EXPERIMENTAL INVESTIGATION ON THE SYNERGETIC EFFECT OF DOLOMITE AND RICE HUSK ASH AS PARTIAL CEMENT REPLACEMENTS IN CONCRETE

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ABSTRACT

There is a need for sustainable alternatives in the production of concrete due to the increasing environmental impact of cement production. The present study aims to experimentally study the synergistic effect of Rice Husk Ash (RHA), Dolomite Powder (DP) as partial replacement of cement in M25 grade concrete.

The silica rich agricultural by-product RHA was added for its pozzolanic property and dolomite powder was added to act as a fine mineral filler for better particle packing. A conventional concrete mix was compared with four modified mixes: M1 (5% RHA + 5% DP), M2 (10% RHA + 10% DP), M3 (15% RHA + 10% DP), and M4 (15% RHA + 15% DP).

The slump test was used to assess workability, and compressive, flexural and split-tensile strength was studied. The 28-day compressive strength of the control mix was 30 MPa while M3 had the highest reported compressive strength of 33.4 MPa. The findings show the feasibility of using a combination of RHA and dolomite powder in the production of sustainable concrete with less cement consumption.

Keywords : Dolomite Powder; Rice Husk Ash (RHA); Supplementary Cementitious Materials; Cement Replacement; Concrete Mix Design; Compressive Strength; Flexural Strength; Split Tensile Strength; Water Absorption; Mechanical Properties.

INTRODUCTION

Cement is one of the most widely-used construction materials, but the manufacturing of cement is energy intensive and generates greenhouse-gas emissions. This has spurred the development and utilization of other materials to effectively reduce the consumption of cement while keeping the same concrete performance level.

Rice Husk Ash (RHA) is an agricultural by-product containing high amounts of silica. With appropriate processing it acts as a reactive silica that can enter into pozzolanic reactions and help to further form C–S–H. Dolomite Powder (DP) is a fine mineral powder, which can play the role of the main filler, and can also enhance the particle packing of the concrete matrix.

The synergistic effect of both RHA and DP may be achieved; however, properties of RHA and DP will be influenced by replacement percentage, particle properties, water to binder ratio, and curing conditions. Thus, it is decided to explore their possible use as a partial replacement in concrete M25 grade while examining workability and strength development in the experimental study.

RELATED WORK

In response to this demand, researchers have started exploring the use of materials that replace the traditional cement to produce sustainable concrete, including materials derived from agricultural and mineral sources. Of all the options available, Rice Husk Ash (RHA) and Dolomite Powder (DP) have garnered significant interest due to their varied, yet complementary, effects on cementitious materials. The literature reviewed in the present study noted that RHA can be contributed with silica rich and pozzolanic properties, while dolomite powder can be contributed mainly on the fine particle size, filler action and particle packing effect.

A. Rice Husk Ash

Rice Husk Ash is an agricultural waste product obtained by the controlled combustion of rice husk. SiO_2 is reported at the source to be about 85-95% of the RHA, which can therefore be a potentially reactive supplementary cementitious material (SCM) if processed appropriately. It is a great benefit because it is able to make use of agricultural waste and there is an opportunity to reduce dependence from traditional cement. The reactive silica in RHA may interact with calcium hydroxide generated during cement hydration to further contribute to production of calcium-silicate-hydrate (C–S–H) and strength development and refinement of cementitous matrix. However, it is dependent on the burning conditions, grind, particle size, and replacement percentage.

The review by Barbhuiya et al. (2025) of RHA in structural concrete, pointed out the potential benefits of RHA to enhance the sustainability and reduce cement use in concrete structures. Indumathi et al. (2024) stated that if the RHA is processed properly, it can help in the strength development and can be a practical application for agricultural waste. Ubayi et al. (2024) noted that moderate (optimal) RHA replacement can yield satisfactory compressive strength while high replacement levels can lead to a decrease in strength due to dilution effect and the requirement for more water. Likewise, Adnan et al. (2022) found that the average performance of RHA was similar to ordinary concrete in compressive, flexural and tensile strengths of around 5–15%.

