Construction and Demolition Waste Recycling

Siddharth Patel
UG Student
Civil Engineering
L.J. Institute of Engineering. & Technology

Anup Pansuria
UG Student
Civil Engineering
L.J. Institute of Engineering. & Technology

Viral Shah
UG Student
Civil Engineering
L.J. Institute of Engineering. & Technology

Sahil Patel
UG Student
Civil Engineering
L.J. Institute of Engineering. & Technology

Abstract

The project 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 in depth about the different properties of construction and demolition waste, perform various tests, so that the recycling processes can be designed accordingly for optimum efficiency. On the basis of 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, kerbstone 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, Demolition, Process Design, Recycling, Waste.

I. INTRODUCTION

A. General[1][2][3][7][15][28]

Construction waste is bulky and heavy and is mostly unsuitable for disposal by incineration or composting. The growing population in the country and requirement of land for other uses has reduced the availability of land for waste disposal. Re-utilization or recycling is an important strategy for management of such waste.

Waste is generated at different stages of construction process. Waste during construction activity relates to excessive cement mix or concrete left after work is over, rejection/ demolition caused due to change in design or wrong workmanship etc.

Estimated waste generation during construction is 40 to 60 Kg. per sq. m. Similarly, waste generation during renovation/ repair work is estimated to be 40 to 50 kg/sq.m. The highest contribution to waste generation is due to demolition of buildings. Demolition of Pucca and Semi-Pucca buildings, on an average generates 500 & 300 kg/ sq.m. Of waste respectively.

Concrete appears in two forms in the waste. Structural elements of building have reinforced concrete, while foundations have mass non-reinforced concrete. Excavations produce topsoil, clay, sand, and gravel. This may be either re-used as filler at the same site after completion of excavation work or moved to another site.

Large quantum of bricks and masonry arise as waste during demolition. These are generally mixed with cement, mortar or lime. Stone arises during excavations or by demolition of old buildings.

According to findings of survey, the most dominant reason for not adopting recycling of waste from Construction Industry is "Not aware of the recycling techniques". While 70% of the respondent have cited this as one of the reasons, 30% of the respondent have indicated that they are not even aware of recycling possibilities.

- Concrete and masonry constitute more than 50% of waste generated by the Construction Industry. Recycling of this waste by converting it to aggregate offer dual benefit of saving landfill space and reduction in extraction of natural raw material for new construction activity.

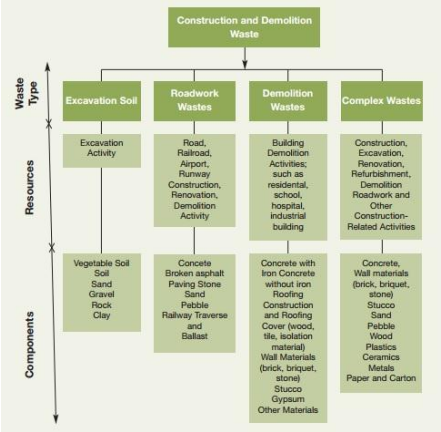
Recycled aggregate can be used as general bulk fill, sub-base material in road construction, fills in drainage projects and for making new concrete.

- Construction and demolition waste is 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.
- It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects).
- Out of 48 million tonnes of solid waste generated in India, C&D waste makes up 25% annually.

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- Projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55,000 million m^3. An additional 750 million m^3. Aggregates would be required for achieving the targets of the road sector.
- 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.
- According to a study commissioned by Technology Information, Forecasting and Assessment Council (TIFAC), 70% of the construction industry is not aware of recycling techniques.
- Estimated waste generation during construction is 40 kg per m^2 to 60 kg per m^2. Similarly, waste generation during renovation and repair work is estimated to be 40 kg per m^2 to 50 kg per m^2. The highest contribution to waste generation comes from the demolition of buildings. Demolition of pucca (permanent) and semi-pucca buildings, on average generates between 300kg per m^2 and 500 kg per m^2 of waste, respectively.
- The presence of C&D waste and other inert matters makes up almost one third of the total MSW on an average.
- The Bureau of Indian Standards (BIS) and other codal provisions do not provide specifications for the use of recycled products in construction activities.
- The demolition of old buildings usually generates wastes such as brick, wood and steel. In India most of the old buildings are mainly made up of good quality bricks. The foundation of the old buildings is of load bearing type where a huge number of bricks were used. When an old building is demolished, almost all the materials are sold at reasonable price.
- This estimate only accounts for new construction. Demolition and renovation/repair-related waste of the older stock generates additional waste. The waste produced per sq m of demolition is 10 times that generated during construction: as per TIFAC, 300-500 kg of waste per sq m. If it is assumed that five per cent of the existing building stock gets demolished and rebuilt completely annually, then about 288 MT more of C&D waste would have been generated in 2013 alone because of demolitions.
- Thus, the total C&D waste generated in India just by buildings in one year — 2013 — amounts to a humungous 530 MT, 44 times higher than the official estimate. Imagine the scenario if the waste generated by infrastructure projects such as roads and dams is added. Not surprisingly, in India, if C&D waste is quantified, it will be more than all the other types of solid waste put together.
- Where is all this C&D waste going? A lot of it is being used by land sharks to illegally fill up water bodies and wetlands around urban centres for real estate development. The rest is just being dumped into rivers and open spaces.

B. Types of Construction and Demolition waste:



Flowchart 1: Types Of C&D Waste[16]

C. Classification of waste:

- Residential
- Industrial
- Commercial
- Institutional
- Agricultural
- C&D

D. Amount of C&D waste as per types:

- Based on structure type
  - (Residential,Commercial,Industrial,Institutional)

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- Based on structure size
  - (Heavy,Med,Light)
- Activity being performed

E. Various components of Construction and Demolition waste:

Major Components	*Minor Components*
– *Cement concrete* – *Bricks* – *Cement plaster* – *Steel (from RCC, door/window frames, roofing support, railings of staircase etc.)* – *Rubble* – *Stone/Timber/wood (marble, granite, sand stone)*	– *Conduits (iron, plastic)* – *Pipes (GI, iron, plastic)* – *Electrical fixtures (copper/aluminium wiring, wooden baton, Bakelite/plastic switches, wire insulation)* – *Panels (wooden, laminated)* – *Others (glazed tiles, glass panes)*

F. Collection of C&D Waste:

- Collection of the C&DW can be done by the trucks having container of different sizes.
- Size of the container depends upon the demolition area/part.
- For handling very large volumes, front-end loaders in combination with sturdy tipper trucks may be used so that the time taken for loading and unloading is kept to the minimum.
- For small generators of construction debris, e.g., petty repair/maintenance job, there may be two options – (i) specific places for such dumping by the local body and (ii) removal on payment basis.
- In case of small towns where skips and tipping trailers are not available, manual loading and unloading should be permitted.
- In case of large towns where C&D waste generates in large amount, Zoning of the towns is necessary. By multiple pickup points of C&D waste we can easily do collection of C&D waste in large cities.
- Close co-ordination between the Sanitary Department, Municipal Engineering Department and Town Planning Department is essential if there is no consolidated Solid Waste Management Department to take care of the construction and demolition waste in addition to other municipal garbage.

G. Segregation of waste:

Segregation of C&D waste can be done by following methods:

(1) On Site
(2) Off Site
  1) ON SITE:- Man-made Sorting , By use of JCB , By use of Cranes .
  VEHICLE USED:- JCD, Cranes, Tractors, Trucks etc.
  2) OFF SITE:- By use of Air Nozzle, By use of Sorting method.
  VEHICLE USED:- Air nozzle, sorting machine, trucks, tractors etc.

