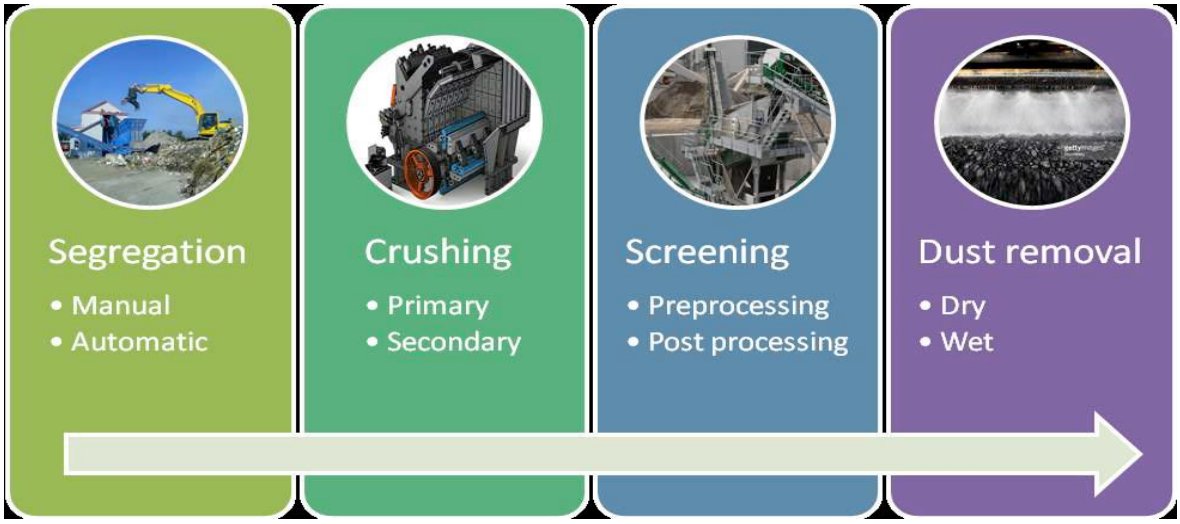

Figure 10. Major Steps in Processing of C&D Waste

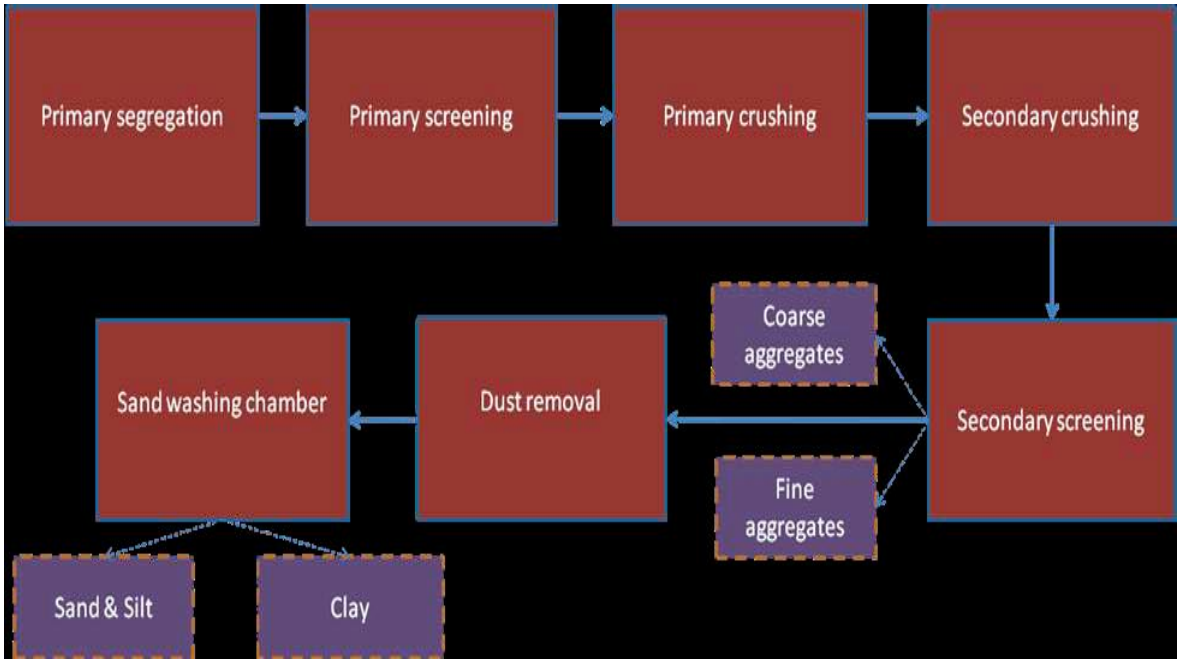

Figure 11. Process Outlay for Processing of C&D Waste into Secondary Raw Materials

SGPPL processing facility is operational for C&D processing on the basis on the Stationary crushers.

Stationary processing unit

Stationary C&D waste processing unit is an assembly of crushing, sieving, and washing machinery interconnected by conveyer belts for material movement. The machinery is housed on steel/concrete platforms on a permanent basis. The crushing units consists dust control systems, noise control systems, magnetic separator devices and other additional devices based on requirements. The systems implemented by SGPPL for processing C&D waste developed completely on automated units. The capacity of stationary processing units is of 500 TPD.

Figure 12. C&D Waste Processing Facility with 300 TPD Capacity, Surat

(Source: Surat Green Precast Pvt. Ltd., Surat)

Chapter 4 Data collection and Analysis

CHAPTER 4

Data Collection and Analysis

4.1 Data collection

Neural network models would really like a lot of historical data to administer an honest estimate. Therefore, this section includes information resources and obstacles that are featured inside the information assortment technique. The data collected was improved to be smart for building the models. Presenting data may be a crucial approach for this chapter so it's presents but and from where the data is collected. Then the collected info is improved and analysed.

4.2 Manufactured Sand (M-Sand)

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from construction and demolition waste material by crushing process at recycling plant of C&D waste management facility.

The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm. Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed.

Thus, the cost of construction can be controlled using manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the

sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

Manufactured Sand is categorized into two categories:

(1) Plaster Sand
(2) Concrete Sand

Figure 13. Collected Sample of Plaster Sand and Concrete Sand

(Source: SGPPL, C&D Waste Management Facility, Surat)

4.3 Recycled Aggregates

Recycled aggregate was arranged from site of Surat Green Precast Private Limited at Kosad, Surat. The use of recycled aggregates not only reduces the usage of virgin aggregate but also provides an alternate to the problems of landfills piling up.

The use of recycled aggregates could address the demand of virgin aggregates and mining of depleting natural resource also may reduce. In this way we can employ 3R's of sustainability namely - reduce, reuse, and recycle. By using such methods, it helps in reducing the amount of waste generated, reusing the material which otherwise would have been wasted and recycling some of the other materials to utilize that in a better way.

The use of recycled concrete aggregates as an alternative aggregate material in concrete has been studied over the past two decades. It is now recognized that the recycled aggregate concrete (RAC), where natural aggregates are replaced with recycled concrete aggregates, is a promising technology for conserving natural resources and reducing the environmental impact of concrete. Figure shows the collected sample of recycled aggregates.

