ISSN: 3107-6513

Eco-Friendly Concrete for Suitable Replacements with Recycled Stone Powder as Fine Aggregate and Waste Pencil Graphite Dust as Cement

G. Lokeswar Reddy[#1], P. Subhasri[#2]

[#1]*P.G Scholar, Department of Civil Engineering, Dr. K. V. Subba Reddy Institute of Technology, Kurnool, Andhra Pradesh, India*

[#2]*Assistant Professor, Department of Civil Engineering, Dr. K. V. Subba Reddy Institute of Technology, Kurnool, Andhra Pradesh, India*

[1]lokeswarreddy123@gmail.com, [2]subhasri230597@gmail.com

***Abstract*—Significant research has been conducted on the use of industrial and domestic wastes in concrete as a means of meeting the growing demand for environmentally friendly building materials. This research examines the joint application of recycled stone powder as a partial substitute for fine aggregate and waste pencil graphite dust as a partial substitute for cement in standard concrete. Recycled stone powder, a plentiful by-product from the stone crushing industry, provides better particle arrangement and shape, which may improve mechanical characteristics.**

On the other hand, pencil graphite dust, a carbon-rich waste product from households, acts as an environmentally friendly cement additive that may offer various functional advantages. The experimental program includes the preparation of concrete mixtures using different amounts of recycled stone powder (0%, 10%, 20%, 30% and 40% by volume of fine aggregate) and pencil graphite dust (0%, 5%, 10%, 15% and 20% by weight of cement) for M40 Grade of concrete. Thorough examinations, which consist of tests for compressive strength, split tensile strength, and flexural strength measures like water absorption and porosity, are performed at intervals of 7, 14, and 28 days for M40 grade of concrete. Initial findings indicate that moderate levels of replacement can attain acceptable strength, while also lowering cement use and encouraging the recycling of waste materials. The research emphasizes the promise of this hybrid concrete made from waste as a sustainable and effective building material, offering a route to environmentally friendly concrete.

Keywords*— *Recycled Stone Powder, waste pencil graphite dust, recycling of waste materials

I. INTRODUCTION

One of the most common building materials used worldwide is concrete. Cement, water, small aggregates (like sand), and big aggregates (like gravel or crushed stone) are combined to create a composite material. The hydration process, a chemical reaction that causes the combination of these components to gradually harden and strengthen, is what happens when they are mixed together.

Due to its strength, durability, versatility, and affordability, concrete is a crucial material in the construction of dams, roads, bridges, buildings, and other structures. Its versatility makes it suitable for both structural and aesthetic uses, as it may be molded into almost any form. Different kinds of concrete may be manufactured based on the application, including reinforced concrete, pre-stressed concrete, lightweight concrete and high-performance concrete. Every kind is made to satisfy particular environmental or structural needs.

Recycled Stone Powder (RSP)

Recycled stone powder is a byproduct of the process of processing and cutting natural stones like granite, marble, and limestone. This fine powder, formerly thought to be waste, is now recognized as a useful substance for environmentally friendly building methods. By recycling stone powder rather than dumping it in landfills, businesses may lessen environmental contamination, conserve natural resources, and encourage sustainable manufacturing.

Recycled stone dust can be used as a partial substitute for cement, sand, or filler materials in concrete and mortar in the building industry. When properly proportioned, its fine particle size improves the packing density of mixtures, which can improve the strength, durability, and workability of concrete.

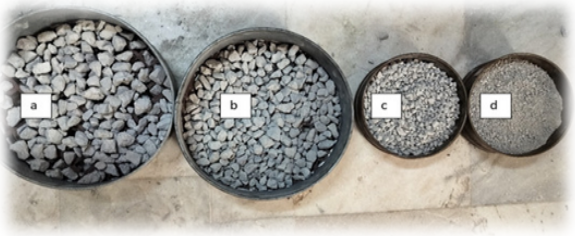


Figure 1: Recycled Stone Powder

Waste Pencil Graphite Dust (WPGD)

In recent times, there has been an increasing focus on managing waste and utilizing resources sustainably, motivating industries to find methods to recycle and repurpose materials that were previously deemed useless. A prime example of such an overlooked resource is Waste Pencil Graphite Dust (WPGD), which is produced during the manufacturing, sharpening, and recycling processes of pencils. This fine, dark powder is largely made up of graphite particles combined with clay, wax, and some minor contaminants. While the quantity of WPGD generated by individual operations may appear small, its build-up across various manufacturing sites leads to considerable industrial waste and possible environmental

ISSN: 3107-6513

contamination. Graphite, the key ingredient in WPGD, is a form of carbon recognized for its remarkable thermal and electrical conductivity, ability to lubricate, chemical resilience, and safety for health. These characteristics make WPGD a valuable secondary raw material that can be reused in multiple applications. Nonetheless, in many instances, this waste is either thrown away or allowed to spread into the atmosphere, resulting in health risks related to dust and environmental concerns. Effective management and recycling of WPGD can significantly reduce these dangers while also providing opportunities for the recovery of materials and cost savings.