- Segregation of the C&D waste can be done by Chemical Mineralogical Appraisal and Mechanical Sorting.
- This both methods are Off site methods.

1) *Chemical Mineralogical Appraisal:*

It is based on Particle Size of waste
X-ray Fluorescence: It is used for composition of major elements.
X-ray Diffrectometry: It recognizes the constitute mineralogical phases.

2) *Mechanical Sorting:*

- Bar screening
- Magnetic separation
- Air classifier

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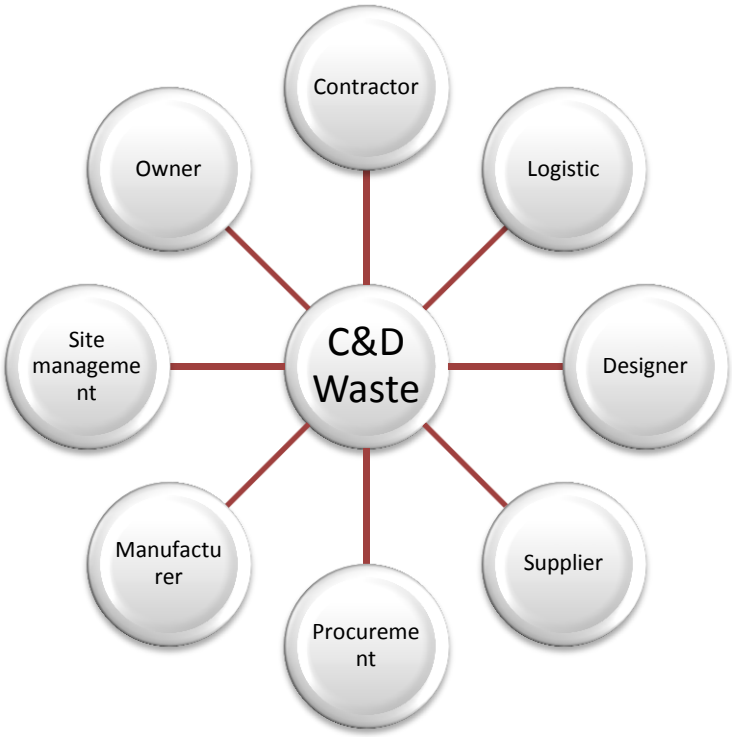
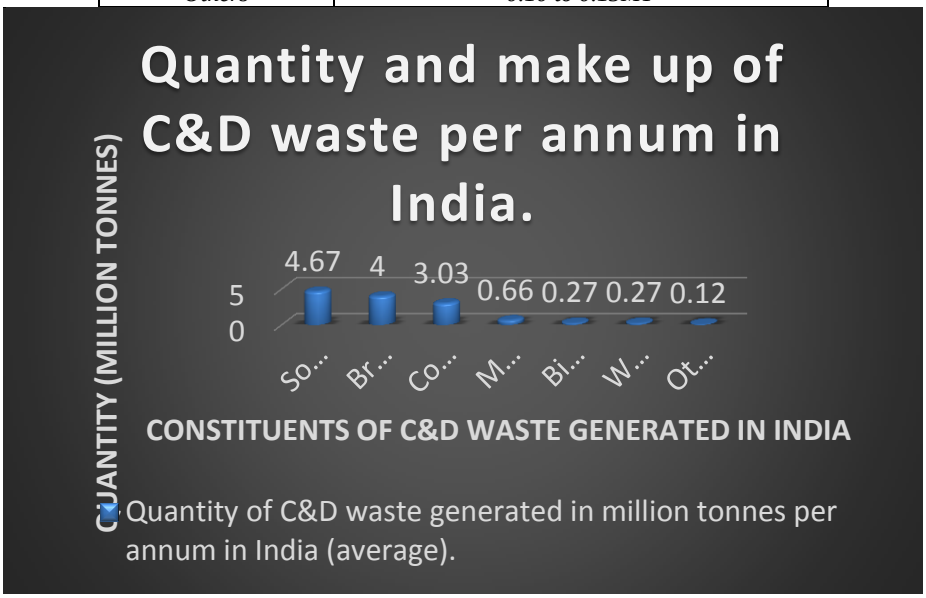


Fig. 1: Contributors of C&D Waste In A Project

Table - 1

The Quantity And Make Up of Construction And Demolition Waste Per Annum In India[28]

Constituent	*Quantity generated in Million tonnes per annum*
Soil,Sand and Gravel	*4.20 to 5.14*
Bricks and Masonry	*3.60 to 4.40*
Concrete	*2.40 to 3.67*
Metals	*0.60 to 0.73*
Bitumen	*025 to 0.30MT*
Wood	*0.25 to 0.30MT*
Others	*0.10 to 0.15MT*



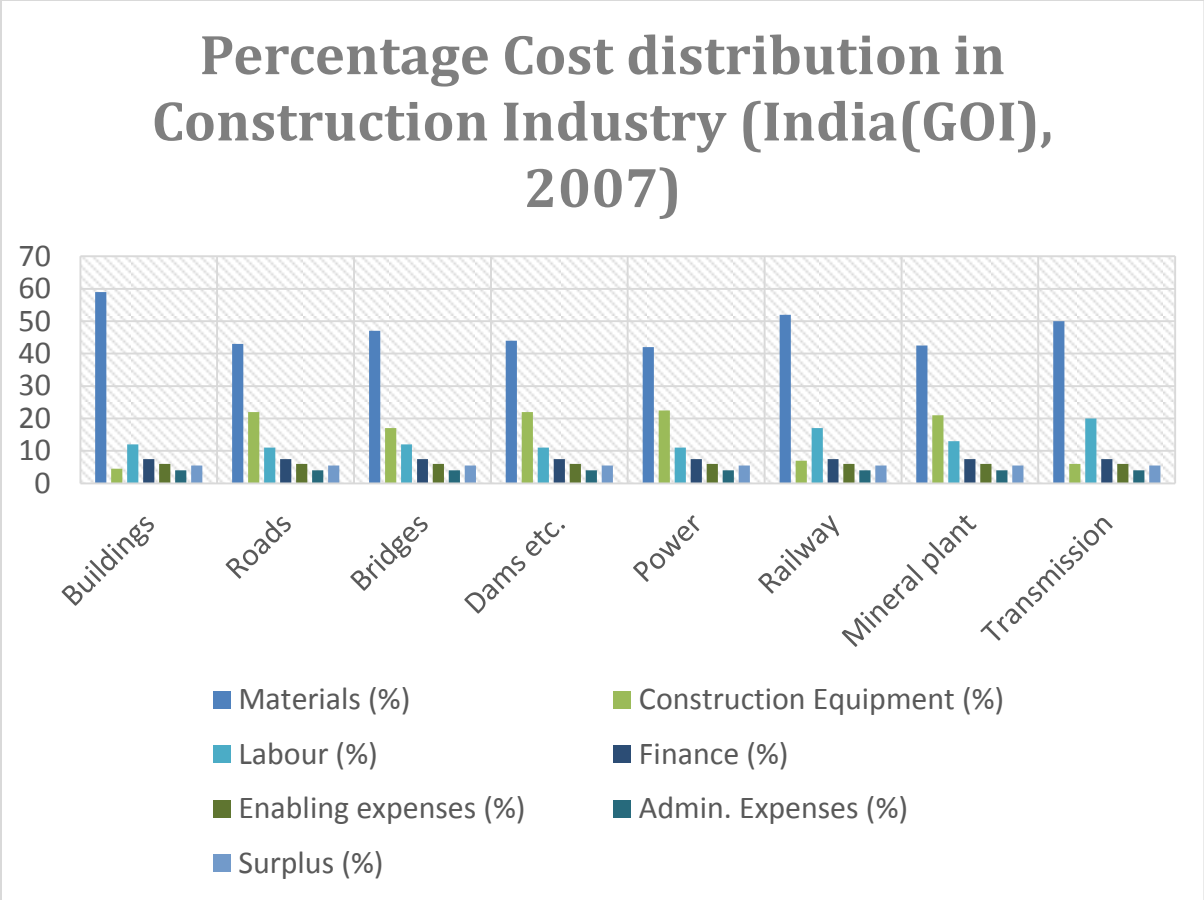
Graph 1: The Quantity And Make Up of Construction And Demolition Waste Per Annum In India