Figure 14. Collected Sample of Aggregate + 20 to 40 MM & Aggregate + -20 MM

(Source: SGPPL, C&D Waste Management Facility, Surat)

4.4 Data Resources

Data collection took a lot of time and great effort because of the great number of data sources of information from ULB, SGPPL and online source. Table 10 (**Error! Reference source not found.**) presents the main sources of data that have been obtained shown in **Error! Reference source not found.**

Table 7 Source of Data Collection

Organisation
Surat Green Precast Private Limited, Surat
Environment Cell, Surat Municipal Corporation, Surat

4.5 Data Analysis

Input Data are vital, it failed to got to be continual or doesn't offer identical which means during this section, the amount of lane and dimension of the roadway, typical cross section offers identical which means, when removing outliers of information AN analysis of the improved data is conferred. This includes the distribution of information consistent with the factors and budgeted value or actual cost of project. the primary input issue is that the kind of project, which has 3 choices; Project Scope New/widening and Improvement project,

variety of lane, Length of road, Right of means, kind of pavement, New a decent soil CMBR, piece of land kind. Thickness of pavement, Overlaying, dimension of made-up Shoulders (WPS) & dimension of exhausting Shoulders (WHS), Cross drain structure (CDS), protection work, length of project and value of project **Error! Reference source not found.** (**Error! Reference source not found.**) presents the number of projects for each scope and the percentage of each to the total number of projects. Type of Project factor includes Three types (1) National Highway (2) State Highway (3) Major District Road. Rate Analysis of Recycled Aggregates with Natural Aggregates is shown in Table 9 as below:

Table 8. Rate Comparison of recycled aggregates with natural aggregates

Test Parameters	% passing as per IS 383:2016					
Particle Size (IS Sieve in mm)	20 mm		10 mm		Fine Sand	
	Natural	Recycled	Natural	Recycled	Natural	Recycled
12.5	18	100	100	100		
10	3	93	93	88	100	100
4.75	0	13	13	0	97	100
2.36	-	2	2	0	93	99
1.18	-	-	1	-	82	73
0.6	-	-	0	-	55	51
0.3	-	-	-	-	12	25
0.15	-	-	-	-	1	10
Specific Gravity	2.867	2.462	2.849	2.558	-	-
Water Absorption (Max 2.0%) (as per IS 2386:2016 (PART 3)	1.03	1.90	1.12	1.8	0.56	0.60
Fineness Modulus (as per IS 2386:2016 (PART 1)	-	-	-	-	2.91	2.42
Combined Flakiness & Elongation Index Max. 40 %	37	38	-	-	-	-
Impact Value Max. 45 %	18	26	-	-	-	-
Grading Zone	-	-	-	-	II	II

Chapter 5 Experimental Planning, Material and Its Properties

CHAPTER 5

Experimental Planning, Material and its Properties

The study being deal with in this search is the casting and testing of a concrete paver block with the partial replacement of recycled aggregates from processed C&D waste in place of naturally availed fine aggregates. A methodology for casting and testing the paver block made by processed construction and demolition waste that mean by recycled aggregates that is manufactured sand (M-Sand) has been used to effectively utilization of construction and demolition waste material for its recycling process in terms of implementing reuse concept and cost optimization for the finished products in use of construction industry for sustainable development. This methodology incorporates five main phases:

[1] Assortment of Tool
[2] Design Structure
[3] Model implementation
[4] Training and Testing
[5] Discussion of results

5.1 Design of Concrete Paver Block

5.1.1 Paver Block

Concrete paving block is a building material used for laying pavements, footpaths, and other kind of exterior pathways for pedestrians and for vehicular movement. They are widely accepted for their aesthetic features and ease of laying.

They are available in various sizes, shapes, colours, and strength grades (concrete mix) depending on the utility and aesthetic requirements. Some specific designs like the Interlocking type of I-shaped 60mm thick paver block and Zigzag shaped 80mm thick paver block are always in demand in the market due to their interlocking properties (does not need

binder) and load bearing properties while other designs like grass pavers, square pavers, etc are made only according to order and as per client requirements.

In Surat, it is observed that most of the paver block units are small or medium scale units which manufacture paver blocks in their own specific mix designs since the quality is rarely checked and more preference is given by clients to cost of the products. 10mm aggregates are used as coarse aggregates and river sand is used as fine aggregates, dust is sometimes used for colour mixing for the top surface and some time it is not.