Figure 2: Waste Pencil Graphite Dust

Applications of Recycled Stone Powder and Waste Pencil Graphite Dust

Both Recycled Stone Powder (RSP) and Waste Pencil Graphite Dust (WPGD) are significant by-products from industrial processes that can be transformed into valuable materials for numerous uses, aiding in the reduction of waste and fostering sustainability.

Recycled Stone Powder (RSP) is produced from the cutting, grinding, and polishing of natural stones like marble, granite, and limestone, and it finds diverse applications in the construction and manufacturing sectors. It is frequently utilized as a partial substitute for cement or sand in concrete and mortar mixtures, enhancing the density, strength, and longevity of the final products. Furthermore, RSP acts as a filler in bricks, blocks, tiles, and paving mixtures, which lowers manufacturing costs and decreases the need for raw materials. In road building, it can be incorporated into asphalt and sub-base layers to bolster load-bearing capabilities. Additionally, thanks to its fine texture and mineral content, RSP is employed in plaster, ceramics, glass, and paint, where it improves smoothness, brightness, and overall quality..

In a similar vein, **Waste Pencil Graphite Dust (WPGD)**, which is produced during the making and sharpening of pencils, presents many potential uses due to its high carbon levels, electrical conductivity, and lubricating qualities? In the construction industry, WPGD can serve as an additive in cement, mortar, or concrete to enhance workability, thermal conductivity, and longevity.

Its fine, layered texture makes it ideal as a filler or strengthener in polymer composites, rubber goods, and coatings, boosting mechanical strength while lowering material expenses.

Thanks to graphite's natural lubrication properties, WPGD is also employed as a dry lubricant for machinery, gears, and locks, as well as in anti-corrosive paints and protective coatings.

In the electrical and energy sectors, processed WPGD can function as a conductive substance in electrodes, batteries, super capacitors, and fuel cells. Moreover, it has shown potential in environmental applications, such as adsorbing heavy metals and organic contaminants from wastewater, as well as in the creation of activated carbon.

II. LITERATURE REVIEW

Silva, L. S., Amario, M., Stolz, C. M., Figueiredo, K. V., & Haddad, A. N. (2023)- A Comprehensive Review of Stone Dust in Concrete: Mechanical Behavior, Durability, and Environmental Performance

The escalating demand for natural resources within the construction industry is progressing upward. At the same time, however, there is a great concern regarding the depletion of these resources. This review paper emphasizes the significance of utilizing alternative aggregate materials in concrete. Particularly, it aims to explore replacing natural sand with stone dust. On the one hand, the depletion of primary sources of natural sand worldwide, combined with environmental and ecological concerns, drives the adoption of alternative aggregate materials for sustainable concrete construction. On the other hand, stone dust, a waste from the quarrying industry, offers a cost-effective and practical solution for producing concrete. This article presents a comprehensive literature review of the main trends in utilizing stone dust in recycled aggregates in the past decade and its influence on concrete properties. It addresses critical research questions regarding the physical and chemical properties of stone dust aggregates compared to natural sand; the impact of stone dust on the workability, mechanical, physical, and durability properties of recycled concrete; and the potential reduction of environmental impacts in terms of energy consumption and emissions through the replacement of natural sand with stone dust. Ultimately, this paper proposes future investigative work based on identified research gaps.

Luo, T., et al. (2021) — "Effects of Graphite on Electrically Conductive Cementitious Composites"

What it is: A focused review on graphite as a conductive filler in cementitious composites: mechanisms, percolation, effects on mechanical and electrical properties, dispersion issues and common mix approaches.

Electrically conductive cementitious composites (ECCCs) have been widely used to complete functional and smart construction projects. The correlation degree between the content of RP and the performance of cement-based materials was obtained based on the gray relation analysis method. Graphite, due to its low cost and wide availability, is a promising electrically conductive filler to generate electrically conductive networks in cement matrixes. Cement-based materials provide an ideal balance of safety, environmental protection, strength, durability, and economy. Today, graphite is commonly applied in traditional cementitious materials. This paper reviews previous studies regarding the effects and correlations of the use of graphite-based materials as

ISSN: 3107-6513

conductive fillers on the properties of traditional cementitious materials. Ultimately, this paper proposes future investigative work based on identified research gaps.The dispersion, workability, cement hydration, mechanical strength, durability, and electrically conductive mechanisms of cementitious composites modified with graphite are summarized. Graphite composite modification methods and testing methods for the electrical conductivity of ECCCs are also summarized.

