

Coral Case Dust: A Seashore Waste Material Used as a Restricted Concrete Alternative

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Abstract

The vast scale of manufacturing usage of Portland concrete and the procurement of accumulates through mining and excavating significantly impact environmental deterioration. Squander, such as coral case, is seen as a soft material and a poor substitute for concrete. Coral case dust (CCD) is a pozzolanic material that exhibits pozzolanic characteristics in cement and mortar. The compressive strength of a CCD mix containing 10% concrete is 40.54 N/mm², which is higher than apparent compressive strength of the solid, which is 30.00 N/mm². The article discusses the design of CCD. Cement mix and exploratory research were conducted on this material, including mechanical strength tests and the strength of CCD. Concrete is 14.33 percent higher than standard cement concrete for M30 grade concrete on seventh day. Aside from that, it was discovered that the multi-day strength of a similar assessment concrete was 27.12 percent higher than strength of ordinary cement. The 7-day and multi-day strength of CCD. Concrete for M35 assessment concrete was 11 percent and 19 percent, respectively, according to findings. According to these results, CCD, like fly ash and rice husk debris, may be utilised as a mineral supplement. According to findings obtained utilizing various factors, including mix design and compressive strength, a CCD of 10% in M30 concrete is the optimal choice for successful partial replacement concrete. Seashells that have been left on the beach may be successfully reused.

Keywords: Coral case dust, waste material, concrete

INTRODUCTION

Engineers and architects have found many compelling reasons to expand the use of waste materials with pozzolanic properties, such as CCD, to replace cement in mortar and concrete partially. In comparison to regular strength concrete, the CCD. Mixtures with 10% cement had higher compressive strength and longer life. The cost of concrete is determined by the materials, the facility, and labor.

Cement is three times the cost of aggregate, and each tonne produced produces one tonne of CO₂, wreaking havoc on the environment. The primary goal is to save as much cement as possible. Rich mixtures may cause structural concrete to shrink and fracture, whereas mass concrete may generate excessive heat during hydration, resulting in cracking.[1,2].The materials required to meet the design mix ratio have stipulated least “mean strength”, also identified as “characteristic strength”, which related to cost of concrete. This article aims to use CSP and other excrements to various approaches ecological and environmental problems and decrease the amount of cement as well as concrete manufacturing, has advantages like lower earth-filling costs, energy efficiency, combined with environmental conservation. A concrete study was performed to determine the addition or substitution of cement components.

Factors Impacting Selection of Mix Proportions^{1, 2}

Mix design is influenced by compressive strength, processability, endurance, a maximum nominal sample that is truly representative, grading and type of material, and quality control. The ostensible size has to be as big as feasible, as per IS: 4563 and IS: 13434.

Mix Proportion designations^{1, 2}

The quantities of the different components in a concrete mix are often referred to as "parts and ratios of cement, fine and coarse aggregates". A concrete mix 1:2:4 implies that the proportions of cement, "fine aggregate and coarse aggregate are 1:2:4", or that mix has single component cement, double components "fine aggregate and four components coarse aggregate. "Volume or mass are used to indicate proportions. IS 4563 specifies a number of different concrete grades, such as M20, M30, and others. The symbol M stands for mixture, while the number represents the strength in MPa after 28 days.

Weighing batching is used to establish the component proportions. It has a significant impact on the finished product's quality. A decreased "water-cement ratio" results in increased intensity and strength, makes installation more challenging. A mechanical vibrator or a plasticizer may be used to help in resolving placement issues.