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Table - 2
Percentage Cost Distribution In Construction Industry (India(Goi), 2007)

	Materials %	*Construction Equipment %*	*Labour %*	*Finance %*	*Enabling expenses %*	*Admin. Expenses %*	*Surplus %*
Buildings	*58-60*	*4-5*	*11-13*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Roads	*42-45*	*21-23*	*10-12*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Bridges	*46-48*	*16-18*	*11-13*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Dams etc.	*42-46*	*21-23*	*10-12*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Power	*41-43*	*21-24*	*10-12*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Railway	*51-53*	*6-8*	*16-18*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Mineral plant	*41-44*	*20-22*	*12-14*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*
Transmission	*49-51*	*5-7*	*19-21*	*7-8*	*5.5-6.5*	*3.5-4.5*	*5-6*

International Journal of Scientific and Research Publications, Volume 2, Issue 10, October 2012 ISSN 2250-3153



Graph 2: The Distribution Of Cost Among Various Modes Of Expenses In Indian Construction Industry

II. LITERATURE REVIEW

The concept of this project especially for India in new. There is a lot of scope for research in this field. The research work and implementation of recycling C&D waste has not been done on a larger scale in India.

The literature review is an important portion for any project. From the many literature reviewed by us, both of national and international level, few research works and papers which we came through are listed here:

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A. On-Site Grinding of Residential Construction Debris:[19]

The Indiana Grinder Pilot

ABSTRACT:

The objective of the pilot project documented in this report was to determine the feasibility of on-site grinding of clean wood, drywall, and cardboard waste from new residential construction as an alternative to conventional landfilling. The evaluation included the identification and assessment of the major technological, economic, and environmental factors associated with the grinding technique. The pilot project was established near Indianapolis, Indiana and involved several organizations, including residential builders and a waste management firm. Although it is not possible for a single case study to comprehensively address all of the issues involved in on-site grinding, key results are presented below.

B. Construction and Demolition Waste recycling for sustainable growth and development :[20]

ABSTRACT

Construction and demolition (C and D) waste is defined as the solid waste generated by the construction, remodeling, renovation, repair, alteration or demolition of residential, commercial, government or institutional buildings, industrial, commercial facilities and infrastructures such as roads, bridges, dams, tunnels, railways and airports. Construction and demolition waste is considered as high volume, low risk. It is commonly understood that this waste can be considered a resource, either for reuse in its original form or for recycling or energy recovery. Because of increasing waste production and public concerns about the environment, it is desirable to recycle materials from building demolition. If suitably selected, ground, cleaned and sieved in appropriate industrial crushing plants, these materials can be profitably used in concrete. Despite this, most Construction and Demolition waste ends up in landfills. This paper highlights the composition of Construction and Demolition waste, the need for its recycling and options that can be implemented for its efficient use in the field of concrete technology in general. (Journal of Environmental Research And Development Vol. 2 No. 4, April-June 2008)

C. Construction and Demolition waste – An Overview of Construction Industry in India:[10]

ABSTRACT

India has established itself as one of the world's fastest growing economies and this growth has brought with it a significant boost in construction activities. With the rapid growth in construction activities, it is important to assess the amount of construction and demolition waste being generated and analyze the practices needed to handle waste in order to propose a sustainable construction approach. It has become essential to study C & D waste generation and handling to develop accurate data and establish sustainable methods to manage construction waste. Reduce, Reuse and Recycle [3R's] is highly useful in handling of construction and demolition waste. It is estimated that the total solid waste generated in India is about 960 million tonnes of which the construction waste alone is 14.5 million tonnes. Construction and Demolition waste in India during 2010 is estimated as 24 million tonnes. If measures to minimize and handle the construction and demolition wastes are not developed and efficiently adopted, it may have an impact on the environment. The paper provides an overview and statistics of construction and demolition waste of the construction industry in India. The paper gives an overview of the current status as well as the future potential for waste minimization, explores how waste management practices can be effectively implemented in construction projects.

(International Journal of Chemical, Environmental & Biological Sciences (IJCEBS) Volume 1, Issue 4 (2013) ISSN 2320-4079; EISSN 2320–4087)

D. Construction waste management in India:[22]

ABSTRACT

The management of construction waste is important today. The scarcity in the availability of aggregate for the production of 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. This paper enlightens the importance of reduce, reuse and recycle (3R) concept for managing the construction waste in India. (American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-2 pp-06-09)

E. Recycling and Reuse of Construction and Demolition Waste for Sustainable Development:[10]

ABSTRACT:

As we are living in 21st century, new technologies are being invented in almost every sector to make human life fast and easier. Beside this we are still finding the solutions to problems related to our environment, energy and natural resources.

Construction industry produces large amount of waste throughout the year. Most of the time construction and demolition waste ends up in landfills disturbing environmental, economic and social life cycle. Construction and demolition waste is the waste materials that are produced in the process of construction, renovation or demolition of residential or nonresidential structures. Components of construction and demolition waste typically include concrete, asphalt, wood, metals, gypsum wallboard, roofing, paper, plastic, drywall and glass.

Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs; and can be considered as one of the solution to solve construction and demolition waste

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problem. Sustainable development in construction will help a lot to reduce the problems related to environment and natural resources as construction industry is a major user of world's resources. Sustainable design, proper use and reuse of the resources/construction materials will make construction industry more economical and green.

Concrete is the second most consumed material after water, so recycling of concrete can save construction costs also it will help to keep environment healthy. Concrete collected from sites is put through crushing machine, usually uncontaminated concrete i.e. free from wood, plastic, paper and other unwanted materials. Metals such as rebar are removed with the help of magnets and other sorting devices.

In many countries like Japan, United States, United Kingdom various recycling techniques are being used and returning good results. Process of recycling construction and demolition waste includes storage, sorting, collection, transportation, recycling and disposing. Recycling methods used in japan are heating and rubbing methods, eccentric-shaft rotor method and Mechanical grinding method.

Recycling of Construction and demolition waste has many benefits such as reduction in transportation cost, it keeps environment clean and reduces natural resource exploitation. To promote recycling and reuse of waste, awareness about its effects and benefits should be communicated with people, contractors, engineers and architects. More numbers of recycling plants should be installed and allowing the use of recycled aggregate instead of natural aggregate for some purpose. In this paper I am going to focus on different recycling techniques and reuse of construction and demolition waste. (OIDA International Journal of Sustainable Development, Vol. 6, No. 7, pp. 83-92, 2013)

F. Economic Aspects of Construction Waste Materials in terms of cost savings: A case of Indian construction Industry[23]

ABSTRACT

The excessive wastage of materials, improper management on site and low awareness of the need for waste reduction are common in the local construction sites in India. Today, in most European countries, it is economically feasible to recycle up to 80–90% of the total amount of construction waste and most demolition and recycling technologies are generally easy to implement and control (Lauritzen, 1998). Considering enormous increase in amount of waste generation owing to the growth in construction industry can lead to wastage of materials which has its economic value. Currently, existence of regional and national policies, laws and regulations governing reuse and recycle principles for C & D waste is minimal in India. Thus the paper aims to focus on the economic feasibility of waste minimization of construction waste materials in terms of cost savings in India. (International Journal of Scientific and Research Publications, Volume 2, Issue 10, October 2012 1 ISSN 2250-3153)