III. METHODOLOGY

MATERIALS

Cement:

A cement particle bonds firmly to the stone when it comes into touch with water. The compounds found in cement stay in the finished result, giving it the desired qualities and encouraging its inclusion into the concrete. The cement is JSW cement, more precisely Ordinary Portland cement (OPC 43 Review).

Fine Aggregate:

Fine sums are tiny particles with a diameter of 4.75mm that are extensively used in the improvement business. This improves the dimensional robustness of the concrete mix. The sand used is locally obtained and fits zone I specifications. It underwent strainer testing inside the investigation office in accordance with IS 383:1970 guidelines.

Coarse Aggregate:

The coarse particles of a certain size and irregular shape used in development activities make up the approximate amounts acquired by the mining approach. These sizes, which include ratings exceeding 40mm, 20mm, and 10mm, are offered in the showcase. This raises the concrete's quality considerably. According to IS 383-1970, the quantity utilized is roughly one and rated at 20 mm.

Recycled Stone Powder (RSP):

Recycled stone powder is a very fine material created from leftover stone debris that comes from activities like mining, cutting, polishing, or breaking down natural stone Instead of letting this waste pile up in landfills or dump sites, the stone pieces are gathered, treated, and ground into a smooth powder with even particle sizes. This recycled powder keeps many of the physical and chemical traits of natural stone, making it valuable for various uses.

S.No	Physical Property	Recycled Stone Powder
1	**Size Distribution**	0.075 mm to 4.75 mm
2	**Shape**	Angular or sub-angular
3	**Surface Texture**	Rough
4	**Specific Gravity**	2.5 to 2.8
5	**Water Absorption**	<2%
6	**Soundness**	<12%
7	**Fineness**	2.3-3.1
8	**Bulk Density**	1.4-1.8 g/cm^3

S.No	Chemical Property	Recycled Stone Powder
1	**Silica (SiO_2)**	40% to 70%
2	**Alumina (Al_2O_3)**	5% to 15%
3	**Calcium Oxide (CaO)**	5% to 40%
4	**Magnesium Oxide (MgO)**	1% to 8%
5	**Sodium Oxide (Na_2O)**	0.2% to 1.5%
6	**Iron Oxide (Fe_2O_3)**	1% to 5%
7	**Loss on Ignition (LOI)**	1% to 3%
8	**Sulphur Content (SO_3)**	Trace to low
9	**Potassium Oxide (K_2O)**	0.3% to 2%
10	**pH Level**	8 to 12

Waste Pencil Graphite Dust (WPGD):

Waste pencil graphite dust is the fine black powder that comes from making, cutting, or sharpening pencils. Since pencil "lead" is really a mix of graphite and clay, this dust mainly consists of carbon-heavy graphite mixed with clay minerals and a little bit of wax or other organic materials. The dust is very fine and light, which makes it easy to float in the air if not handled correctly.

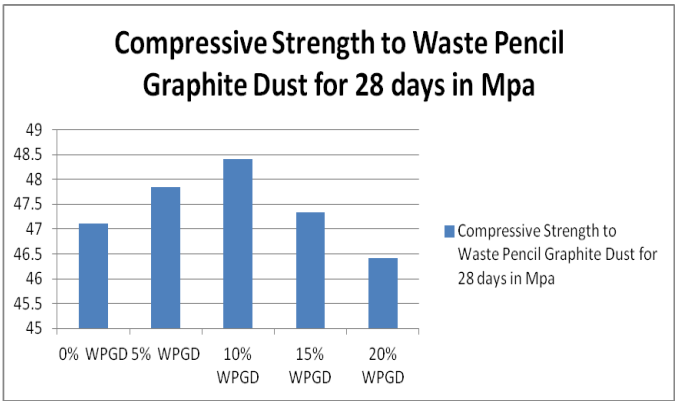
S.No	Physical Property	Waste Pencil Graphite Dust
1	**Particle Size**	Very fine (<75 microns)
2	**Shape**	Soft, smooth, slippery
3	**Color**	Black/gray
4	**Specific Gravity**	1.8–2.3
5	**Surface Texture**	Rough, porous
6	**Water Absorption**	Very Low
7	**Soundness**	<0.1%
8	**Fineness**	90-100%
9	**Bulk Density**	Low (0.3–0.7 g/cm^3)

