SSRG International Journal of Civil Engineering
ISSN: 2348-8352/ https://doi.org/10.14445/23488352/IJCE-V11I10P104

Volume 11 Issue 10, 37-40, October 2024

Original Article

Cost-Effective and Sustainable Construction: Mechanical Strength Behavior of Wire Mesh Panels with Integrated C&D Wastes

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Received: 05 August 2024 Revised: 04 September 2024 Accepted: 06 October 2024 Published: 30 October 2024

Abstract - *India, as a developing country, is focusing on enhancing its structural and infrastructural development while addressing waste generation to mitigate environmental impact. The present research investigates the use of coarse aggregates from Construction and Demolition (C&D) waste to produce more easily assembled concrete panels for affordable housing. Basic tests like split tensile strength, flexural strength, and compressive strength, were conducted on standard specimens for M25 grade concrete. Comparing the results to standard concrete examples, it was found that replacing 50% of the coarse aggregate with C&D waste resulted in considerable improvements: 5.3% increase in compressive strength, 4.3% elevation in split tensile strength, and 3.8% increase in flexural strength. Additionally, utilizing C&D waste in wire mesh wall panels reduced construction costs to Rs.750 per square meter and enhanced construction efficiency while maintaining structural integrity. This approach not only addresses pollution from construction activities but also promotes sustainable practices by conserving natural resources. Additional investigation is recommended to further optimize the usage of various C&D waste combinations in building materials, demonstrating the potential of C&D waste to enhance concrete performance as well as to promote sustainable construction.*

Keywords - *Construction & Demolition Wastes, Sustainable Construction, Wire mesh Panels, Mechanical Strength Behavior, Cost-effective.*

1. Introduction

India, as a developing nation, significantly focused on enhancing its structural and infrastructural development to improve its global standing. This progress, however, came with the challenge of managing pollution C&D waste [1- 3]. Crushed stone, various stones (marble, granite, sandstone), bricks, cement plaster, steel (from RCC, door/window frames, roof racks, stair railings, etc.), and wood (in particular from the demolition of old buildings) were among the materials that made up C&D waste. About 150 million tons of C&D waste are produced in India each year [4]. In Hyderabad alone, C&D waste production was around 1,000 tons in 2018, which doubled to 2,000 tons in the last three years. Projections indicated that in the next five years, the city would generate approximately 3,650,000 tons of waste, equivalent to 365,000 truckloads [5]. The Greater Hyderabad Municipal Corporation (GHMC) operated two recycling plants for C&D waste, where the waste was processed into coarse, fine, and silty materials. These materials were then substituted for conventional coarse and fine aggregates in the manufacturing of building components like medians and paving stones [2, 6-16]. This paper explored the creation of wire mesh wall panels using C&D waste by substituting fine and coarse aggregates, aiming to transform waste into a low-cost, sustainable construction material.

Concrete, as well as fired clay aggregate from C&D waste, were included in metakaolin-slag-potassium-silicate geopolymer mixes that were assessed by Matteo Panizza et al. [17]. To determine their appropriateness for industrial usage and their potential as construction materials, the research comprised rigorous mechanical and physical evaluation. According to the findings, geopolymers containing at least 50% C&D aggregate showed potential qualities for application in architectural components; nevertheless, additional specialized research was required for other aspects. Rodríguez et al. [18] conducted a study titled "Construction and Demolition Waste Application and Maximum Daily Output in Spanish Recycling Plants," published in Waste Management and Research. The investigation found that independent of the kind of waste handled, wet mixtures of macadam, gravel, and sand were the most often generated recycled materials in Spanish C&DW facilities. The main uses for Recycled Aggregates (RA) were in unbound applications such as drainage fills with moderate quality criteria, granular subgrades in pavements, and localized fills. Plant managers considered pure RA suitable for more regulated-bound applications like concrete, mortar, and HMA. RA continued to see limited use, either due to outdated legislation or competition with natural aggregates. The infrequent and incomplete RA quality checks made clear the necessity of internal quality control systems to verify and facilitate the final product's commercialization. The highest daily production of about 30% of C&DW plants was less than the literature-defined cost-effectiveness threshold.

2. Details of the Prototype

The process of manufacturing the wire mesh wall panels (1m*1m*0.1m) involves the following steps.