G. Use of Recycled Aggregate Concrete:[24]

ABSTRACT

Use of recycled aggregate in concrete can be useful for environmental protection. Recycled aggregates are the materials for the future. The application of recycled aggregate has been started in a large number of construction projects of many European, American, Russian and Asian countries. Many countries are giving infrastructural laws relaxation for increasing the use of recycled aggregate. This paper reports the basic properties of recycled fine aggregate and recycled coarse aggregate & also compares these properties with natural aggregates. Basic changes in all aggregate properties are determined and their effects on concreting work are discussed at length. Similarly the properties of recycled aggregate concrete are also determined. Basic concrete properties like compressive strength, flexural strength, workability etc. are explained here for different combinations of recycled aggregate with natural aggregate. Codal guidelines of recycled aggregates concrete in various countries are stated here with their effects, on concreting work. In general, present status of recycled aggregate in India along with its future need and its successful utilization are discussed here. (IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684, PP: 52-59)

H. Maximizing Reuse and Recycling of Construction Materials:[25]

ABSTRACT

The demolition of building structures produces significant amounts of materials that are for the most part landfilled. The total Construction and Demolition (C&D) waste in U.S. was estimated to be 154 Million Metric Ton (MMT) in 2003. As its primary purpose, deconstruction seeks to maintain the highest possible value for materials in existing buildings by dismantling buildings in a manner that will allow the reuse or efficient recycling of the salvaged materials. This paper intends to provide an overview of U.S. construction and demolition waste and includes sections on waste statistics, benchmark data, policies, and strategies to maximize reuse and recycling.

I. Construction & Demolition Waste in India:[8]

ABSTRACT

With the advent of industrialization March there has been huge depletion of natural resources. The recycling of the construction material to serve the ever increasing need for more cities ought to be sustainable.

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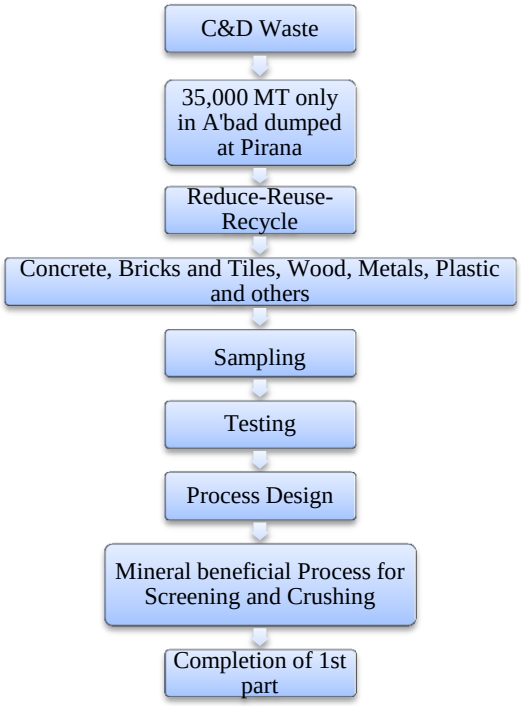
***J. Waste quantification models for estimation of construction and demolition waste generation: A review*[9]**

ABSTRACT

Quantification is crucial for construction and demolition waste management. Accurate estimation can be satisfied by developing waste quantification model that is applicable for regional or nation-wide C&D waste generation. This paper presents a review on quantification models for C&D waste from literatures and how they correlate. Most studies combine the empirical waste assessment data or waste generation factor obtained in the field with area of activity level extracted from national statistical database from their respective countries, which provides annual data on sector activities. National or regional estimates provide general figures and forecasts for annual C&D waste generation. Studies found that waste generation factor will differs according to locations. Since volume and characteristic of waste are crucial for waste quantification, quantitative data record from waste audit findings could benefit the authorities for the annual estimates. National C&D waste reduction plan should start from well-established waste minimization plan at project sites. Copyright © 2012 Inderscience Enterprises Ltd.
(International Journal of Global Environmental Issues (10.1504/IJGENVI.2012.049378))

III. METHODOLOGY

A. Sequential steps of Project:



Flowchart 2: Methodology of Project

B. Methodology:

- The main aim of our project was regarding research and development (R&D) of construction and demolition(C&D) waste by further studying its properties in detail.
- The general scenario of construction waste and solid waste is explained in detail in Chapter1.
- As civil engineers it our duty to move towards constructive technology rather than destruction.
- During our primary survey of construction and demolition waste quantity we found that in Ahmedabad itself 35000MT of waste is dumped at Pirana and daily 300MT of construction waste is collected.
- So in line with our Ahmedabad Municipal Corporations policy of Reduce Reuse Recycle we derive our methodology for recycling of construction and demolition waste and making useful products out of it.
- So we carried out sampling of concrete, bricks, tiles, wood, metals, plastic etc. i.e. the different components of C&D waste.
- In-depth testing of these approximately 37kgs of C&D waste collected from 11 different sites. On the basis of various result of these testing we designed a process.

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IV. DATA COLLECTION

A. Sampling

The very next thing on focus, after the general study of various aspects of construction and demolition waste at national and local level was sampling. The basic meaning of sampling is to collect randomly the desired material from various points/location on which one has to make study. Thus for carrying out any research work practically on any material, sampling is necessary.

In context to construction and demolition waste, in Ahmedabad city there are more than 15 sites solely assigned for dumping of C&D waste. All these sites are assigned by Ahmedabad Municipal Corporation (AMC). Out of which 11 sites were selected for carrying out sampling. Within the limits of AMC the whole city is divided into 6 zones. Thus the site selection for sampling was done I such a way that all zones were covered. The sites which are on major locations of the city and the sites where good amount of C&D waste is dumped were selected.

The below given list is about the sites from which samples of C&D waste were taken and further tests were conducted on it, which is explained in the next chapter.

B. Sampling Sites:

- West Zone:
  Vasna- Surainagar noh khado
  AEC crossroads
  Balolnagar
  Near Saurashtra Chhatralay
- North Zone:
  Asarva
  Naroda- Canal road
  Noblenagar, Galaxy underbridge
- Central Zone:
  Geeta Mandir
  Prem Darwaja
  Dudheshwar
- New West Zone:
  Mumatpura



Sampling Done On 8th July,2014 (11:00am To 5:30pm)

V. TESTS

A. Overview:

The samples which were collected from 11 sites across the city were further taken to college laboratory for carrying out tests. The testing of this material is important because without checking its properties minutely, the process design for recycling plant is not possible.

Though the sites from which sampling was done, were solely assigned for dumping of only construction and demolition waste, various others things were also being duped there. So first of all before carrying out tests on the samples the primary segregation was done.

During this the unwanted waste was separated by simply hand picking. This unwanted waste consisted of plastic, metal wastes, bitumen wastes (road debris) etc. Out of the total sample collected i.e. 38.942 kg the unwanted waste separated was 2.637 kg. So the tests were conducted on the remaining amount of material left i.e. 36.305 kg.

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Whole of the testing process was carried out in laboratory (Civil Engineering department) of L.J. Institute of Engineering and Technology

B. Tests conducted:

- Sieve analysis (Particle size distribution)
- Impact value test

1) *Sieve Analysis Report*[26]

Sieve analysis is the most primary and basic test of civil engineering. It is commonly known as the gradation test. It is a basic essential test for all aggregate technicians.

The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications. The gradation data may be used to calculate relationships between various aggregate or aggregate blends, to check compliance with such blends, and to predict trends during production by plotting gradation curves graphically, to name just a few uses. Used in conjunction with other tests, the sieve analysis is a very good quality control and quality acceptance tool.

