EXTRACTION AND ANALYSIS OF MAXIMUM AMOUNT OF SAND FROM CONSTRUCTION AND DEMOLITION WASTE

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Abstract - As urban areas grow, they will increasingly rely on naturally sourced materials, leading to increased transportation emissions and environmental impacts associated with activities like quarrying. In some areas of India, sand is even imported from other countries. However, recycling of construction and demolition waste (C&DW) can potentially help address these challenges. Currently, a significant portion of C&DW is either improperly disposed of or sent to landfills, resulting in land use conflicts and a loss of valuable construction resources.

The objective of our project is to extract and reuse sand from construction and demolition waste. While there are several recycling technologies for construction waste available, they concentrate mainly on extracting and utilizing coarse recycled aggregates. Our approach is different, as we implement selective removal of the sand and determine the ideal rotor speed of the crusher to extract the highest amount possible. Our aim is to enhance the quality of the extracted recycled sand and ensure its suitability for construction purposes.

***Key Words*:** construction and demolition waste, sand, recycled aggregates, recycling, extraction.

1. INTRODUCTION

Construction and Demolition waste, abbreviated as C&D waste, refer to the waste that comes from the construction, remodeling, or demolition of buildings and other structures. C&D waste may stem from diverse origins, including residential, commercial, and industrial projects.

Some of the most common materials include:

- **Concrete**: This is the most common type of material generated from C&D activities, accounting for approximately 70% of all C&D waste. Concrete can be recycled and used in road construction and as a base material for new construction projects.
- **Wood**: This includes materials such as lumber, plywood, and pallets. Wood can be reused for various purposes or recycled into particleboard or other wood-based products.
- **Metals**: This includes materials such as steel, copper, and aluminum. These materials can be recycled and reused in new construction projects.
- **Asphalt**: This is a common material used in road construction. It can be recycled and reused in new asphalt pavement.

It is estimated that C&D waste accounts for a significant proportion of the total waste generated globally. In fact, according to the World Bank, the construction industry alone accounts for around 40% of the world's total waste.

1.1 ENVIRONMENTAL IMPACTS AND THE NEED FOR RECYCLING C&D WASTE

Improperly managing Construction and Demolition (C&D) waste can cause significant environmental problems. When C&D waste is sent to landfills, it decomposes and produces methane, a powerful greenhouse gas that contributes to climate change and various health issues. Landfills can also contaminate soil and water, posing risks to humans and the environment.

Transporting C&D waste to landfills can lead to air pollution from trucks and machinery emitting harmful pollutants. C&D waste contains valuable resources like wood and metal that can be recycled, but if not managed properly, it can deplete resources and worsen environmental degradation.

Contamination of nearby water sources can also occur, harming aquatic life and endangering human health. Construction and demolition activities generate noise pollution, which has negative effects on wildlife and human well-being.

Recycling C&D waste reduces landfill waste, preserves natural resources, and mitigates environmental impacts such as greenhouse gas emissions, air pollution, and water pollution. Recycling also brings economic benefits by creating jobs, providing raw materials, and reducing waste disposal costs. Overall, recycling C&D waste promotes sustainability, conserves resources, reduces waste, and stimulates economic growth.

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2. METHODOLOGY

2.1 BACKGROUND

Concrete is the largest consumer of natural resources in the construction sector. The construction industry heavily relies on primary resources such as crushed rock, river sand, gravel, cement, and water, which are predominantly used as natural aggregates.

Over-extraction of natural sand (FNA) is a serious problem that can have far-reaching impacts on both the environment and the economy. One of the most significant ecological consequences of excessive sand extraction is the alteration of water flow, which can affect aquatic ecosystems and the livelihoods of people who depend on them. In addition, the erosion of coastlines caused by over-extraction can lead to the loss of valuable land and infrastructure.

Given the high demand for concrete, finding alternative sources for producing fine natural aggregates (0-4mm) is critical to mitigate the adverse effects of sand extraction from rivers and seas. Moreover, the production of natural aggregates requires a considerable amount of energy and is associated with emissions. By using recycled aggregates in concrete mixtures instead of natural aggregates, the amount of CO2-eq. emissions related to aggregate production can be reduced. This shift towards sustainable practices in construction can have a positive impact on the environment and the economy.

2.2 METHOD OF RECYCLING IN A C&D WASTE RECYCLING PLANT

A typical process flow chart of the facilities is shown in Fig. 1.

