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INVESTIGATION OF CHEMICAL PROPERTIES BY SCRUTINIZING OF THE ANTHRACITE WASHERY REPUDIATED BY FRAGMENTARY SUBSTITUTION OF COARSE AGGREGATE EXPLORATION

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ABSTRACT
The booming construction sector's rapid expansion has greatly depleted natural resources and caused environmental harm. In response, considerable efforts are being made to repurpose industrial by-products and waste to replace natural resources in order to enhance sustainability. Aggregates, a vital element of concrete comprising 70-80 percentage of its volume, significantly affect its properties. Acknowledging construction's waste repurposing potential, this study introduces Coal Washery Rejects (CWR) as a substitute for coarse aggregates and examines the resulting mechanical traits of CWR-infused concrete. This research employs CWR to partially replace coarse aggregates, ranging from 0 percentage to 30 percentage. Mechanical properties including compressive and splitting strength, durability (measured by Rapid Chloride Permeability Test), water absorption, porosity, and drying shrinkage were evaluated for concrete with 30 percentage CWR replacement, across varying curing periods. These findingswere compared with those of conventional M 25 grade concrete (CC). The results reveal a gradual decrease in strength properties with increasing CWR replacement, remaining modest at 20 percentage and 30 percentage replacement levels, but significantly declining beyond 30 percentage replacement. Thus, a 30 percentage CWR replacement level is optimal for structurally sound concrete. The study replaces coarse aggregates with 30 percentage CWR in one aspect and incorporates 30 percentage CWR replacement for coarse aggregates and 30 percentage FA replacement for cement in FA-based concrete. Compressive strength, water absorption, Rapid Chloride Permeability Test, and drying shrinkage properties were examined across diverse curing periods and juxtaposed with conventional M 25 grade concrete. This investigation underscores these alternative materials' potential in sustainable concrete production, offering insights into their mechanical and durability attributes.

KEYWORDS:
Coal Washery Rejects (CWR), Mechanical traits of CWR-infused concrete, Rapid Chloride Permeability Test (RCPT), Enhanced sustainability, Mechanical properties of concrete.

I.INTRODUCTION

GENERAL
Long-standing research aims to boost concrete properties using industrial by-products and modern waste. Recent work focuses on integrating industry by-products (fly ash, silica fume, GGBFS, glass cullet) into construction to replace aggregates or cement, addressing environmental concerns. Growing eco-consciousness spurs waste recycling. Many sectors yield substantial waste, including residues and scrap. Studies over 20 years explore urban waste in building materials, uncovering positive impacts alongside eco-benefits. Aggregates, 70-80 percentage of concrete volume, vital for properties, face scarcity due to construction growth. Seeking alternatives like coal powder, slag, plastics, rubber,

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research counters shortages and environmental woes. Careful evaluation is crucial due to aggregates' significance. Waste categories include industrial by-products, recyclable waste (coal ash, metal slags, plastics). Introducing coal washery rejects (CWR), this study pioneers CWR, a novel waste from coal washing, as coarse aggregate in concrete. Assessing CWR's viability aligns with sustainable production and resource challenges.

1. Coal Washery Residues

Research explores boosting concrete attributes with industrial by-products and waste, a longstanding pursuit. Recent focus integrates by-products (fly ash, silica fume, GGBFS, glass cullet) in construction, replacing aggregates or cement. Environmental awareness drives waste recycling. Urban waste enhances building materials and final product properties. Aggregates shape concrete traits, vital as demand surges due to rapid construction growth. Waste materials like coal powder, slag, plastics replace aggregates, mitigating extraction concerns. Evaluating waste integration is vital. This study introduces coal washery rejects (CWR), coal washing by-product, as potential aggregate replacement. Assessing CWR's viability for sustainable concrete production addresses environmental and resource issues. Construction growth prompts vital by-product and waste utilization for sustainability. Aggregate alternatives tackle shortages and environmental concerns. Research spotlights various materials like coal ash, blast furnace slag, plastics.

2. Recycled Aggregates from Mechanical Sources

Industrial waste aggregates encompass diverse categories shaped by chemical composition and weight. Organic aggregates originate from sources like plastics, rubber, leather, and select food sectors. Inorganic counterparts span industrial slags, mining residues, and coal industry remnants. Hybrid aggregates merge organic and inorganic elements, like glass-reinforced plastics and specific industrial slimes. Weight-based categorization yields lightweight examples: plastics, rubber, much food and agricultural waste, and coal-based powder. In contrast, most industrial slags surpass conventional aggregates in weight.