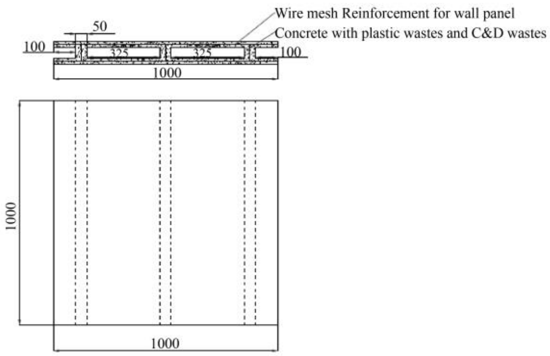

Fig. 1 Details of wire mesh wall panel

2.1. Mix Design

The following mix design has been prepared for the M30grade concrete to make the wire mesh wall panel.

Table 1. Materials used to make wire mesh wall panel for M25 grade

Materials Used	Weight (kg) per Cum
Ordinary Portland cement	332.800
Fly ash to be replaced by 20% with the cement	83.200
Sand/Quarry Dust	1084.94
Coarse aggregate (6mm)	723.30
Coarse aggregates are replaced with construction demolition wastes by 25%, 50%, 75% and 100%	
25%	180.825
50%	361.650
75%	542.475
100%	723.30
Water content	208.00

2.2. Casing and Curing

In a concrete mixer, all of the basic ingredients are combined and stirred for fifteen minutes. After that, the prepared mixture must be taken out of the mixer and poured into the appropriate molds in the next thirty minutes. Vibrators or vibrating tables can be used to compact the concrete in molds of the desired sizes and shapes. After compacting the panels, they are left for 24 hours to allow the ingredients to bond completely. To achieve the required strength, the specimens are removed from the molds after this twenty-four-hour and left to cure in water for a total of twenty-eight days.

2.3. Test Results

The main components of C&D waste are bricks, cement plaster, cement concrete, stone (sandstone granite, marble), steel (from RCC, timber/wood (particularly from the destruction of historic buildings), rubble, and door/window frames, roofing support, staircase rails, etc.). In this research work, cement concrete, bricks, and cement plaster from C&D waste are selected for further processing.

In this research, preliminary tests were conducted to evaluate workability and mechanical properties for an M25 mix design with coarse aggregate replacements of 25%, 50%, 75%, and 100%. Workability tests on fresh concrete, such as slump flow and compaction factor tests, were performed for the M25 grade mix with varying levels of coarse aggregate replacement.

The results from the slump flow and compaction factor tests indicate that C&D waste does not adversely affect the workability of fresh concrete. Hardened concrete specimens were utilized for assessing mechanical parameters like split tensile strength, compressive strength, and flexural strength. The tests showed that replacing 50% of the natural coarse aggregate with C&D waste provides the best balance, resulting in improved strength characteristics compared to other replacement levels.

The experimental outcomes reveal that the compressive strength of the conventional specimen is 28.3 MPa. In comparison, the specimen with 50% C&D waste replacement (C&D 50) "has a compressive strength of 29.8 MPa, which is 5.3% higher than the Conventional Concrete (CC) specimen. Similarly, in the split tensile strength tests, the conventional specimen has a strength" of 3.76 MPa, whereas the C&D 50 specimen has a strength of 3.92 MPa, marking a 4.26% increase. In the flexural strength tests, the C&D 50 specimen shows a strength of 3.53 MPa, which is 3.94% greater than the CC specimen.

These outcomes demonstrate that C&D waste can be effectively utilized as coarse aggregate in concrete. When properly recycled to the appropriate size, C&D waste can enhance the strength of concrete. Future work should explore the combination of kinds types of C&D waste and their incorporation into wire mesh panels for further study.