The change in raw materials includes use of 10mm recycled aggregates for coarse materials and M-sand for fine aggregates. It is by consideration that manufacturing of I shaped 60mm paver blocks (since from the market analysis it was observed that this is one of the most commonly manufactured kind of paver block which is made and stocked due to market demand).

5.1.2 Experimental Planning

For this experiment different specimens are to be made by partial replacement of recycled aggregates and manufactured sand with the availed natural aggregates in partial replacement of 0 %, 20%, 40%, 605 and 80% respectively by casting of interlocking type of concrete paver block in size of 200 mm × 100 mm with standard thickness of 60 mm. The same to be checked for its different testing parameters at 7 day and 28 days.

Initially the colour and concrete is mixed in a colour pan mixer and poured to a thickness of an average 5mm for surface colouring and vibrated in rubber or fibre mould to remove air gaps. Later the concrete mix is prepared in a concrete pan mixer and poured into the mix and vibrated in a second vibrator. The pavers are cured inside the mould for one day and then taken out after which final curing happens over a period of 10 days.

5.2 Material

5.2.1 Cement

Among the various kind of cement, the cementations material used in all mixtures is ordinary Portland cement – 53 Grade (OPC-53 Grade). The physical and chemical

properties of the physical and chemical properties of the cement are described as follows:

Table 9. Chemical Properties of Cement

A. CHEMICAL PROPERTIES			
Sr. No.	**Particulars**	**Test Result Obtain**	**Requirement as per**
1	Lime Saturation Factor ((SFL)	0.91	0.80 to 1.02
2	Alumina to iron Oxide Ratio % (A/F)	1.22	0.66 (min.)
3	Insoluble Residue (% by mass)	0.84	3.0 (max.)
4	Magnesia - MgO (% by mass)	3.46	6.0 (max.)
5	Sulfuric Anhydride – SO3 (% by mass)	2.38	3.0 (max.)
6	Total loss on ignition (% by mass)	1.38	4.0 (max)
7	Maximum Chloride (% by mass)	0.04	0.10 for normal mix

Table 10. Physical Properties of Cement

B. PHYSICAL TESTING			
1	Fineness (Blaine) 1. Specific surface (m2/kg)	318	225 (min.)
2	Soundness: Expansion by 1. Le-chatelier Method (mm) 2. Auto clave (%)	1.6 0.13	20 (max) 0.8 (max)
3	Compressive strength (MPa) 1. 3 day 2. 7 day 3. 28 day	38 47 63	27.0 (min) 37.0 (min) 53.0 (min)

5.2.2 Fine Aggregate

The fine aggregate used throughout the experimental investigation were alluvial sand from two different sources. Sieve analysis of fine aggregate was performed on both the samples to determine the particle size distribution of fine aggregate. Sieve analysis was also done for dividing the sample of aggregate into different fractions, each consisting of the same size. The sieves used for the sieve analysis of fine consist of a series of a series were as follow: 4.75 mm, 2.36 mm, 1.18 mm, 600 μm and 150 μm. Weight of the fine aggregate sample was taken as 1.0 kg, for both the sand from different sources.

This wet sample was kept in oven as 1.0 kg. This wet sample was kept in oven for 24 hours at 105º C temperature to be air-dried to avoid lumps in the sample. The actual sieving operation, of shaking of sieves, was performed manually.

Fineness modulus is defined as the sum of the cumulative percentage

retained on the sieves of the standard series from 4.75 mm to 150 μm. As describe from Table fineness modulus of sample was 2.98. As per IS: 383-1970 grading zone of fine aggregate was confined as Zone II for sample.