S.No	Chemical Composition	WPGD (%)
1	**Silica (SiO_2)**	5–25%
2	**Alumina (Al_2O_3)**	1% to 5%
3	**Iron Oxide (Fe_2O_3)**	0.2% to 2%
4	**Calcium Oxide (CaO)**	<1%
5	**Magnesium Oxide (MgO)**	<1%
6	**Sodium Oxide (Na_2O)**	0.2% to 1%
7	**Potassium Oxide (K_2O)**	0.3% to 2%
8	**Sulfur Trioxide (SO_3)**	0.1% to 0.3%
9	**Loss on Ignition (LOI)**	10% to 20%
10	**pH Level**	Typically 7 to 9

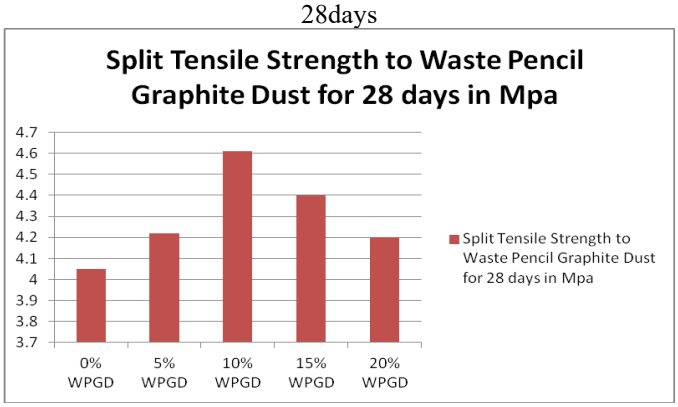
IV. MIX DESIGN

Grade	M30
Proportion	1:1.49:2.49
W/C ratio	0.45
Cement	438
Fine Aggregate	654
Coarse Aggregate	1089
Water	197

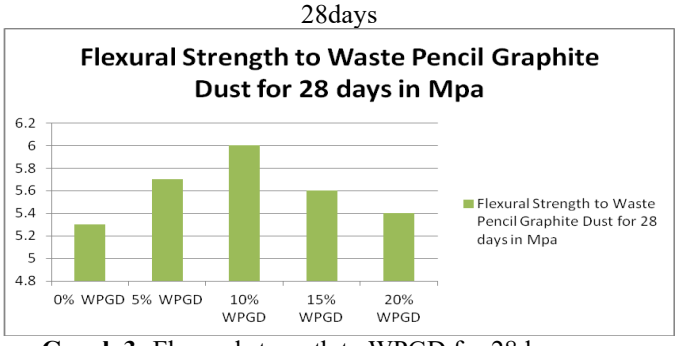
ISSN: **3107-6513**



Graph 1: Compressive strength to WPGD for 28days

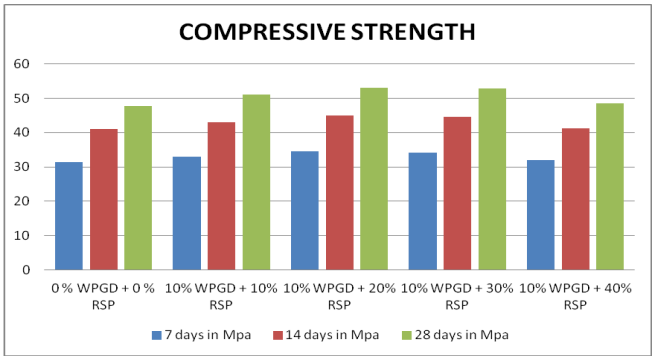


Graph 2: Split Tensile strength to WPGD for 28days



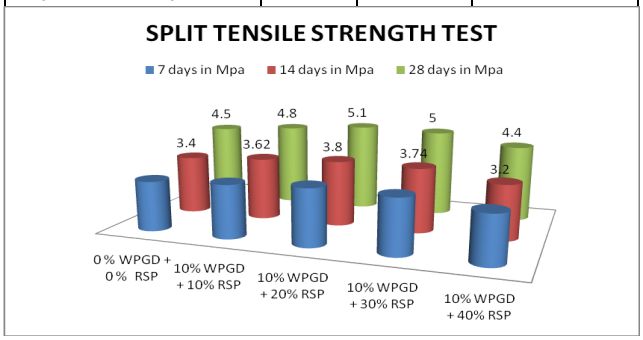
Graph 3: Flexural strength to WPGD for 28days

Mix % Replacement	7 days	14 days	28 days in Mpa
0 % WPGD + 0 % RSP	31.5	41	47.8
10% WPGD + 10% RSP	33	43	51
10% WPGD + 20% RSP	34.5	45	53
10% WPGD + 30% RSP	34.2	44.5	52.8
10% WPGD + 40% RSP	32	41.2	48.5