The reports of the sieve analysis test performed are as given below:

5.2.2.1

The Test Report Of Sieve Analysis Test

Table - 3

Test Report of Geeta Mandir Site

Site name	*Geeta-mandir*	
C&D waste collected(kg)	*3.998*	
Unwanted waste(kg)	*0.000*	
Total waste collected(kg)	*3.998*	
IS Sieve Size (mm)	*Retained Weight (kg)*	*Passing Weight (kg)*
63	*0.359*	*3.639*
50	*1.055*	*2.584*
40	*0.365*	*2.219*
25	*0.647*	*1.572*
20	*0.150*	*1.422*
12.5	*0.219*	*1.203*
10	*0.037*	*1.166*
6.3	*0.099*	*1.067*
4.75	*0.065*	*1.002*
<4.75	*0.956*	*0.046*
Total	*3.959*	

Table - 4

Test Report of Asarava Site

Site name	*Asarva*	
C&D waste collected(kg)	*3.850*	
Unwanted waste(kg)	*0.021*	
Total waste collected(kg)	*3.829*	
IS Sieve Size (mm)	*Retained Weight (kg)*	*Passing Weight (kg)*
63	*0.000*	*3.829(100%)*
50	*0.000*	*3.829(100%)*
40	*0.474*	*3.355()*
25	*0.526*	*2.289*
20	*0.269*	*2.560*
12.5	*0.347*	*2.213*
10	*0.082*	*2.131*
6.3	*0.275*	*1.856*
4.75	*0.162*	*1.694*
<4.75	*1.645*	*0.049*
Total	*3.780*	

Table - 5

Test Report of Balol Nagar Site

Site name	*Balol nagar*	

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C&D waste collected(kg)	3.944	
Unwanted waste(kg)	0.000	
Total waste collected(kg)	3.944	
IS Sieve Size (mm)	Retained Weight (kg)	Passing Weight (kg)
63	0	3.944
50	0.233	3.711
40	0.279	3.432
25	0.736	2.696
20	0.338	2.358
12.5	0.607	1.751
10	0.101	1.650
6.3	0.316	1.334
4.75	0.148	1.186
<4.75	1.096	0.090
Total	3.854	

Table - 6
Test Report of AEC Site

Site name	AEC	
C&D waste collected(kg)	3.248	
Unwanted waste(kg)	0.000	
Total waste collected(kg)	3.248	
IS Sieve Size (mm)	Retained Weight (kg)	Passing Weight (kg)
63	0.000	3.248
50	0.290	2.958
40	0.046	2.912
25	0.322	2.590
20	0.089	2.501
12.5	0.421	2.080
10	0.108	1.972
6.3	0.490	1.482
4.75	0.433	1.049
<4.75	0.982	0.067
Total	3.181	

Table - 7
Test Report of Vasna Site

Site name	Vasna	
C&D waste collected(kg)	3.048	
Unwanted waste(kg)	0.100	
IS Sieve Size (mm)	Weight of Particles retained (kg)	Passing Weight
63	0.143	2.905
50	0	2.905
40	0.294	2.611
25	0.757	1.854
20	0.264	1.59
12.5	0.213	1.377
10	0.023	1.354
6.3	0.082	1.272
4.75	0.051	1.221
<4.75	1.070	0.151
Total	2.897	

Table - 8
Test Report of Saurastra Chhatralay Site

Site name	Saurastra Chhatralay	
C&D waste collected(kg)	3.205	
Unwanted waste(kg)	0.017	
IS Sieve Size (mm)	Weight of Particles retained (kg)	Passing Weight
63	0	3.188
50	0.232	2.956
40	0.194	2.762

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25	*0.210*	*2.552*
20	*0.086*	*2.466*
12.5	*0.313*	*2.153*
10	*0.080*	*2.073*
6.3	*0.218*	*1.855*
4.75	*0.140*	*1.714*
<4.75	*1.612*	*0.102*
Total	*3.085*	

Table - 9
Test Report of Naroda Site

Site name	*Naroda*	
C&D waste collected(kg)	*3.926*	
Unwanted waste(kg)	*2.097*	
IS Sieve Size (mm)	*Weight of Particles retained (kg)*	*Passing Weight*
63	*0.218*	*1.611*
50	*0.156*	*1.455*
40	*0.230*	*1.225*
25	*0.192*	*1.033*
20	*0.086*	*0.947*
12.5	*0.219*	*0.728*
10	*0.074*	*0.654*
6.3	*0.196*	*0.458*
4.75	*0.098*	*0.36*
<4.75	*0.277*	*0.083*
Total	*1.746*	

Table - 10
Test Report of Nobelnagar Site

Site name	*Nobelnagar*	
C&D waste collected(kg)	*3.465*	
Unwanted waste(kg)	*0.171*	
IS Sieve Size (mm)	*Weight of Particles retained (kg)*	*Passing Weight*
63	*0.152*	*3.142*
50	*0.486*	*2.656*
40	*0.383*	*2.273*
25	*0.149*	*2.124*
20	*0.200*	*1.924*
12.5	*0.465*	*1.459*
10	*0.079*	*1.38*
6.3	*0.201*	*1.179*
4.75	*0.109*	*1.07*
<4.75	*0.944*	*0.126*
Total	*3.168*	

Site name	*Prem Darwaja*	
C&D waste collected(kg)	*3.443*	
Unwanted waste(kg)	*0.166*	
IS Sieve Size (mm)	*Weight of Particles retained (kg)*	*Passing Weight*
63	*0.664*	*2.613*
50	-	*2.613*
40	*0.632*	*1.981*
25	*0.486*	*1.495*
20	*0.580*	*0.915*
12.5	*0.224*	*0.691*
10	*0.318*	*0.373*
6.3	*0.030*	*0.343*
4.75	*0.071*	*0.272*
<4.75	*0.173*	*0.099*
Total	*3.178*	

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Table - 13
Test Report of Mumatpura Site

Site name	*Mumatpura*	
C&D waste collected(kg)	*3.393*	
Unwanted waste(kg)	*0.063*	
IS Sieve Size (mm)	*Weight of Particles retained (kg)*	*Passing Weight*
63	*0.203*	*3.127*
50	*0*	*3.127*
40	*0.139*	*2.988*
25	*0.229*	*2.759*
20	*0.312*	*2.447*
12.5	*0.594*	*1.853*
10	*0.066*	*1.787*
6.3	*0.260*	*1.527*
4.75	*0.132*	*1.395*
<4.75	*1.263*	*0.132*
Total	*3.198*	

Table - 14
Test Report of All Sites

Site name	*All Sites*	
C&D waste collected(kg)	*38.942*	
Unwanted waste(kg)	*2.637*	
Total waste Collected(kg)	*36.305*	
IS Sieve Size (mm)	*Weight of Particles retained (kg)*	*Passing Weight*
63	*1.739*	*34.566(88.76%)*
50	*2.452*	*32.114(92.93%)*
40	*3.036*	*29.078(90.54%)*
25	*4.306*	*24.772(85.19%)*
20	*2.955*	*21.817(88.07%)*
12.5	*4.397*	*17.420(78.11%)*
10	*1.089*	*16.331(93.74%)*
6.3	*2.437*	*13.894(85.07%)*
4.75	*1.525*	*12.369(89.02%)*
<4.75	*10.915*	*1.454(11.75%)*
Total	*34.851*	

Aggregate impact value (%)	*Toughness Properties*
<10	*Exceptionally tough / Strong*
10 – 20	*Very tough / Strong*
20 – 30	*Good for pavement surface course*
>35	*Weal for pavement surface course*