3. Utilizing Coal Ash for Concrete Aggregates

Coal combustion yields fly ash and bottom ash. Fly ash, fine residue from combustion, carries trace carbon. Bottom ash, wet or dry, is coarse; boiler type determines granule size. Boiler slag forms pellets via water jets. Ash properties vary by coal type, combustion, processing. Fly ash use in cement is known; scarce data on fly ash, coal bottom ash (CBA), boiler slag as concrete additives. Limited research on bottom ash, boiler slag as concrete aggregates.

4. Solid Residual Ash

CBA (Coal Bottom Ash) properties vary due to burning, production, and ash type. Its lower density than sand makes it a potential lightweight concrete aggregate. Various CBA types absorb water differently (2 percentage to 32 percentage). Its porosity absorbs more water in mixes, affecting water-cement ratio. CBA acts as internal curing for high-strength concrete with low initial water. Its porosity stores water, boosting concrete properties

5. Project Objectives and Focus

The study introduces CWR as coarse aggregate alternative in concrete, assessing mechanical and durability properties. CWR replaces coarse aggregates by 0-30 percentage. Compressive strength, Split tensile strength, Bond, MOE, RCPT, Drying shrinkage, Water absorption, porosity, UPV, and Impact strength are compared with M25-grade concrete across curing times. Research leverages construction waste reuse.

II. LITERATURE INSPECTION

Literature Review

Ganjian et al. (2009) explored the utilization of tire waste to replace both coarse aggregates and cement in concrete production. Snelson et al. (2009) incorporated tire rubber waste and ash in concrete, substituting rubber chips for two coarse limestone aggregate sizes.

Manso et al. (2009) highlighted steel slag's properties, including higher specific gravity, water retention, and porosity at 10.5

Pacheco-Torgal and Jalali (2010) used ceramic waste as coarse aggregate and cement replacement in concrete, utilizing ceramic bricks and white stoneware with silica, alumina, quartz, and feldspar content.

Guney et al. (2010) studied waste foundry sand, rich in silica, as aggregate in high-performance concrete derived

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from metal casting with clay as a binding material.

Suzuki et al. (2009) employed porous waste ceramic coarse aggregate in high-performance concrete under saturated surface-dry conditions. This section reviews studies incorporating various waste materials into concrete to enhance properties and sustainability.

III. EXPERIMENTAL PLAN

3.1. Materials: The composition of materials significantly impacts concrete characteristics. This section outlines the materials used for conventional concrete (CC) and Coal Washery Rejects (CWR)-based concrete, detailing their chemical and physical attributes.

Cement Ordinary Portland Cement 53 grade (Penna), conforming to IS 12269 (1987), was utilized. Cement'schemical properties, as provided by the manufacturer, are displayed in Table 3.1.1.a.

S.No	Particulars	Test result	Requirement as per IS:12269-1987
	Chemical Composition		
1	% Silica(SiO_2)	19.79	
2	% Alumina(Al_2O_3)	5.67	
3	% Iron Oxide(Fe_2O_3)	4.68	
4	% Lime(CaO)	61.81	
5	% Magnesia(MgO)	0.84	Not more Than 6.0%
6	% Sulphuric Anhydride (SO_3)	2.48	Max. 3.0% when $C_3A>5.0$ Max. 2.5% when $C_3A<5.0$
7	% Chloride content	0.003	Max. 0.1%
8	Lime Saturation Factor $CaO-0.7SO_3/2.8SiO_2+1.2Al_2O_3+0.65Fe_2O_3$	0.92	0.80 to 1.02
9	Ratio of Alumina/Iron Oxide	1.21	Min. 0.66

Summary of physical properties and various tests conducted on cement as per IS 4031(1988) are presented in the Table 3.1.2.

Coarse Aggregate Crushed granite stones, 20 mm and 10 mm in size, are used. IS 2386 (Part III, 1963) indicates dry bulk specific gravity of 2.6 and water retention of 0.3 percentage. For 20 mm aggregate, mass density is 1580 kg/m3, impact strength is 17.9 percentage, and crushing strength is 22.8 percentage. Grading follows IS 383(1970).