B. Dolomite Powder

Dolomite powder is a finely-grained carbonate mineral that is mainly made up of calcium magnesium carbonate. It's behavior in concrete is determined by its fineness, particle size, chemical composition and the level of replacement. The dolomite is not used as pozzolanic material and its main contribution within the scope of this study is related to the filler action and particle packing. The fine particles of dolomite may fit into voids between larger particles, alter the internal structure of the cement paste, and possibly form a denser cementitious matrix.

Divekar and Sawant (2023) reported that the presence of dolomite particles in concrete can help with early hydration and create a denser microstructure in the concrete. It is important to choose the right replacement level for dolomite as it can be seen that it can increase the strength of concrete, and further increase in the replacement level can decrease the strength of concrete as observed by Gusain et al. (2023). By incorporating appropriate amounts of dolomite, along with other beneficial properties in terms of durability-related properties and drying shrinkage, Chen et al. (2022) reported that workability and long-term strength properties are improved. Moreover, Umale et al. (2022) proposed dolomite powder as a readily available material for reducing the cement consumption and enhancing the desired mechanical properties.

C. Research Gap and Combined Use

As identified from existing literature, previous studies have proved the individual effect of RHA and dolomite powder, but there is not much research available on the combined application of RHA and dolomite powder, and its possible synergistic effect. The main contribution of RHA is silica enrichment in pozzolanic activity and that of dolomite as filler action and particle packing. They are likely to have complementary effects in the cementitious matrix when used together.

In view of this research gap, this research investigates the partially replacing of cement with RHA and dolomite powder in M-25 concrete grade with regard to workability and mechanical properties of the resultant concrete. This study assesses various replacement combinations and provides a comparison to conventional concrete to determine the effects of these two materials on the performance of concrete and their potential role in creating a more sustainable construction.

MATERIALS AND EXPERIMENTAL PROGRAM

A. Cement

The basic binding material used in the manufacturing of M 25 grade concrete was ordinary Portland Cement (OPC). The experimental part of the report indicates OPC 43 grade as per IS 8112:2013 and the cement was found to be fresh, dry and lumpy. The main binding effect of the cement is from hydration in the presence of water, where it gives rise to the strength of the concrete matrix. The report also mentions the fineness of the cement is 6%, specific gravity is 3.14, normal consistency is 32%, initial setting time of 45 min and final setting time of 460 min, but the report does not mention that it is a 53 grade OPC cement, so it should be confirmed from the laboratory records.

B. Fine Aggregate

The fine aggregate for concrete was used natural river sand. The experimental programme classifies sand as Zone II in IS 383:2016 and categorises it as clean and free from organic impurities. The voids between the coarse aggregate particles are filled by fine aggregate, which also helps to pack and workability of the fresh concrete. The material's reported characteristics are: specific gravity = 2.72; water absorption = 0.4%; bulk density = 1587.71 kg/m³; fineness modulus = 3.25. The fine aggregate for final M25 mixture was 745.90 kg/m³. The grading of the fine aggregate was taken care of while designing the mix in order to achieve the desired proportion between the coarse and fine aggregate.

C. Coarse Aggregate

In this study, crushed angular coarse aggregate of maximum nominal size (MNS) 20 mm was used. Experimental results showed that the aggregate met the requirement given in IS 383 for aggregate. Coarse aggregate is the bulk of concrete and provides load bearing skeleton of hardened concrete. Its specific gravity, water absorption, bulk density and fineness modulus were reported to be 2.68, 0.25 %, 1565 kg/m³ and 7.058 respectively. The material was mixed with natural river sand for providing the desired grading of aggregate. The actual mix proportion for the final mix was 1180.93 kg/m³ of coarse aggregate. Angular aggregate was also taken into account in the calculation of mix-design for M25 reported in the study.