C. 5.2.2.1 The Test Report of Impact Value Test is given below :

1) *The fraction retained from 63mm IS sieve:*

Table - 15
The Fraction Passing Through 12.5mm IS Sieve

The fraction passing through 12.5mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 12.5mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.204*	*0.082*	*40.916*
4	*0.266*	*0.072*	*27.067*
1	*0.375*	*0.183*	*48.8*
Average value			*38.927*

Table - 16
The Fraction Passing Through 10mm IS Sieve

The fraction passing through 10mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 10mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.204*	*0.017*	*8.334*
4	*0.266*	*0.024*	*9.022*

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1	*0.375*	*0.013*	*3.466*
Average value			*6.940*

Table - 17
The Fraction Passing Through 4.75mm IS Sieve

The fraction passing through 4.75mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 4.75mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.204*	*0.037*	*18.137*
4	*0.266*	*0.056*	*21.052*
1	*0.375*	*0.064*	*17.066*
Average value			*18.751*

Table - 18
The Fraction Passing Through 2.36mm IS Sieve

The fraction passing through 2.36mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 2.36mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.204*	*0.016*	*7.843*
4	*0.266*	*0.027*	*10.150*
1	*0.375*	*0.027*	*7.200*
Average value			*8.397*

Table - 19
The Fraction Passing Through 1.18mm IS Sieve

The fraction passing through 1.18mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 1.18mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.204*	*0.006*	*2.943*
4	*0.266*	*0.012*	*4.511*
1	*0.375*	*0.014*	*3.733*
Average value			*3.729*

Table - 20
The Fraction Passing Through <1.18mm IS Sieve

The fraction passing through <1.18mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through <1.18 IS sieve (g) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.204*	*0.037*	*18.137*
4	*0.266*	*0.071*	*26.691*
1	*0.375*	*0.060*	*16.000*
Average value			*20.276*

2) *The fraction retained from 50mm IS sieve*

Table - 21
The Fraction Passing Through 12.5mm IS Sieve

The fraction passing through 12.5mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 12.5mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.400*	*0.210*	*52.512*
4	*0.610*	*0.236*	*38.688*
1	*0.506*	*0.228*	*45.059*
Average value			*45.419*

Table - 22
The Fraction Passing Through 10mm IS Sieve

The fraction passing through 10mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 10mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.400*	*0.026*	*6.522*
4	*0.610*	*0.026*	*4.262*
1	*0.506*	*0.033*	*6.521*
Average value			*5.768*

Table - 23
The Fraction Passing Through 4.75mm IS Sieve

The fraction passing through 4.75mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 4.75mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.400*	*0.076*	*19.000*

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4	*0.610*	*0.065*	*10.655*
1	*0.506*	*0.074*	*14.624*
Average value			*14.759*

Table - 24
The Fraction Passing Through 2.36mm IS Sieve

The fraction passing through 2.36mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 2.36mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.400*	*0.024*	*6.000*
4	*0.610*	*0.031*	*5.081*
1	*0.506*	*0.034*	*6.719*
Average value			*5.933*

Table - 25
The Fraction Passing Through 1.18mm IS Sieve

The fraction passing through 1.18mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 1.18mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.400*	*0.007*	*1.750*
4	*0.610*	*0.013*	*2.131*
1	*0.506*	*0.017*	*3.359*
Average value			*2.413*

Table - 26
The Fraction Passing Through <1.18mm IS Sieve

The fraction passing through <1.18mm sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through <1.18mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.400*	*0.054*	*13.500*
4	*0.610*	*0.085*	*13.934*
1	*0.506*	*0.117*	*23.122*
Average value			*16.852*

3) *The fraction retained from 40mm IS sieve :*

Table - 27
The Fraction Passing Through 12.5mm IS Sieve

The fraction passing through 12.5mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 12.5mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.275*	*0.104*	*37.818*
4	*0.425*	*0.221*	*52*
1	*0.167*	*0.006*	*3.592*
Average value			*31.126*

Table - 28
The Fraction Passing Through 10mm IS Sieve

The fraction passing through 10mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 10mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.275*	*0.021*	*7.636*
4	*0.425*	*0.025*	*5.882*
1	*0.167*	*0.010*	*5.998*
Average value			*6.505*

Table - 29
The Fraction Passing Through 4.75mm IS Sieve

The fraction passing through 4.75mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 4.75mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.275*	*0.044*	*16.000*
4	*0.425*	*0.055*	*12.941*
1	*0.167*	*0.044*	*26.347*
Average value			*18.429*

Table - 30
The Fraction Passing Through 2.36mm IS Sieve

The fraction passing through 2.36mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 2.36mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*

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7	*0.275*	*0.019*	*6.909*
4	*0.425*	*0.028*	*6.588*
1	*0.167*	*0.021*	*12.574*
Average value			*8.690*

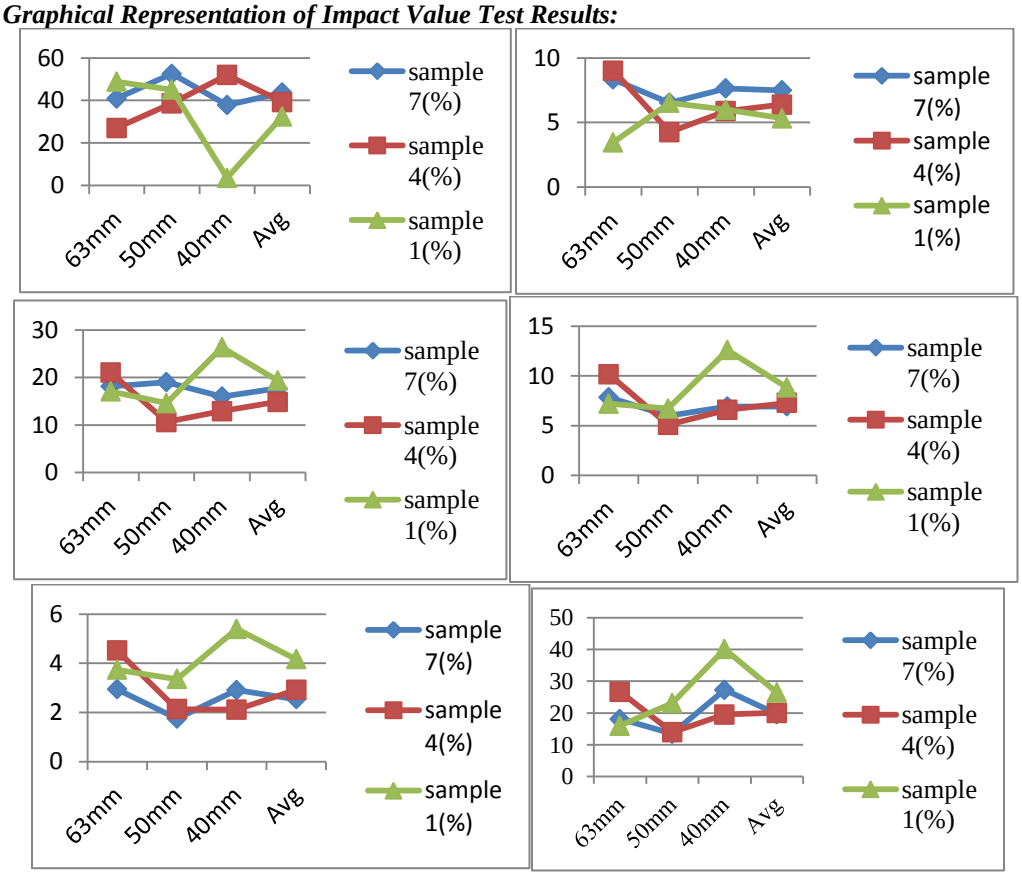
Table - 31
The Fraction Passing Through 1.18mm IS Sieve