Table 3.1.1.b) Physical Properties of Cement

S.No.	Physical properties	Test result	Test method/ Remarks	Requirement as per IS 12269 (1987)
1	Specific gravity	3.15	IS 4031(1988) – part 11	-
2	Fineness (m^2/Kg)	311.5	Manufacturer data	Min.225 m^2/kg
3	Normal consistency	30%	IS 4031 (1988)- part 4	-
4	Initial setting time (min)	90	IS 4031 (1988)- part 5	Min. 30 min
5	Final setting time (min)	220	IS 4031 (1988)- part 5	Max. 600 min
6	Soundness Lechatelier Expansion (mm) Autoclave Expansion (%)	0.8 0.01	Manufacturer data	Max. 10 mm Max. 0.8%
7	Compressive strength (MPa) 3 days 7 days 28 days	25 39 57	IS 4031 (1988)- part 6	27 MPa 37 MPa 53 MPa

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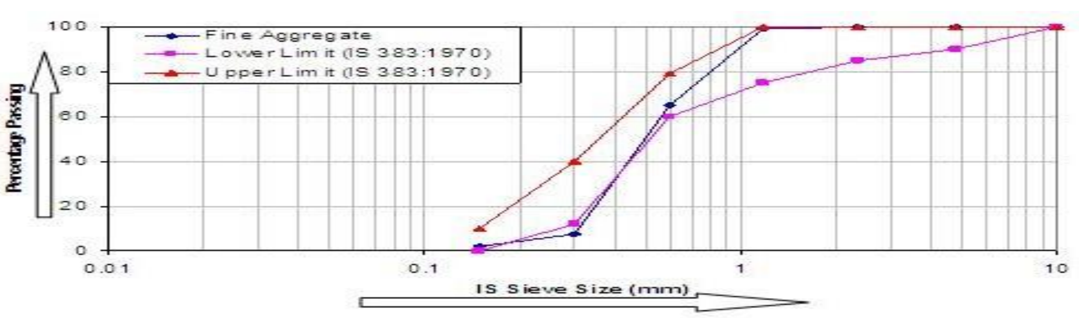
Table 3.1.2.1. Sieve analysis of 20 mm Coarse Aggregate

S.No	Sieve size	Cumulative percent passing	
		20 mm	IS 383 (1970) limits
1	20 mm	100	85-100
2	16 mm	56.17	N/A
3	12.5 mm	22.32	N/A
4	10 mm	5.29	0-20
5	4.75 mm	0	0-5

Table 3.1.2.2. Sieve analysis of 10 mm coarse aggregate

S.No	Sieve size	Cumulative percent passing	
		10 mm	IS 383 (1970) limits
1	10 mm	99.68	85-100
2	4.75 mm	8.76	0-20
3	2.36 mm	2.4	0-5

3.1.3. Fine Aggregate Natural river sand was used as the fine aggregate. Bulk specific gravity in an oven-dry state



Graph. 3.1.3. Grading curve of fine aggregate

is 2.6, water absorption is 1 percentage (IS 2386). Gradation was established via sieve analysis (IS 383),

3.1.4. Water Usual water meets concrete needs, except when contaminated (sewage, industrial waste). Testing ensures suitability and avoids problematic sources.

3.3. Test Methods This section outlines fresh and hardened concrete property assessments.

Tests on Fresh Concrete

3.3.1.1. Slump Cone Test Measures concrete workability, fluidity, consistency, aligning with quality.

3.3.1.2. Concrete Slump Test Assesses fresh concrete, examining workability and consistencyacross batches. Noted for simplicity, this test employs:

- Slump cone,
- Measuring scale,
- Tempering rod (steel).

Procedure:

1. The slump test mold is a truncated cone, 300 mm (12 in) tall, with a base diameter of 200 mm (8 in) and a top opening of 100 mm (4 in).
2. Position the mold on a flat surface, fill it with concrete in three layers of desired workability.
3. Compact each layer 25 times using a 16 mm (5/8 in) steel rod with rounded end.
4. Smooth the top surface by sweeping and rolling the tempering rod.
5. Securely hold the mold against its base to prevent shifting during pouring, aided by handles or footrests.
6. Lift the cone vertically after leveling, allowing concrete to slump unsupported.
7. The reduction in central point's height to the slumped concrete surface is the slump.
8. Measure the slump by aligning the tempering rod placed over the cone with the slumped area.
9. Record the slump's reduction in concrete height compared to the mold (usually rounded to the nearest 5 mm or 1/4 in).