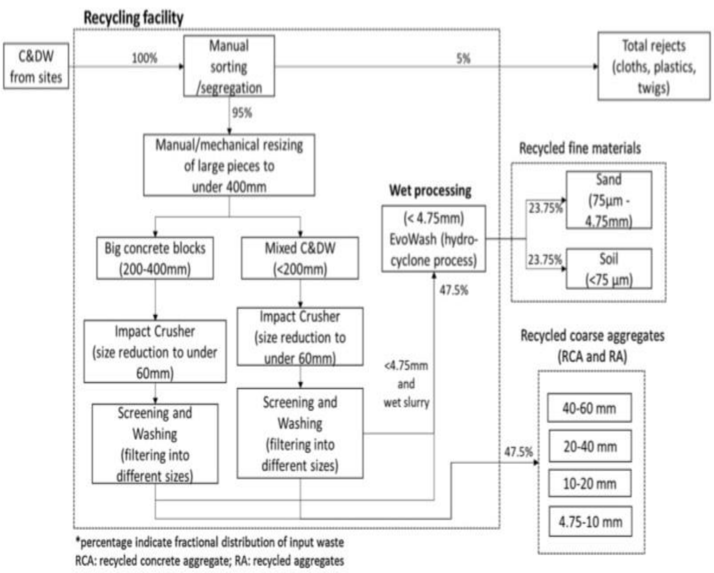

Fig 1 – typical process flow chart

STAGE - I

C&DW undergoes manual sorting after being unloaded. The purpose of this manual sorting process is to remove any impurities or cross-mixing, such as glass, clothing, wood and twigs, whole bricks, and other debris that may be mixed in with the C&DW.

During this manual sorting process, large pieces of waste over 400mm in size are manually resized to less than 400mm to make them easier to handle and process. This resizing is done manually by workers who visually inspect the waste.

STAGE - II

After the manual sorting process, the waste pieces in both systems are passed through a vibrator sieve to separate any pieces that are larger than 60mm. These larger pieces are then resized to below 60mm to make them easier to handle and process. Any pieces that cannot be resized to below 60mm are crushed until they are smaller than this size limit. The goal of this step is to ensure that all waste pieces are of a uniform size and can be efficiently and effectively processed.

Overall, the use of parallel systems and a vibrator sieve helps to ensure that the processing of concrete blocks and mixed C&DW waste is done in an efficient and effective manner, with waste pieces being properly separated and resized for optimal processing.

STAGE - III

All materials are continuously washed for removal of impurities and dust. This washing process is important for ensuring that the C&DW fraction is clean and free of any contaminants that may be harmful to the environment.

After the washing process, the C&DW fraction consists only of inert stony coarse aggregates of different sizes. This means that the C&DW fraction no longer contains any organic or hazardous materials and can be safely used as a construction material.

STAGE - IV

The waste is passed through different grates or sieves to separate the aggregates into different size categories. The size categories mentioned in the passage are 4.75-10mm, 10-20mm, 20-40mm, and 40-60mm.

This process is important because different size categories of aggregates are used for different applications in construction. For example, smaller aggregates may be used for concrete mixtures, while larger aggregates may be used for road construction.

STAGE - V

Fine particles smaller than 4.75mm including the slurry of clay and sand (fine aggregate) is sent to a chamber in which sand (>75um) is separated from clay (<75um) through a centrifuge (the process referred to as wet-process).

Sand particles under 8mm are sent into the cyclonic separator, where they are further separated into two categories,

(i) 0.75mm-3.75mm {plaster sand}

(ii) 3.75mm-8mm {M-Sand}

All aggregates of various sizes and sand are either sold directly to market or used to make products, such as kerb stones, paver blocks etc. which are then sold. The remaining fraction of soil/clay is used for backfilling purposes in nearby areas.

This is the generalised process of a C&D waste recycling plant.

2.3 SUGGESTED IMPROVEMENTS IN THE PROCESS

After studying the recycling process in the selected C&D waste recycling plant from 1.2, some suggestions to the above mentioned process were drafted.

<u>SUGGESTION – I</u>

- During **STAGE – II, '**Any pieces that cannot be resized to below 60mm are crushed until they are smaller than this size limit'. That means the crusher crushes the material into smaller proportions. In this context, a vertical shaft impact (VSI) crusher has emerged as a preferred choice due to its numerous advantages over other crusher types.

The main advantage of the VSI crusher is its ability to produce cubic particles in all size fractions, contributing to a better aggregate morphology. This feature is highly desirable for many applications as it improves the quality of the final product, making it more suitable for use in construction, road building, and other industries. The VSI crusher achieves this by using a high-speed rotor to accelerate the feed material and then throwing it against a stationary anvil, thereby breaking it into smaller pieces. The resulting particles have a more uniform shape and size distribution, which contribute to better aggregate packing and reduced voids in the concrete mix.

Regarding the use of VSI, some operational advantages deserve to be mentioned here. One of the most significant advantages of VSI is the control of product size distribution by rotor rotation. This feature allows for the adjustment of the crusher to produce the desired size and shape of the final product, thereby increasing the flexibility of the system. Additionally, the low labour costs associated with VSI make it an attractive option for many projects. The VSI crusher requires minimal operator intervention, and its maintenance is relatively simple, leading to reduced operational costs.

Another advantage of VSI over other crusher types is that it does not crush the fines. This feature means that the VSI crusher is suitable for crushing materials with a high proportion of fines, which are usually difficult to handle with other crusher types. Additionally, the VSI crusher consumes 6% less energy than the conic crusher for the same feed rate. This feature makes it more energy-efficient, leading to lower operational costs and reduced carbon footprint, which is crucial for many environmentally conscious projects.