The fraction passing through 1.18mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through 1.18mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.275*	*0.008*	*2.909*
4	*0.425*	*0.009*	*2.117*
1	*0.167*	*0.009*	*5.389*
Average value			*3.469*

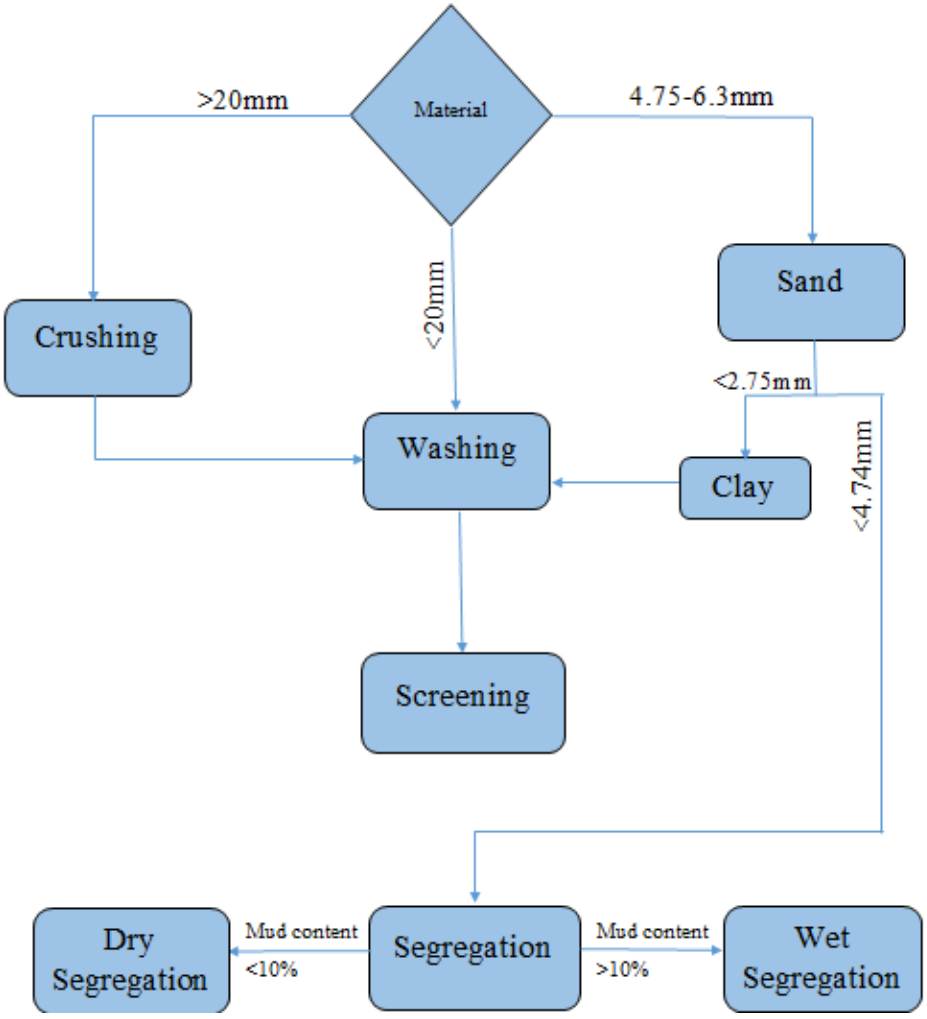
Table - 32
The Fraction Passing Through <1.18mm IS Sieve

The fraction passing through <1.18mm IS sieve			
Sample No	*Net weight of aggregates in the measure (kg) (A)*	*The fraction passing through <1.18mm IS sieve (kg) (B)*	*Aggregate impact value = (B/A)*100 %*
7	*0.275*	*0.075*	*27.272*
4	*0.425*	*0.083*	*19.529*
1	*0.167*	*0.067*	*40.119*
Average value			*28.973*

D. 5.2.2.2 Graphical Representation of Impact Value Test Results:



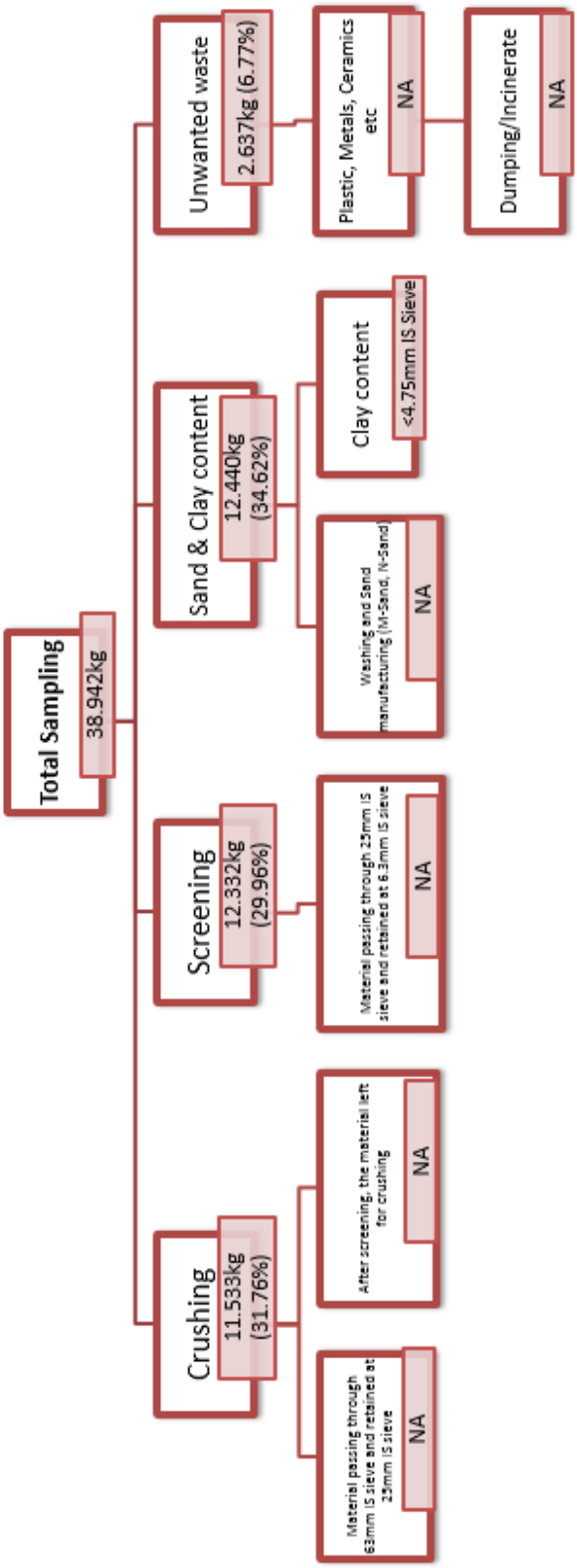
VI. DATA ANALYSIS



Flowchart 3: Process Analysis Based On Conclusion of Test Results

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Detailed Analysis of Test Reports:



Flowchart 4: Detailed Analysis of Test Reports

A. Theoretical explanation of Test Results:

The total material left after testing is segregated as shown in above given flowchart into mainly three sections. The first section is of material which is crushable i.e. particles greater than 20mm. Second section is directly sent for screening i.e. whose particle size is between 6.3mm to 20mm.

Now the process of washing is conducted for the remaining portion of the total material left. This is mainly called as sand.

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Further, the particles whose size is less than 2.75mm is directly sent to washer and the remaining part is again segregated by two methods namely: Wet segregation (mud content >10%) and Dry segregation (mud content <10%).