Table 11. Properties of River Sand

Sieve Size	Weight Retain (kg)	Cumulative weight retain (kg)	Cumulative percentage weight retain (%)	Cumulative percentage passing (%)
4.75 mm	0.002	0.002	0.2	99.8
2.36 mm	0.061	0.063	6.3	93.7
1.18 mm	0.375	0.438	43.8	56.2
600 mic	0.221	0.659	65.9	34.1
300 mic	0.223	0.882	88.2	11.8
150 mic	0.06	0.942	94.2	5.8
Receiver	0.058	1	-	-
Total	1	-	298.6	-

The physical properties of fine aggregate, i.e. porosity, water absorption and specific gravity, would affect the workability of fresh mix. So, it is necessary to define these properties to understand the results of the mix properly. The absorption of the fine aggregate was obtained by oven-drying method as the increase in mass of an oven dried sample, when it immersed in water for 24 hours. To define water absorption of fine aggregate of wet sample was oven dried for 24 hours at 105º C. Then weighted oven dried sample was immerged in water for 24 hours. Finally, the sample was weighted in their saturation surface dry (SSD) condition.

5.3 Mix Design

The standard mix ratio adopted in this experiment is the mix design suggested as per IS standards for manufacture of M30 grade equivalent paver blocks. Mix Proportions for casting of concrete paver block of M30 grade is shown in Table 10 as below:

Table 12. Mix Design

% Replacement of C&D Waste FA	0%	20 %	40 %	60 %	80 %
Cement	416	416	416	416	416
Water	262	262	262	262	262
Fine Aggregates	1019	815	611	407	203
Fine C&D Aggregates	0	176	354	531	708
Coarse Aggregates	928	928	928	928	928

Chapter 6 Experimental Results and Discussion

CHAPTER 6

Experimental Results and Discussion

6.1 Compressive Strength

Compressive Strength of concrete paver block is defined as the Characteristic strength of its standard size cube at 28 days. Samples for the test comprises of Casted Paver Block 200 x 100 x 60 mm casted for all design mix as per BIS 516 and tested at the age of 7 day and 28 days.

Table 13. Compressive Strength Result

Percentage replacement of C&D Waste Fine Aggregate	No. of Specimen Tested	Average Load obtained (KN)	Compressive Strength of paver block (N/mm2)
0	8	1935.63	40.42
20	8	1944.83	31.35
40	8	1967.33	35.67
60	8	1958.70	36.98
80	8	1916.93	29.48

(Source: Test Conducted at Bhumi Research Centre, Surat)