Use of Alternate Binding Materials

The majority of India's buildings and bridges are constructed of concrete, which acts

as the backbone of the country's infrastructure. Increased cement prices and a shortage of river sand, on the other hand, not only raise building costs but also represent a grave danger to the country's future. Additionally, each tonne of cement produced produces one tonne of CO₂. This results in substantial environmental degradation and depletion of the ozone layer. Due to the widespread use of naturally occurring resources in roads and other structures, they have gradually depleted⁵. Daily, the cost of obtaining and processing such materials increases. Simultaneously, a considerable quantity of industrial and household waste poses significant environmental challenges regarding disposal and safe storage⁶. Alternatives must be explored in order to circumvent such obstacles. Throughout the decades, the whole building sector has sought a feasible and practical alternative. Recently, cementitious qualities have been discovered in waste materials such as "coral case powder, rice husk ash, fly ash, bagasse ash, silica fumes, and rubber" [7]. While coral case dust (CCD) has never been used in material, its natural composition is like lime, implying that it could be a viable alternative to cement. This research aimed to ascertain if CCD might be utilized to replace cement in concrete partially.

Coral case Dust or Powder (CCD.)

The word "coral case" refers to the exterior encompassing of rigid-shelled corals and several "soft-shelled corals" outer coatings[8]. The overall structure of the Coral case, which varies considerably across species, consists of a protein matrix coated in mineral crystals, most commonly calcium compounds such as calcium carbonate. It is a non-cellular calcium deposit. More complex corals mineralize at a faster rate than softer corals[9, 10]. Numerous variables influence the overall quality of the coral shell. However, it is essential first to understand the coral shell's structure. Between 94 and 97 percent of the calcium carbonate in the coral casing. [11,12]

Organic debris and coral case pigment make up the remaining 3%. The Coral case was gathered from the beach and pulverized in a flour grinder. They were then evaluated for chemical characteristics, such as those shown in Table 1. Additionally, the shell has up to 8,000 small holes. The shell's exterior is covered with a mucous covering known as the fingernail skin or sprout, which is initially stored on the shell fair before developing into a layer. The color, form, and structure of the shell all contribute to the coral shell's quality. Coral comes in various colors, from white to shades of brown, and its shape varies as well (Fig. 1).



Fig. 1: Collection of coral shell in seashore (a) Beachfront(b) Coral shell

Table 1: Cement chemical properties and CCD.

Cement (%)	CCD (%)
CaO = 65	CaO = 89
SiO ₂ = 22	SiO ₂ ≤ 1
Al ₂ O ₃ = 6.5	Nil
MgO = 1.6	MgO = 0.40
SO ₂ = 2.1	Nil
K ₂ O = 0.6	K ₂ O ≤ 1
Na ₂ O = 0.45	Na ₂ O ₃ = 1.56
Fe ₂ O ₃ = 3.12	Fe ₂ O ₃ = 2.12

Requirements of Concrete Mix Design

The following considerations guide the selection and proportioning of mixed components:

- A least compressive strength is mandatory due to its structural concerns.
- Workability needed to complete compaction with compressing equipment available.
- Requirements for long-term survival and environmental conditions
- Temperature-induced shrinkage cracking in bulk concrete.

Design Mix Procedure for M30 Grade Concrete^{3, 13, 14}**Design stipulations**

- Characteristics compressive strength
required at 28 days → 30 MPa
- Maximum size of aggregates → 20 mm (Angular)
- Degree of compaction → 0.80 Compacting Factor
- Degree of workability → Good
- Type of exposure → Mild
- Entrapped air as % of volume of concrete → 2

Test Data for Materials

- a) Specific gravity of cement → 3.15
- b) Compressive strength of cement at seven days → satisfies the requirement of IS: 269¹⁵
- c) Specific gravity of coarse aggregates → 2.63
- d) Specific gravity of fine aggregates → 2.57
- d) Water absorption of Coarse aggregate → 0.5 %,
- e) Water absorption of Fine aggregate → 0.9 %
- e) Free moisture of Coarse aggregate → Nil
- f) Free moisture of Fine aggregate → 2.00 %

Mix Design results per m³ of concrete for M30 grade 189: 473: 486:1189,0.4 ; 1 : 1.03 : 2.51

Similarly, the exact amount of M 35 grade concrete is computed and shown below.