Now the crushed material is washed before undergoing screening.

At the end, after completion of each separate process, the screening and washing is done.

B. Theoretical explanation of detailed analysis :

We carried out total sampling of 38.942 kg of C and D waste collected from 11 different sites of Ahmedabad.
Various tests namely Crushing and screening were carried out on these samples.
Out of the total collected sample 2.673 kg of unwanted waste was recovered.
The sand and clay content was found to be 12.440 kg i.e. approx. 35 %.
The unwanted waste comprised of plastic, metals, ceramics, etc.
This unwanted waste cannot be recycled and has to be dumped or incinerated depending on the properties of the waste.
The sand and clay content can be recycled for washing and manufacturing of sand which can be further used in new construction.
Sieve analysis was also carried out of the crushed materials to determine its properties.

VII. CONCLUSION

A. Estimated weight of aggregates of various size and sand after crushing:

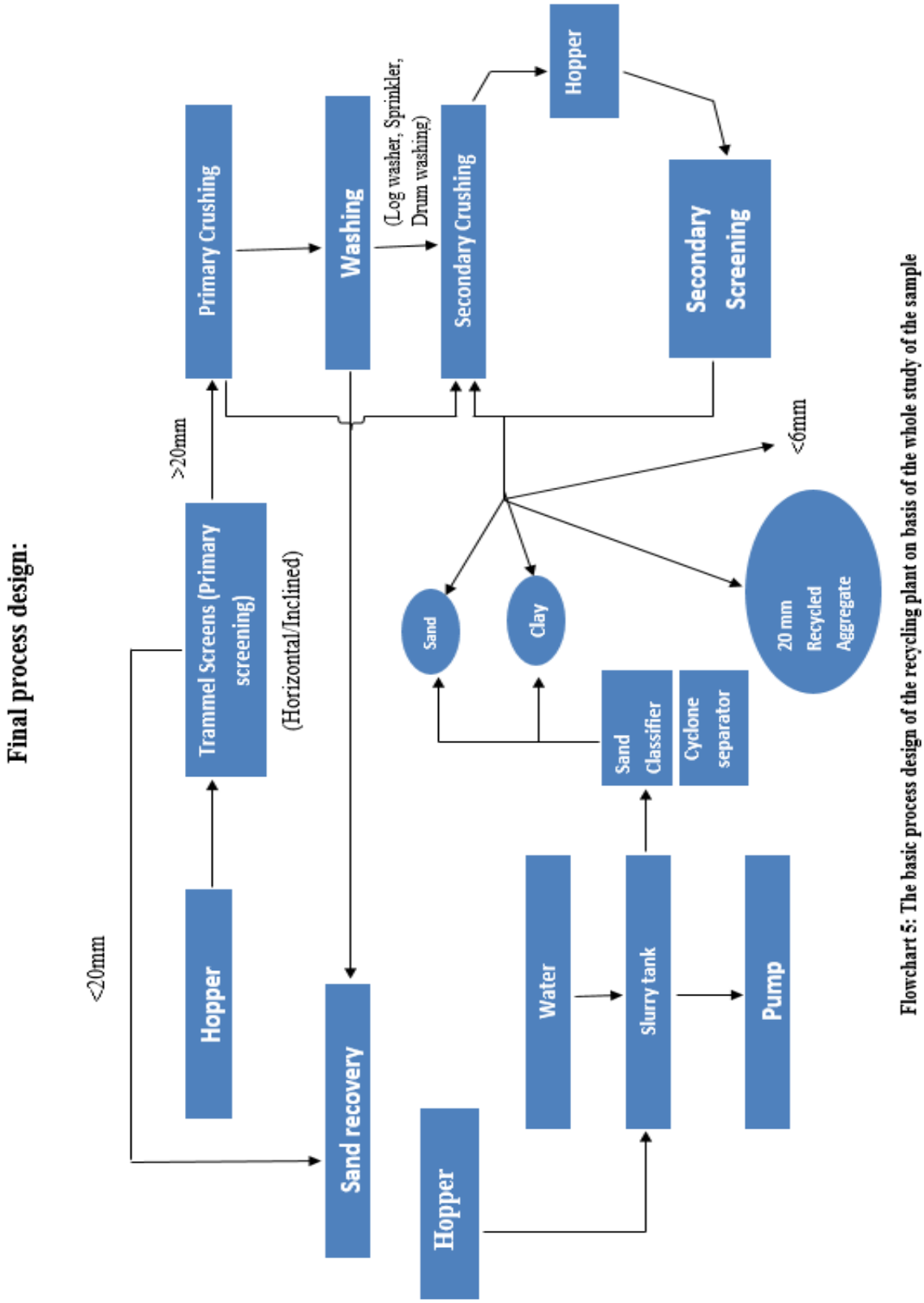
The conclusion of the particle size distribution is that, out of the total material tested (36.305kg), 40% is crushable. The different size of aggregates which we got after crushing is shown in the table given below:

Sieve Size	*25-63mm*
Total Weight	*14.522kg*
Aggregate Size	*Weight(kg)*
6-8mm	*4.356*
10mm	*2.904*
20mm	*2.178*
<20mm (Crushable)	*7.729*
Dust	*0.290*

The remaining material other than crushable are fine aggregates and sand. The content of this from the total is 60%. The detail classification of fine aggregates and sand is given as below.

Sieve Size	*4.75-20*
Total Weight	*21.783*
Aggregate Size	*Weight(kg)*
>6mm	*4.243*
Course Sand	*4.247*
Fine Sand	*4.792*
Dust	*8.495*

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Flowchart 5: The basic process design of the recycling plant on basis of the whole study of the sample

B. The detailed explanation of the process:

The above given flowchart explains each and every process of the recycling plant. Mainly there are two products for which the whole process is designed, they are Aggregate and Sand. The whole process consists of mainly three cycles, crushing, screening and washing. Sand recovery is done in more than one process.

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First of all the construction and demolition waste is sent for initial screening through hopper. This screen may be of many types, for example horizontal and inclined. This screening is mainly done to segregate the large crushable materials which are greater than 20mm while smaller than 20mm particles are directly send for sand recovery.

Now primary washing is done of the remaining material and further it is washed with the help of various kind of washers like log washer, sprinkler, drum washer etc. After the completion of washing, the material is taken for secondary crushing. Now with the help of conveyor belt the crushed material is sent for secondary screening through hopper.

This secondary screening is important part of the process because by doing so the material (C&D waste) is finally differentiated into four products. These products are sand, clay and aggregates (recycled). The material which is still left is sent again for crushing and the cycle is repeated.

The sand recovered in the initial sand recovery as shown in flowchart is collected in a hopper. It is then sent to slurry tank where the material washed by pumping of water. Now with the help of sand clarifier and cyclone separator, the two products sand and clay are separated respectively.

ACKNOWLEDGEMENT

We take this opportunity to express our profound gratitude and deep regards to our Prof. Chinmay Shah, Prof. Mayank Bhatt and HOD(Civil Department) S.M.Zuned for their exemplary guidance, monitoring and constant encouragement throughout the course of this thesis. The blessings, help and guidance given by their time shall carry us a long way in the journey of life on which we are about to embark.Our thanks and appreciations also go to our colleagues in developing the project and people who have willingly helped us out with their abilities.Apart from our college faculty and colleagues, we are also thankful to the company AMDAVAD ENVIRO PROJECTS PVT LTD. Under which we are able to carry out this project. Special thanks to Mr. Kaustuv Patnaik who is our external guide in project and Mr. Vinit Patel, Director of AEP.Under the guidance of them, we are able to flourish our minds in more 'GREENER WAY'.

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