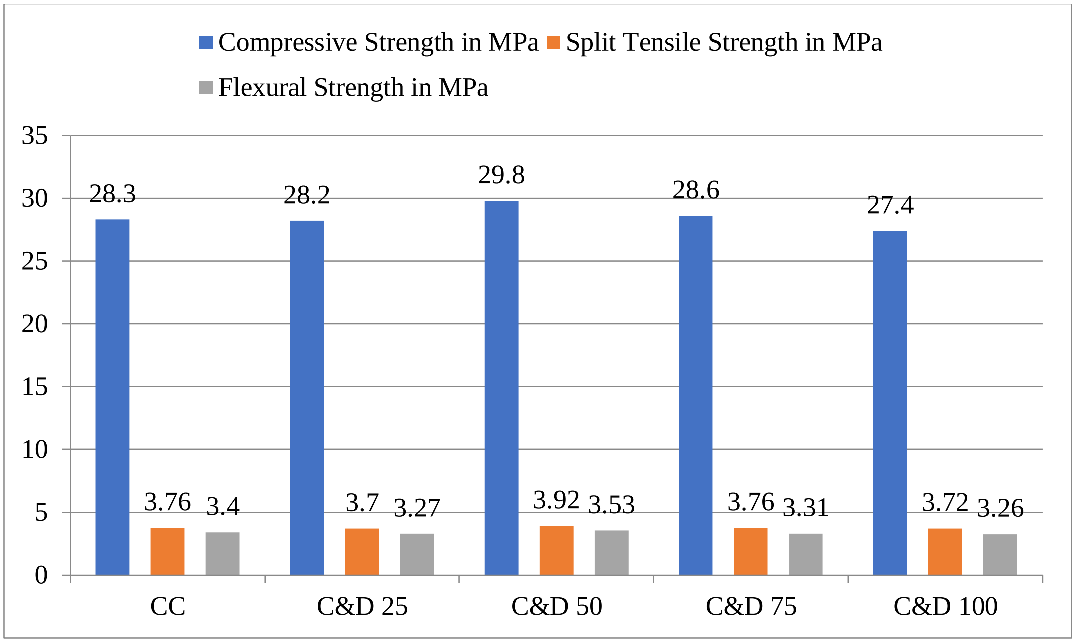

Fig. 2 Mechanical properties of concrete with C&D wastes for the replacement of" concrete

Table 2. Mechanical test properties of different replacements of C&D waste

Mix Designation	Compressive Strength in MPa	Split Tensile Strength in MPa	Flexural Strength in MPa
CC	28.3	3.76	3.4
C&D 25	28.2	3.7	3.27
C&D 50	29.8	3.92	3.53
C&D 75	28.6	3.76	3.31
C&D 100	27.4	3.72	3.26

2.4. Cost Analysis

The cost of manufacturing a conventional concrete wall panel is approximately Rs.1022 per square meter. In contrast, constructing walls with bricks costs around Rs.840 per square meter. Using wall panels made from C&D waste, the cost drops to about Rs.750 per square meter. Thus, utilizing C&D waste for wall panels not only reduces costs compared to other materials but also speeds up construction due to their size (1m x 1m x 0.1m).

Table 3. Wire mesh wall panel-cost analysis

Quantity of one wall panel as per our diagram = 0.1 Cum			
Materials	**Quantity**	**Unit**	**Item rate**
Cement	28.87	Kg	242.51
Fly ash	7.22	Kg	0.00
Sand/Quarry dust	94.12	Kg	80.00
Coarse Aggregate	62.75	Kg	28.24
Water	18.04	Kg	0.00
Wire Mesh	2	Sq.m	322.80
C&D Wastes (Transportation & Crushing)	0.1	Cum	74.50
Total rate per wall panel			**748.05**
Conventional brick wall			
Quantity of one wall panel as per our diagram = 0.1 Cum			
Materials	**Quantity**	**Unit**	**Item rate**
Bricks	50	No	350.00
Cement	50	Kg	420.00
Sand/Quarry dust	40	Kg	34.00
Total rate per wall per Sq.m			804.00
Conventional wall panels available in the market			
Materials	**Quantity**	**Unit**	**Item rate**
Wall panel (Size of 1 Sq.m – Commercial and Residential purpose)	1	Sq.m	1022.20

3. Conclusion

The study demonstrated that Construction and Demolition (C&D) waste, classified by properties such as size, shape, and brittleness, effectively replaced natural coarse aggregates in concrete, particularly at a 50% replacement level. Comparing this replacement to traditional concrete, there were notable strength gains of 5.3% in compressive strength, 4.3% in split tensile strength, and 3.8% in flexural strength. Additionally, utilizing C&D waste in wire mesh wall panels reduced construction costs to Rs.750 per square meter, facilitating faster and more efficient construction while maintaining structural integrity. This approach not only addressed pollution from construction activities but also promoted sustainable practices by conserving natural resources. Future research was suggested to explore various combinations of C&D waste types to further optimize their use in building materials, demonstrating the potential of C&D waste to enhance concrete performance and promote sustainable construction.

