Waste Products as an Alternative Construction Material - A Review

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Abstract: The world’s economy is based on the infrastructure of the country. Ancient history shows that old construction works are done with surki and lime but not with sand. Sand is used only after introduction of cement in construction industry. Worldwide sand is used as fine aggregate in concrete and average of 40 billion tones of natural sand is used annually. This large amount of consumption reduced the water table amount and destroys the flora and fauna of the biodiversity. So alternative construction materials identification for natural sand plays a major role for civil engineers in construction industry for sustainable environment. The main objective of this study is to find the optimum percentage of replacement with waste products to alter the fine aggregate.

1. Introduction
Sand is one the main ingredients of concrete used for plastering, concreting and finishing works, for construction of dams, house, water tanks, roadways, bridges, offshore structures etc. in conventional concrete sand is used minimum of 25% this consumption lead to shortage in conventional material[1,2]. Large amount of industrial waste and its byproducts also can be used effectively as fine aggregate which has similar properties[3,4].

2. Materials Used
There are many alternative construction materials which can be used effectively in concrete they are Crumbed Rubber, Steel Slag, Copper Slag, Glasscrete, Saw Dust, CeramicWaste and quarry dust[5,6,7].

| Crumbed Rubber | Steel Slag | Copper Slag | Glasscrete |
|----------------|------------|-------------|------------|

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Ceramic Waste | Saw Dust | Demolition Waste | Quarry Dust
---|---|---|---

**Figure 1.** Alternative Fine Aggregates

2.1 **Crumbed Rubber**

The waste rubber tier when crushed is called crumb rubber[8,9]. The waste generated by rubber industries increases annually and the disposal of it into land causes serious environmental impact. This rubber crumb can also be used in concrete as fine aggregate[10,11]. The physical properties of rubber crumb are as below

| Physical Properties      | Crumbed Rubber |
|--------------------------|----------------|
| Appearance               | Black and Rough|
| Specific Gravity         | 1.72           |
| Density                  | 0.83           |
| Moisture Content         | 2%             |
| Fineness modulus         | 4.48%          |

2.2 **Steel Slag**

Various types of slags obtained in production of steel but blast furnace slag and steel slag is occurred as the byproduct[12,13] of steel production in electrical furnace. The physical properties are as below

| Physical Properties | Steel Slag |
|---------------------|------------|
| Appearance          | Brown and Rough |
| Specific Gravity    | 2.93       |
| Bulk Density        | 1911.11 kg/m³ |
| Water Absorption    | 1%         |
| Shape               | Highly angular |

2.3 **Copper Slag**

Copper slag is an individual by product material produce by copper stetting and refining processes [14,15]. This has similar property of sand; hence copper slag can be replaced for fine aggregate. The physical properties of copper slag are as below

| Physical Properties | Copper Slag |
|---------------------|-------------|
| Appearance          | Black and Glassy |
| Specific Gravity    | 3.47        |
| Bulk Density        | 2.08 g/cc   |
| Water Absorption    | 0.17 %      |
| Moisture Content    | 0.1%       |
2.4. Glasscrete
Waste glass is crushed into specified size and can be replaced by fine aggregate in concrete[16]. The physical Properties of glasscrete are as below.

| Physical Properties | Glasscrete |
|---------------------|------------|
| Appearance          | All Color and Rough |
| Specific Gravity    | 3.01       |
| Bulk Density        | 1310 kg/m³ |
| Water Absorption    | 1.5 %      |
| Shape               | Highly angular |

2.5. Ceramic Waste
Ceramic industries produce ceramic waste about 15 – 20 % in production stage because once broken cannot be used. This can be crushed to required size and can be used as a replacement of fine aggregate[17]. The physical properties of ceramic waste are as below.

| Physical Properties | Ceramic Waste |
|---------------------|--------------|
| Appearance          | White – Brown |
| Specific Gravity    | 2.5          |
| Bulk Density        | 1188 kg/m³   |
| Water Absorption    | 0.18%        |
| Shape               | Angular      |

2.6. Saw Dust
Saw dust is a byproduct of cutting, grinding, drilling of pulverizing wood with a saw[18]. This can also be used as fine aggregate in concrete. The physical properties are as below.

| Physical Properties | Saw Dust |
|---------------------|----------|
| Appearance          | Dark Brown |
| Specific Gravity    | 2.19     |
| Bulk Density        | 1040 kg/m³ |
| Water Absorption    | 2 %      |
| Moisture Content    | 0.3%     |

2.7. Demolition Waste
Demolition waste is generated whenever any demolition activity takes places. This can be crushed and replaced instead of fine aggregate [19]. The physical Properties of demolition waste are as below.