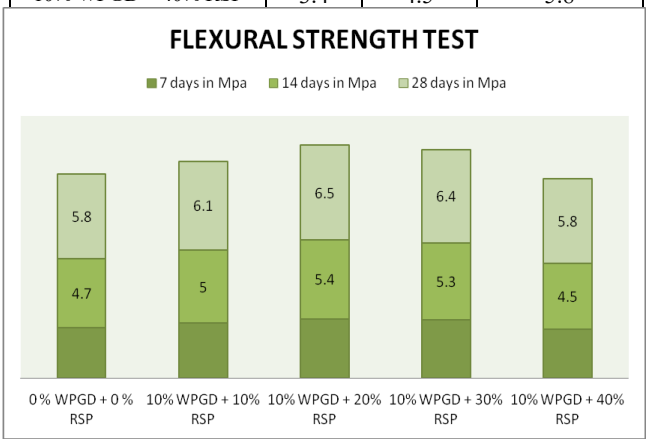
Graph 3: Comparison of 7,14,28 days - compressive strength

Mix % Replacement	7 days	14 days	28 days in Mpa
0 % WPGD + 0 % RSP	2.9	3.4	4.5
10% WPGD + 10% RSP	3.1	3.62	4.8
10% WPGD + 20% RSP	3.3	3.8	5.1
10% WPGD + 30% RSP	3.2	3.74	5
10% WPGD + 40% RSP	2.8	3.2	4.4



Graph 4: Comparison of 7,14,28 days-Split tensile strength

Mix % Replacement	7 days	14 days	28 days in Mpa
0 % WPGD + 0 % RSP	3.5	4.7	5.8
10% WPGD + 10% RSP	3.8	5	6.1
10% WPGD + 20% RSP	4.1	5.4	6.5
10% WPGD + 30% RSP	4	5.3	6.4
10% WPGD + 40% RSP	3.4	4.5	5.8



Graph 5: Comparison of 7,14,28 days-Flexural tensile strength

V. CONCLUSION

The following conclusions are reached from the compressive, split tensile and flexural strength tests carried out on M40 grade concrete using Waste Pencil Graphite Dust (WPGD) as a partial cement substitute and Recycled Stone Powder (RSP) as a partial fine aggregate substitute: results:

The inclusion of 10% WPGD as a cement substitute demonstrated good performance at all curing ages, proving that WPGD may be used as an additional cementitious ingredient without having a detrimental impact on the strength of the concrete.

The mechanical characteristics of concrete were greatly affected by the substitution of recycled stone powder (RSP) for natural fine aggregate. RSP substitution resulted in an increase in strength values up to an ideal point, at which point they began to decline. 20% was determined to be the ideal amount of RSP replacement, and at that point:

✓ The greatest increase was in compressive strength, which surpassed the goal mean strength of M40 concrete.

ISSN: **3107-6513**

- ✓ The split tensile strength was greater, demonstrating better adherence and tensile resistance inside the concrete matrix.
- ✓ The peak flexural strength further confirmed the improved crack resistance and performance under bending.

In addition to a decrease in all three strength characteristics, a decrease in RSP replacement of over 20% was seen. more precisely Ordinary Portland cement (OPC 43 Review).

REFERENCES

[1] The **He, W., Hao, W., Meng, X., Zhang, P., Sun, X., & Shen, Y. (2022)**
Influence of Graphite Powder on the Mechanical and Acoustic Emission Characteristics of Concrete
https://doi.org/10.3390/buildings12010018

[2] *Energy from Discarded Graphite-Based Pencils: Recycling the Potential Waste Material*
https://www.sciencedirect.com/science/article/pii/S0924424722000413

[3] **Pellegrini Cervantes et al. (2022)**
Recycled Conductive Mortar Using Graphite Powder
https://www.intechopen.com/chapters/85152

[4] K. **Recycling Stone Powder as Cementitious Material in Concrete** Journal: Journal of Building Engineering, Science Direct
https://www.sciencedirect.com/science/article/abs/pii/S2352710224013408

[5] **Singh, N., Shivam, Mishra, S., & Kumar, R. (2022)** *Reusing Granite Dust as Sand Replacement in Concrete.*
https://www.ijert.org/reusing-granite-dust-as-sand-replacement

[6] **Jakhar, A., & Chaudhary, M. (2023)** *Utilization of Stone Slurry Powder in Concrete.*
https://www.propulsiontechjournal.com/index.php/journal/article/view/2082