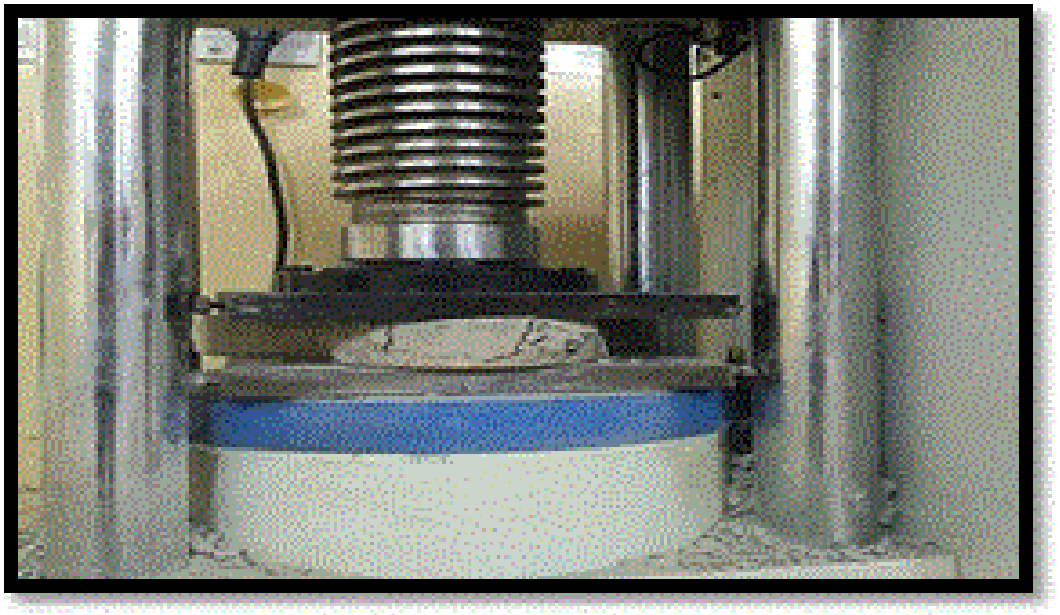

Figure 15. Compressive Strength

6.1.1 Discussion Compressive Strength Test Result

All sample shows satisfactory result for compressive strength incorporating recycled fine aggregate with partial replacement of natural fine aggregate.

With increasing the percentage of replacement of manufactured sand in a place of natural fine aggregate, the compressive strength increases at certain limit with 60 % replacement and decreases with further replacement M30 grade of concrete.

Strength of Paver Block in M30 grade of concrete 60% replacement of manufactured sand with natural available sand give better performance.

6.2 Flexural Strength

It was noted 4.8 Mpa which is greater than 4.5Mpa. It is satisfied minim requirement.

Figure 16. Flexural Strength

6.3 Abrasion Resistance Test

Table 14. Abrasion Resistance Result

Abrasion Value (mm)	Age Days	Variation of % replacement of FA				
		0	20	40	60	80
	28	2.31	2.31	2.32	2.31	2.32
	56	2.32	2.30	2.31	2.30	2.30

6.4 Cost Analysis and Comparison

Cost Analysis for 60 % Fine Aggregate Replacement for 1 cum concrete					
Grade M30-Conventionl Concrete					
Sr. No.	**Item**	**Unit**	**Rate per**	**Quantity**	**Total**
1A.	**Material**				
	Cement	**Bag**	**300**	**8.32**	**2,496**
	CA	**Kg**	**0.6**	**928**	**556.8**
	FA (Natural)	**Kg**	**0.55**	**1019**	**560.45**
	Sub Total-A				**3613.25**
Grade M30-Concrete replacing by Recycled C&D Waste Fine Aggregate					
Sr. No.	**Item**	**Unit**	**Rate per**	**Quantity**	**Total**
	Material				

1B.	**Cement**	**Bag**	**300**	**8.32**	**2,496**
	CA	**Kg**	**0.4**	**928**	**371.2**
	Natural FA	**Kg**	**0.55**	**407**	**223.85**
	FA (C&D)	**Kg**	**0.350**	**612**	**214.2**
	Sub Total-B				**3305.25**
	Diff. in RA(A-B)				**308**

Chapt0er 7 Discussion of results, conclusion and future scope

CHAPTER 7

EXPERIMENT RESULTS AND DISCUSSION

7.1 Conclusion

The C&D debris is a source of construction material. Technologies for its processing are well developed and plant and equipment are available for processing of this material for smallest quantity to a large quantity. The quality of produce of processed C&D debris has been found to be acceptable for building construction, road construction and for manufacture of downstream products, not only in India but worldwide. Gainful utilization of this material provides eco-friendly and economical constructions.

By the above results we can deduce that the paver block manufacturing by using C&D has similar kind of load bearing capacity than the traditionally availed paver block. With increased compressive strength less C&D Paver Block are required to bear the required load which in turn will help in saving overall cost of the finishing items in construction. Using such paver block by utilization of construction and demolition waste at its effective way helps in reducing the exploitation of the natural resources which will help in achieving the sustainable development goals in construction industry.