D. Rice Husk Ash

One of the partial substitution materials for cement is Rice Husk Ash (RHA). It is acquired from the controlled burning of rice husk and grinding it to a fine powder. According to the report, RHA is an agricultural by-product that contains silica and has pozzolanic properties. The reported chemical composition includes approximately 85–95% SiO_2, 0.5–2% Al_2O_3, 0.5–2% Fe_2O_3, 1–3% CaO, 0.5–2% MgO, and 2–8% loss on ignition. The high silica content makes it suitable for use as a supplemental cementitious material. Reactive silica could also react with the $Ca(OH)_2$ produced during cement hydration and lead to further C–S–H formation. The percentages of replacement of RHA ranged from 5% to 15% for the experimental mixes.

E. Dolomite Powder

The second cement-replacement material studied was Dolomite Powder (DP). The report refers to dolomite as a natural carbonate mineral, $CaMg(CO_3)_2$, and mentions that the dolomite stone was "ground into powder. The micronized dolomite used in the study was obtained from Asthra Chemicals, Chennai and described as a very white smooth powder. The content of calcium carbonate and magnesium carbonate were around 54% and 45%, respectively, and there were 2% SiO_2, bulk density 0.85 g/cm³, and whiteness of 96%. The chemical composition was reported as 30–35% CaO, 18–22% MgO, 45–48% CO_2, 1–3% SiO_2, 0.5–2% Al_2O_3, and 0.5–1% Fe_2O_3. It is a fine particulate material that has a dominant effect as a mineral filler and on the particle packing in the cementitious matrix.

F. Water

Concrete mixing and curing were done with clean potable water. The report states that it did not contain any acids, organic material, suspended solids or other contaminating materials that could negatively impact the performance of the concrete. Setting, hardening and strength development of cement is directly affected by water as it is necessary for the hydration process.

The water-to-cement ratio (w/c) used for the mix design was 0.50. Approximate mix proportion reported of the final mix was 170 l of water per m3 of concrete. The report emphasizes the importance of both water quality and the water-to-cementitious-material ratio, as too much or poor-quality water can have an impact on the properties of hardened concrete. The same water was used for curing the cast specimens after demoulding.

G. Mix Design and Replacement Levels

The IS 10262:2019 Mix Design approach has been adopted for designing the concrete of grade M25. The design parameters included in the reported cases were: 20 mm maximum aggregate size, water–cement ratio of 0.50, medium workability, angular aggregates, and no chemical admixture. The final reported amount of each per cubic metre was: 336 kg cement, 745.90 kg fine aggregate, 1180.93 kg coarse aggregate and about 170 L of water. The report also provides a target mean strength of ~ 31.6 MPa.

There were a detailed experimental program, which included one conventional mix and four modified mixes:

Mix	Cement (%)	RHA (%)	Dolomite (%)
Control Mix	100	0	0
M1	90	5	5
M2	80	10	10
M3	75	15	10
M4	70	15	15

The five mixes were compared to study the effect of increase in combined RHA and dolomite replacement. The following table with detailed data (M1–M4 table) is the set of data that corresponds to the strength results reported.

H. Batching, Mixing, Casting and Curing

Materials were all batched by weight. In the beginning, these materials (cement, RHA, dolomite powder, fine aggregate and coarse aggregate) were dry mixed in order to ensure uniform distribution of the components. Then water was slowly added and mixing was continued until the concrete mixture was homogeneous, about 3-5 minutes. The compressive strength was tested by casting concrete cubes of dimensions 150 x 150 x 150 mm. The concrete was poured into the moulds in three layers and compacted using the tamping rod. The report reads that for each mix there were three cubes for 7 day testing and three cubes for 28-day testing and that there were five mixes and therefore 30 cubes for every mix. The specimens were removed from the moulds after about 24 hours and thereafter were cured in clean water at room temperature till the desired test age.

I. Workability and Strength Testing

The workability of fresh concrete was determined using the slump cone test in terms of IS 1199: 2018. The slump values obtained were 85 mm, 80 mm, 75 mm, 70 mm and 65 mm for common mix, mix M1, mix M2, mix M3 and mix M4 respectively. Therefore, the more combined replacement levels that were raised, the more slump decreased as well.