3.2.3. Concrete Slump

3.2.3.1. Slump Varieties Concrete slumps exhibit diverse shapes, falling into the followingtypes: 1. Collapse Slump 2. Shear Slump 3. True Slump

1. Collapse Slump: Concrete fully collapses, often from excess moisture or high workability.
2. Shear Slump: Top portion shifts sideways or slides down an incline, indicating shear or collapse.
   - For shear/collapse, retest with fresh sample.
   - Persistent shear suggests weak mix cohesion.
3. True Slump: Concrete subsides, retaining shape.
   - Highly consistent mixes show Zero slump, making distinctions challenging (Table 3.2.3.1)

Mainly used in tests:

Compaction Variability Test:

1. Fill upper container with cement until overflow.
2. Cement flows from upper to lower container.
3. Cement falls into designated chamber.
4. Trim excess cement with plane blades.
5. Weigh cement in chamber - partially compacted weight.
6. Add fresh cement, vibrate for full compaction.
7. Re-weigh for fully compacted weight.

Calculate Compaction Variability: Compaction Variable = (Weight of partially compacted concrete) / (Weight of fully compacted concrete).

Mechanical Property Tests for Concrete

This section outlines testing methods for concrete's mechanical properties, emphasizing compressive strength and splitting tensile strength (STS).

Compressive Strength Test: Compressive strength was assessed on cubic specimens (150 mm x 150 mm) at 7, 28, 56, and 90 days, following IS 516 (1991) guidelines. Three specimens per age and mix were tested, and strength (f'c) calculated by dividing the maximum load by cross-sectional area.

Splitting Tensile Strength Test: Splitting tensile strength (STS) was evaluated on cylindrical specimens (150mm x 300 mm) at 28, 56, and 90 days, using IS 5816 (1999). Three specimens per age and mix were tested, recordingmaximum load and computing strength (fct) using relevant measurements.

Where:

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- fct represents concrete's splitting tensile strength (in N/mm²).
- P denotes the maximum load applied to the specimen (in Newton).

Degree of workability	Slump		Compacting Factor	Use for which concrete is suitable
	mm	in		
Very low	0-25	0-1	0.78	Very dry mixes; used in road making. Roads vibrated by power operated machines.
Low	25-50	1-2	0.85	Low workability mixes; used for foundations with light reinforcement. Roads vibrated by hand operated Machines.
Medium	50-100	2-4	0.92	Medium workability mixes; manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations.
High	100-175	4-7	0.95	High workability concrete; for sections with congested reinforcement. Not normally suitable for vibration

$$f_{ct} = 2P / (\Pi \, l \, d)$$

- l signifies the length of the specimen (in mm).
- corresponds to the cross-sectional diameter of the specimen (in mm).

Bond Strength Test: Cylindrical specimens (100mm x 200mm) with 200mm embedded length were removed from the curing tank after 7, 28, and 56 days. Testing followed IS: 2770 (part I)-1967, utilizing a Universal Testing Machine (UTM) to pull the embedded bar until bond failure, determining load at failure and bond strength.

Modulus of Elasticity (MOE): Determined per BIS: 516-1959, using LVDT for displacement measurement. Stress loading started at 14.0 N/mm²/min up to (C+0.5) N/mm². After one minute at this load, it reduced, then reapplied to reach (C+0.15) N/mm². C is 33

Concrete Durability Tests: Durability assessments include water absorption, surface absorption, water and chloride permeability. Mix-specific evaluation addresses test limitations and characteristics.

Test Methods: Describes methodologies for assessing concrete's solidified properties.

Durability Property Tests: Explains evaluating durability aspects: compressive strength, water absorption, rapid chloride permeability, drying shrinkage.

Compressive Strength Test: Cubic specimens (150mm x 150mm) from varied mixes were tested at 7, 28, and 56 days, per IS 516 (1991). Calculated f'c by dividing max load by cross-sectional area.

Drying Shrinkage Test: Assesses drying strain in SCC and CC following ASTM C 157 (2008). Cylinders (150mm x 300mm) moist-cured for 7 days, then exposed to controlled drying. Length changes monitored using a comparator with digital extensometer at intervals.

Where:

$$\text{Drying shrinkage} = \frac{R_i - R_t}{L}$$

- Ri: Initial dial gauge reading of the specimen after 7 days of moist curing.
- Rt: Dial gauge reading of the specimen after "t" days of drying.
- L: Length of the specimen after 7 days of moist curing.

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3.5. Rapid Chloride Permeability Test (RCPT)

Introduction

Reinforced concrete structures, designed for longevity, can suffer corrosion and deterioration due to chloride ingress from harsh environments, compromising steel reinforcement. To prevent this, impermeable concrete is used. Timely quality control and design decisions require accelerated testing methods for evaluating chloride ingress.