Employing products made by using and utilize construction and demolition waste abstain the disposal of waste on the otherwise usable lands which is beneficial both ecologically and economically. The clear benefit is the natural resources savings, often energy and CO2 emissions savings. It is observed and obtained that higher compressive strength was achieved when 60% fine aggregate was replaced by C&D waste fine aggregate It has also conclude that all the properties of C&D waste fine aggregate are within permissible limits. C&D waste fine aggregate and recycled concrete is 3.28% more economical than conventional concrete. This causes up to 25% saving in cost of fine aggregate if 60% FA is replaced by manufactured sand per cubic meter of concrete. By this study it can also be conclude that a large quantity of construction and demolition waste material can be reduced, recycled, and reused efficiently in manufacturing different products construction industry. C&D waste

processing into recycled products can generate employment through new enterprises. Utilisation of recycled products from processed C&D waste helps relieve pressure on natural resources by reducing extraction of virgin materials like sand. The biggest environmental issues can be reduced such as unauthorised dumping of C&D waste in wetlands or stream/river channels disrupts local hydrology, associated ecosystems and piles of C&D waste contribute to particulate air pollution when carried by wind.

7.2 Recommendation

The use of C&D waste also needs to be upscale through developing better awareness on the use of C&D waste as a secondary raw material and its potential to generate income.

The awareness has to be spread among different stakeholders including the ULB, stone processing unit enterprises, construction material manufacturers, builders, architects and even waste generators in order to develop sense of ownership, develop capacities and initiate action from all the stakeholders.

Awareness activities in form of round table meetings, stakeholder awareness workshops, capacity development workshops, circulars (from ULB to contractors and public), and other mass community mobilisation programs can be organised by SMC.

More research and development activities need to be initiated focused on use of fine particles (silt and clay) and other inert materials of C&D waste into recycle and reuse of construction and other allied sectors.

The public enterprises invest in for the business cases on a model pilot scale on a PPP model which would encourage more enterprises to adopt the business models, resulting in better efficiency in C&D waste recycling and finished products manufacturing in the city.

7.3 Future Scope

(1) Use of C&D waste in structural concrete.

(2) Various techniques for on-site sorting of C&D waste.

(3) Use of sustainable Paving Block for traffic roads.

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Appendix A: Plagiarism Certificate

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Document Information

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Appendix B: Collected C&D Waste & Its Application

Appendix C: Products from C&D Waste Processing

Recycled Sand

Recycled Aggregate

Appendix D: Tipping Fee & Containers Specifications

TIPPING FEES TO BE PAID BY AUTHORIZED AGENCY FOR DISPOSAL OF WASTE AT DESIGNATED DISPOSAL SITES:

C&D WASTE VOLUME	**ILLUSTRATIVE RATES, (Rs/Container)**
Container (<3 m3)	90
Container (6 m3)	180
Container (9 m3)	270
Container (>12 m3)	360

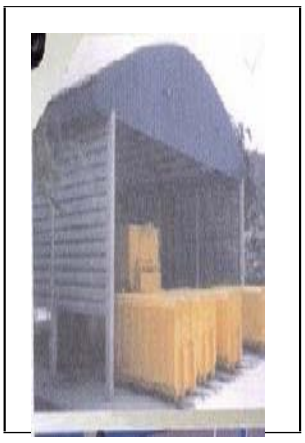
SPECIFICATIONS OF TYPICAL CONTAINERS TO BE USED FOR STORING C&D WASTE

	Model		
Container Specification	**Hook Loader**		**Dumper Placer**
Container Type	**Closed**		**Closed**
Volume (m3)	9	12-16	1.5*, 2.5-3.5**, 4.5-5***
Material of Construction	Commercial Mild Steel of Appropriate IS specification (Not less than 3mm for walls/sides and not less than 4mm for floor/bottom)		
Recommended Chassis	16-25 T GVW		7*, 9**, 12*** T GVW
Lifting Arrangement	Rear lifting		Rear lifting

Dimensions of the containers to adhere to the RTO norms. Total loading not to exceed GVW. The containers shall have integral securement system to ensure that the rear end of the container is well secured with the vehicle chassis.

Illustrative Pictures of Different Containers & Vehicles:

Typical Containers



Appendix E: Images During Testing

Appendix F: Research Paper Publication Certificate

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PUBLICATION CERTIFICATE

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