Required amount of M30 Mix for 1 m³ concrete

Cement	= 473 kg	Fine aggregate	= 486 kg
Coarse aggregate	= 1189 kg	Water	= 189 lit
W/C	= 0.4		

Required amount of M35 Mix for 1 m³ concrete

Cement	= 540 kg	Fine aggregate	= 502 kg
Coarse aggregate	= 1289 kg	Water	= 189 lit
W/C	= 0.35		

EXPERIMENTAL PROCEDURE

Several hundred kilograms of coral were gathered from a nearby beach. The amounts of sand, fine aggregate, cement, and CCD, as well as the characteristics of the components needed to create concrete, were estimated. "The specific gravity, fineness of coarse and fine aggregates, and coarse aggregate impact strength were all determined via a series of experiments. (See Table 2 for further information)". Table 3 also includes specimen information, and the design mix for a unique grade of concrete was made using weigh batching and sample mix utilized in experiment. In potable water, cubes and cylinders were cured for seven and twenty-eight days, respectively. Overall results of compression strength tests on cubes were compared and discussed,

as were the results of split tensile testing on cylinders.

Table 2. Physical properties of materials

Sl No.	Test Name	Test values	Permissible values ^{13, 16}
1	Specific gravity of fine aggregate	2.51	2.3
2	Specific gravity of coarse aggregate	2.53	2.7
3	Specific gravity of CCD	1.09	---
4	The fineness of the cement	2.28%	10%
5	Impact value of the coarse aggregate	36.08%	45%
6	Fineness modulus of fine aggregate	2.324	2.65
7	Fineness modulus of coarse aggregate	2.57	2.85
8	The standard consistency of cement	28%	33% to 35%
9	Initial and final setting of cement	55 min 8.10 hr	17 min 09 hr
10	Initial and final setting time of OPC with 10% of CCD	50 min 9.30 hr	
11	Initial and final setting time of OPC with 20% of CCD	59 min 10.10 hr	

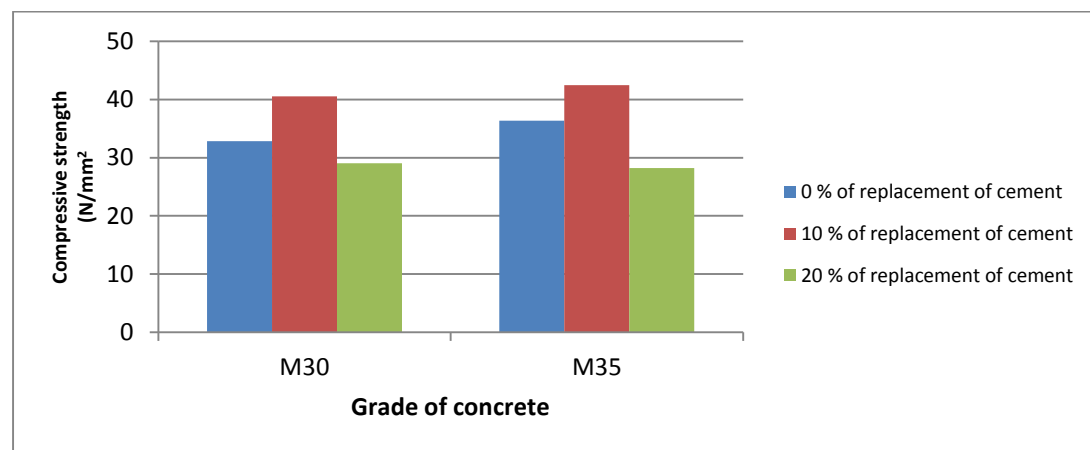
Table 3 : Spécimen détails

SL N	Grade of concrete	Type	No. of cubes	No of Cylinders
1	M30	Normal	9	3
2	M30	10% partial replacement with cement	9	3
3	M30	20% partial replacement with cement	9	3
4	M35	Normal	9	3
5	M35	10% partial replacement with cement	9	3
6	M35	20% partial replacement with cement	9	3

These specimens were cured till they were ready for testing in a curing tank. On the seventh and twenty-eight days, specimens have been removed from tank, cleaned dry out, examined utilizing compressive testing equipment. Table 4 shows 7-day compressive strength data, whereas Figure 2 shows the 28-day findings.