3.5.1. Test Procedure (ASTM C 1202)

In ASTM C1202, the rapid chloride permeability test exposes a 50 mm thick, 100 mm diameter water-saturated concrete specimen to 60 V direct current for 6 hours. Two containers areused, one with 3.0.

Table: 3.5.1. RCPT ratings as per ASTM C1202.

S.No	Charge Passing (Coulombs)	Charge Passing (Coulombs)
1	>4000	High
2	2000-4000	Moderate
3	1000-2000	Low
4	100-1000	Very Low
5	<100	Negligible

IV. RESULTS AND DISCUSSION

4.1 Introduction This discusses test results of concrete with coal washery rejects (CWR). It replaces coarse aggregates at 0 percentage and 30 percentage, studying strength (compressive, split tensile, bond, Modulus of Elasticity) and durability (RCPT, water absorption, porosity, drying shrinkage) properties at 28, 56, and 90 days.

4.2 Concrete's CWR-based mechanical properties 4.2.1.

Compressive strength Concrete's mechanical properties (CWR-based)studied, including compressive strength, for CC and CWR mixes at different curing periods.

4.2.2. Splitting TensileStrength: Evaluating concrete's splitting tensile strength with coal washery rejects (CWR).

4.2.3. Bond Strength: Testing concrete-reinforcement bonding with coal washery rejects replacement, across various curing periods.

4.2.4 Modulus of Elasticity (MOE) This section examines concrete's modulus of elasticity over different curing periods.

4.3 Durable Concrete Properties: Concrete durability involves weathering, chemical resistance, and abrasion while maintaining engineering traits, tailored to exposure conditions. 4.3.1 RCPT: Testing permeability in concrete with coal washery rejects.

4.3.2 Water Absorption: Testing water absorption in coal washery rejects concrete during different curing stages.

4.3.3 Concrete Porosity: Testing porosity in coal washery rejects concrete at different curing intervals.

4.3.4 Concrete Drying Shrinkage: Testing drying shrinkage in coal washery rejects concrete at varying curing durations.

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CONCLUSIONS

Conclusions drawn from the investigation using coal washery rejects (CWR) as coarse aggregate partial replacementare as follows:

- Concrete mixes with CWR partial replacement showed decreased values in compressive, splitting tensile, bond strength, and MOE properties, contrasting conventional concrete. - Reduced CWR strength links to diminished compressive, splitting tensile, bond, and MOE properties in CWR-based concrete. - CWR20 and CWR30 mixes had slightly reduced strength, comparable to M25 grade concrete. - CWR40 and CWR50 mixes displayed further diminished strength. - Recommend 30 percentage CWR partial replacement for desired concrete characteristics. - RCPT values showed moderate trend vs. conventional concrete. Water absorption consistently lower than conventional concrete across curing periods. - Porosity values slightly exceeded conventional concrete. - Drying shrinkage values notably lower than conventional concrete.

Future Work Future prospects arising from the project investigation include:

- - Investigating durability properties of CWR-based concrete mixes.
- - Exploring sand replacement with bottom ash in CWR-based concrete for improved sustainability.
- - Analyzing micro-level characteristics of CWR-based concrete mixes.
- - Summarizing conclusions from the study on fly ash and CWR in concrete.

REFERENCES:

- Topcu IB, Canbaz M (2007) Utilization of crushed tile as aggregate in concrete. Iran J Sci Technol Trans B Eng 31(5):561–565.
- Binici H (2007) Effect of crushed ceramic and basaltic pumice as fine aggregates on concrete mortars properties. Constr Build Mater 21(6):1191–1197.
- Suzuki M, Meddah MS, Sato R (2009) Use of porous ceramic waste aggregates for internal curing of high-performance concrete. Cem Concr Res 39(5):373–381.
- Pacheco-Torgal F, Jalali S (2010) Reusing ceramic wastes in concrete. Constr Build Mater 24(5):832–838.
- Guney Y, Sari YD, Yalcin M, Tuncan A, Donmez S (2010) Reuses of waste foundry sand in high-strength concrete. Waste Manage (Oxf) 30(8–9):1705–1713.
- Energy Statistics (2013), National Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India.
- Annual Report (2013–14), Ministry of Coal, Government of India.
- Neville AM (1995) Properties of concrete, 4th edn. Longman, London.
- IS: 2386-1963. Part III. Methods of test for aggregates for concrete. Specific gravity, Density, Voids, Absorption and Bulking, Bureau of Indian Standards, New Delhi.
- IS: 516-1991. Methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi (India).
- IS: 5816-1999. Splitting tensile strength of concrete method of test, Bureau of Indian Standards, New Delhi (India).