The rotation (rotor speed) is the parameter that mostly influences the shape, size distribution, and porosity of aggregate particles. The VSI crusher allows for precise control of the rotor speed, thereby achieving the desired shape and size of the final product. This feature is particularly important for projects that require the production of high-quality aggregate materials.

- **Here, for experimental purposes, the input was controlled and the speed of the crusher was varied at different RPM.**

- **This is done, so as to observe at which speed maximum amount of FRA can be extracted from the crushing of the CRA.**

<u>SUGGESTION - II</u>

- It is possible to further crush the concrete blocks that are separated via a vibrating screen/sieve [STAGE - IV] with sizes larger than 8mm in order to obtain more sand from them.

- Once the concrete is crushed into smaller pieces, it can be screened again to separate the sand and gravel from larger pieces of concrete. [Sent to start of STAGE – IV again]

- The sand and gravel can then be used to make new concrete or for other construction purpose.

When CRA is crushed and recycled, the process is similar to the recycling of larger concrete blocks. The resulting sand and gravel can then be used for construction purposes.

3. OBSERVATIONS AND RESULTS

- Here, for experimental purposes, the input was controlled and the speed of the crusher was varied at different RPM.
- This is done, so as to observe at which speed maximum amount of FRA can be extracted from the crushing of the CRA.

The original operating speed is adjusted at 45m/s.
The varied speeds are listed below:

I. **25m/s**
II. **35m/s**
III. **55m/s**

After experimenting at the above stated conditions, the following observations were made:

Sieve size (mm)	Natural sand	FRA at 25m/s	FRA at 35m/s	FRA at 45m/s	FRA at 55m/s
0.15	1%	2%	3%	4%	7%
0.3	5%	4%	6%	8%	15%
0.6	10%	7%	12%	13%	24%
1.2	15%	12%	16%	18%	31%
2.4	22%	20%	26%	36%	42%
4.8	50%	46%	53%	60%	74%
8.6	80%	81%	84%	76%	89%
10	99%	96%	97%	99%	99%

Table 1 cumulative passing percentages of FRA at different sieve sizes

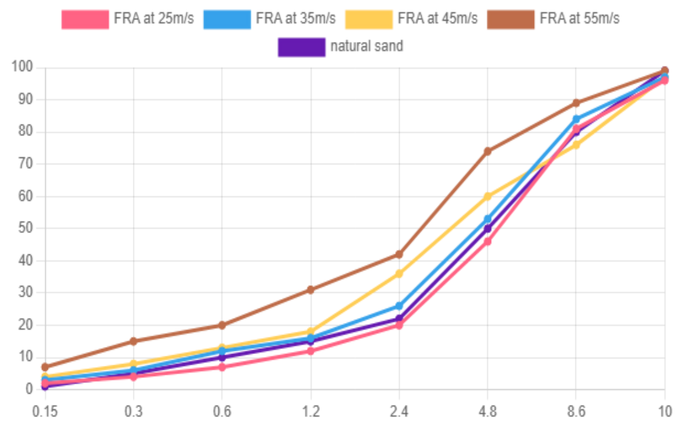

Fig 2 – sieve size vs. passing percentage

From the above representation we can infer that:

- When a crusher operates at higher speeds, it generates more impact and shear forces on the sand particles, resulting in more fine particles being produced. This is because the sand particles get subjected to more collisions and breakages, leading to a higher proportion of smaller particles i.e. the sand is crushed to a much finer level, than that is preferred.
- Applications that require a finer particle size distribution, such as mortar and plaster, may benefit from using Fine Recycled Aggregates.
- However, fine proportions of sand are not preferred for construction purposes as they can weaken the overall structure and reduce the load-bearing capacity of the material.
- Therefore, it is generally recommended to avoid operating the crusher at higher speeds to produce sand with a desirable particle size distribution.
- Also when we look at slower speeds of the rotor, we can observe that the particle sizes obtained are much similar than the other operating speeds.
- Operating the crusher at relatively slower speeds can result in more consistent particle sizes with less fine particles. This is because the sand particles experience less impact and shear forces, leading to less breakage and fragmentation.
- So the crusher should be operated at relatively slower speeds than the above speeds.
- For further testing let us consider the FRA produced at 35m/s of rotor speed.

4. CONCLUSION

The emphasis on producing recycled sand as the primary output is uncommon, but the findings presented in this study verify that this approach could be compelling in broadening the range of recycled products and, in turn, expanding the recycling industry.

We conducted experiments to observe the effect of varying the speed of the crusher rotor on the amount of Fine Recycled Aggregates (FRA) extracted from the crushing of Coarse Recycled Aggregates (CRA).

We found that at higher speeds of the rotor, the sand was crushed to a much finer level than preferred, resulting in a higher proportion of smaller particles. This may be beneficial for applications that require a finer particle size distribution, but for construction purposes, it can weaken the overall structure and reduce the load-bearing capacity of the material.

On the other hand, operating the crusher at slower speeds resulted in more consistent particle sizes with less fine particles, as the sand particles experienced less impact and shear forces, leading to less breakage and fragmentation.

Therefore, it is generally recommended to operate the crusher at relatively slower speeds to produce sand with a desirable particle size distribution.

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