| Physical Properties | Demolition Waste |
|---------------------|------------------|
| Appearance          | Dull white- Red- Grey |
| Specific Gravity    | 2.5               |
2.8. Quarry Dust
Quarry dust is a waste obtained during quarrying process. The property is same as granite and can be replaced for fine aggregate. The physical properties of quarry dust are as below

| Physical Properties       | Quarry Dust |
|---------------------------|-------------|
| Appearance                | Dark Grey   |
| Specific Gravity          | 2.57        |
| Bulk Density              | 1.85 g/cc   |
| Water Absorption          | 2%          |
| Fineness Modulus          | 2.41%       |

3. Experimental Investigations
The waste materials obtained from various products can be replaced for fine aggregate. The experimental results are

3.1. Rubber Crumb
Rubber crumb can be replaced from 0% to 100% as fine aggregate. In this 5% of replacement gives 5% higher in compression strength, 10% higher in split tensile strength and 2% higher in flexural strength compare to the conventional concrete [20].

3.2. Steel Slag
Steel slag can be replaced from 0% to 100% as fine aggregate. In this 25% of replacement gives 10% lower in compression strength, 12% higher in split tensile strength and 8% higher in flexural strength compare to the conventional concrete.

3.3. Copper Slag: CS
Copper slag can be replaced from 0% to 100% as fine aggregate. In this 40% of replacement gives 35% higher in compression strength, 6% higher in split tensile strength and 10% higher in flexural strength compare to the conventional concrete.

3.4. Glasscrete: GC
Glasscrete can be replaced from 0% to 100% as fine aggregate. In this 30% of replacement gives 9% higher in compression strength, 6% higher in split tensile strength and 8% higher in flexural strength compare to the conventional concrete.

3.5. Ceramic Waste: CW
Ceramic Waste can be replaced from 0% to 100% as fine aggregate. In this 30% of replacement gives 5% higher in compression strength, 30% higher in split tensile strength and 7% higher in flexural strength compare to the conventional concrete.

3.6. Saw Dust: SD
Saw Dust can be replaced from 0% to 100% as fine aggregate. In this 5% of replacement gives 0% higher in compression strength, 2% higher in split tensile strength and 1.5% higher in flexural strength compare to the conventional concrete.
3.7. Demolition Waste: DW
Saw Dust can be replaced from 0% to 100% as fine aggregate. In this 10% of replacement gives 3% higher in compression strength, 8% higher in split tensile strength and 2% higher in flexural strength compared to the conventional concrete.

3.8. Quarry Dust: QD
Quarry Dust can be replaced from 0% to 100% as fine aggregate. In this 30% of replacement gives 12% higher in compression strength, 10% higher in split tensile strength and 8% higher in flexural strength compared to the conventional concrete.

4. Analysis Of Results
The test results for 28th day concrete compression strength, tensile strength and flexural strength results are investigated and optimum percentage of replacement is individual material is identified. The following are the optimum percentage of replacement.

![Figure 2. % of Replacement](image)

The alternative materials for fine aggregate can be replaced from 0% to 100% in that rubber crumb can be replaced 5%, steel slag can be replaced 25%, copper slag is replaced 40%, glasscrete can be replaced 30%, sawdust can be replaced 5%, demolition waste can be replaced 10% and quarry dust can be replaced 30%. The strength parameter which enhances the mechanical property is as below.

Table 9. Percentage of Increase in Strength

| Materials | Compression Strength | Tensile Strength | Flexure Strength |
|-----------|----------------------|-----------------|-----------------|
| RC        | 5                    | 10              | 2               |
| SS        | 10                   | 12              | 8               |
| CS        | 35                   | 6               | 10              |
| GC        | 9                    | 6               | 8               |
| CW        | 5                    | 30              | 7               |
| SD        | 0                    | 2               | 1.5             |
| DW        | 3                    | 8               | 2               |
The table shows that copper slag is one of the alternative construction materials which can be replaced effectively instead of natural sand in concrete for better results. It is available easily and cost is very low so it can be effectively utilized in construction industry.

![Percentage of Increase in Strength](image)

**Figure 3.**% of increase in strength

5. Conclusion

- The investigation is done to conclude that.

- The demand of the natural sand is stabilized by altering new construction materials.

- Waste material which has similar property of natural sand is utilized and waste is minimized.

- The mechanical property of the concrete is enhanced due to effective utilization of alternative fine aggregate.

- Copper slag is available easily in market for low cost. Cost of copper slag is very low compare to natural sand.

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