References

[1] Sylvain Guignot et al., "Recycling Construction and Demolition Wastes as Building Materials: A Life Cycle Assessment," *Journal of Industrial Ecology*, vol. 19 no. 6, pp. 1030-1043, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[2] Shahiron Shahidan et al., "Utilizing Construction and Demolition (C&D) Waste as Recycled Aggregates (RA) in Concrete," *Procedia Engineering*, vol. 174, pp. 1028-1035, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[3] Misgina Mebrahtom et al., "Comparative Study of Eco-Friendly Wire Mesh Configurations to Enhance Sustainability in Reinforced Concrete Structures," *Scientific Reports*, vol. 14, no. 1, pp. 1-17, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[4] Centre for Science and Environment, "*Another Brick off the Wall- Improving Construction and Demolition Waste Management in Indian Cities*," *Report*, pp. 1-146, 2020. [Google Scholar] [Publisher Link]

[5] Greater Hyderabad Municipal Corporation, Construction & Demolition Waste Management Rules, pp. 1-6, 2016. [Online]. Available: https://www.ghmc.gov.in/announcements/GHMC%20C&D%20Website%20Info_compressed.pdf

[6] Jeyanth Baskaran, Prabhakaran Veerasamy, and Vijay Manibharathi, "Feasibility of Construction Demolition Waste in Concrete as a Coarse Aggregate," *IOP Conference Series: Materials Science and Engineering*: *First International Conference on Sustainable Infrastructure with Smart Technology for Energy and Environmental Management*, Tamil Nadu, India, vol. 955, pp. 1-10, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[7] Qinfeng Zhao et al., "How Can C&D Waste Recycling do a Carbon Emission Contribution for Construction Industry in Japan City?," *Energy and Buildings*, vol. 298, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[8] Nikola Tošić et al., "Multicriteria Optimization of Natural and Recycled Aggregate Concrete for Structural Use," *Journal of Cleaner Production*, vol. 87, pp. 766-776, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[9] Andreu Gonzalez-Corominas, and Miren Etxeberria, "Effects of Using Recycled Concrete Aggregates on the Shrinkage of High Performance Concrete," *Construction and Building Materials*, vol. 115, pp. 32-41, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[10] Malindu Sandanayake et al., "Current Sustainable Trends of Using Waste Materials in Concrete-A Decade Review," *Sustainability*, vol. 12, no. 22, pp. 1-38, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[11] S. Shahidana, I. Isham, and N. Jamaluddin, "A Review on Waste Minimization by Adopting in Self Compacting Concrete," *MATEC Web of Conferences*, vol. 47, pp. 1-7, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[12] Abigail Landa Sanchez et al., "Corrosion Behavior of Steel-Reinforced Green Concrete Containing Recycled Coarse Aggregate Additions in Sulfate Media," *Materials*, vol. 13, no. 19, pp. 1-20, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[13] Gombosuren Chinzorigt et al., "Strength, Shrinkage and Creep of Concrete Including CO_2 Treated Recycled Coarse Aggregate," *Journal of Asian Concrete Federation*, vol. 4, no. 2 pp. 89-102, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[14] Mona S. Mohammed, Hala ElKady, and Hamdy A. Abdel- Gawwad, "Utilization of Construction and Demolition Waste and Synthetic Aggregates," *Journal of Building Engineering*, vol. 43, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[15] Ahmed Anees Alani et al., "Demolition Waste Potential for Completely Cement-Free Binders," *Materials*, vol. 15, no. 17, pp. 1-15, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[16] Suleman Ayub Khan et al., "Sustainable Alternate Binding Material for Concrete Using Waste Materials: A Testing and Computational Study for the Strength Evaluation," *Journal of Building Engineering*, vol. 80, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[17] Matteo Panizza et al., "Assessment of Geopolymers with Construction and Demolition Waste (CDW) Aggregates as a Building Material," *Construction and Building Materials*, vol. 181, pp. 113-133, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[18] C. Rodríguez et al., "The Incorporation of Construction and Demolition Wastes as Recycled Mixed Aggregates in Non-Structural Concrete Precast Pieces," *Journal of Cleaner Production*, vol. 127, pp. 152-161, 2016. [CrossRef] [Google Scholar] [Publisher Link]