Table 4: Compressive strength of concrete for seven days

Grade of concrete	Percentage of replacement	Compressive strength (N/mm ²)
M30	0	25.72
M30	10	29.64
M30	20	18.75
M35	0	26.44
M35	10	32.12
M35	20	20.2

**Figure 2:** Showing compressive strength of concrete for 28 days

After treating seven and twenty eight days“ compressive -strength” of M30-grade-concrete without adding CCD was 25.72 and 32.84 N/mm², respectively. Compressive strengths of 29.64, 40.54 N/mm², 18.75 N/mm², and 29.03 were obtained by substituting CCD for cement by 10% and 20%, respectively. Without using CCD in place of cement, compressive strength of M35 grade concrete was 26.44 and 36.33 N/mm², respectively, after 7 and 28 days of curing. “When 10% and 20% CCD was substituted, compressive strength was 32.12 N/mm², 34.46 N/mm², 20.2 N/mm², and 28.19 N/mm², respectively”.

When compared to Controlled Concrete, Concrete with CCD exhibits higher compressive strength in all proportions. The concrete containing 10% CCD as a partial replacement, on the other hand, has higher compressive strength. Strengths in compression have risen by 27.12 percent.

Discussion of Results

In view of the test findings shown in Tables 4 and Figure 2, the following conclusions may be drawn. The test findings indicate that compressive strength increases when 10% of t cement is replaced with Coral case powder. When compared to conventional concrete strength, a more remarkable result is obtained. The table below shows an increase in compressive strength as a percentage above regular concrete.

M30 - 7 days = 14.33 % M30 28 days = 27.12 %

M35 - 7 days = 10.09 % M35 - 28 days = 18.56 %

The replacement strength of 20% is far fewer than usual strength of M30 and M35, respectively. This study found that adding CCD to the cement mix increased the nominal strength value by 10%.

Table 5: Split tensile strength of concrete

Grade of concrete	Percentage of replacement	Split tensile Strength
M30	0	2.50
M30	10	2.78
M30	20	2.55
M35	0	2.65
M35	10	3.06
M35	20	2.93

Calculated split tensile strength results are shown in Table 5. When flexural strengths are compared to Control Concrete for M 30, split tensile strength increased 11.20 percent for CCD. 10% and 4.03 percent for CCD. 20%. Similarly, when CCD. 10% was used, Flexural Strengths of M35 Grade Concrete increased by 15.48 percent, and when CCD. 20% was used, Flexural Strengths increased by 14.03%. The split tensile strength of M30 and M35 concrete improved in comparison to Control Concrete. M30 and M35 concrete's split tensile strength increased when compared to that of Control Concrete.

CONCLUSION

A beach trash item is a coral case. It contains a lot of calcium and protein. These substances can form bonds with one another. Therefore, this research looked at potential of utilizing this binder in concrete production. In place of cement, CCD. (coral case dust) was used, which uses much energy and generates a lot of CO₂. CCD. Installation is both cost-effective and environmentally friendly. After determining the fundamental characteristics of each component, the required mix design was produced in accordance with ISO standard for concrete grades 30 and

35. They were then used to create concrete cubes that were cured for the necessary length of time prior compression testing before even being compressed. According to findings of experiments, an increasing percentage of CCD. Strength characteristics in substantial increase compressive strength by up to 10% while increasing the percentage of CCD raises compressive strength by 20%. Concrete's split tensile and flexural strengths followed a similar pattern. Compressive Strength: 1) Concrete with a 10% CCD has greater compressive strength than other types of concrete, for M30 Grade Concrete with 10% CCD. Specimens, the Compressive Strength Increase Percentage increases to 27.12 percent. 2) Similarly, concrete containing 10% vermiculite increased its strength by 18.56 percent above control concrete and other CCD. levels in M35 grade concrete. 3) As CCD. Concentration increased; compressive strength dropped. Additionally, CCD may be utilized for fly ash and rice husk as supplement for minerals.

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