The compressive strength was measured by Compression Testing Machine (CTM) per IS 516:2018. The load was gradually increased until failure and the compressive strength was obtained by dividing the failure load by the loaded area of the cube. The following compressive strengths were reported:

Mix	7 days	14 days	28 days	56 days	90 days
Control	22.5	25.6	30.0	31.0	31.2
M1	23.4	26.8	31.5	32.0	32.0
M2	25.0	28.6	32.8	33.0	33.2
M3	**25.8**	**29.4**	**33.4**	**34.2**	**34.6**
M4	24.3	25.9	32.4	33.0	33.0

All strengths are in Mega-Pascals (MPa). The highest compressive strength was observed at all ages for M3 with 15% RHA and 10% dolomite, which was 33.4 MPa at 28 days and 34.6 MPa at 90 days.

Additionally, the flexural and split tensile strength at 28 days were tested. The flexural strength for M3 was 4.2 MPa, while the split-tensile strength was 3.1 MPa; both exceeded those of the common mix, which were 4.1 MPa and 2.95 MPa, respectively.

MIX DESIGN AND TEST METHODS

The experimental program was designed to examine the effect of the partial replacement of cement with Rice Husk Ash (RHA) and Dolomite Powder (DP) on the workability and strength development of M25 concrete. The experimental design was based on the principle that a conventional concrete mixture was established as a reference mix or common mix and then gradually a part of the cement was substituted with RHA and DP. With this technique, it is possible to compare the performance of all modified mixtures to the conventional concrete under the same curing and testing conditions. The materials used were cement, natural river sand, coarse aggregate (20 mm), RHA, dolomite powder and potable water.

A. M25 Mix Design

The mix design of the concrete was carried out based on the procedure mentioned in IS 10262:2019 according to the requirement of M25 grade of concrete. The design was based on 20 mm maximum size coarse aggregate, angular aggregate, medium workability and water to cement ratio of 0.50. The final reported quantities of the conventional mix were: 336 kg cement,

745.90 kg fine aggregate, 1180.93 kg coarse aggregate, and about 170 litres of water. A target mean strength of about 31.6 MPa was also calculated in the report.

The common mix was used as the control concrete with 100% cement without RHA and dolomite. Four modified mixtures were then prepared adding various proportions of RHA and DP to the cementitious fraction. The following replacement levels were used in the experimental results reported:

Mix ID	Cement	RHA	Dolomite Powder
Control Mix	100%	0%	0%
M1	90%	5%	5%
M2	80%	10%	10%
M3	75%	15%	10%
M4	70%	15%	15%

Hence, in the experimental programme, instead of increasing the amount of concrete materials, RHA and dolomite were added while the respective amount of cement was reduced. This permitted the impact of the substitution of cement by the two proposed materials to be assessed within the existing mix-design**.**

B. Mixing and Preparation of Concrete

All materials used for the constituents were batched by weight for consistency among the various mixtures. In the beginning, dry mixing of cement, RHA, dolomite powder, fine aggregate and coarse aggregate were performed. This was a necessary step to achieve a relatively uniform distribution of the fine replacement materials throughout the aggregate and the cementitious matrix. The water was then added in steps and mixed by hand for about 3–5 min to get a uniform and homogeneous concrete.

Mixing was done in a similar manner for both common mix and modified mixes. Hence, the experimental variable was the cement replacement ratio of RHA and DP. This procedure offered an even footing for the comparison of the workability and hardened-concrete strength of the resulting work.

C. Casting and Curing

The fresh concrete was then poured in 150 × 150 × 150 mm cube moulds. The work of placing the concrete was done in three lifts and the workmanship was compacted with tamping rod to eliminate entrapped air and to get properly consolidated specimens. The report provides three cubes for the 7-day tests and three cubes for the 28-day tests for each mix, a total of 30 cubes for five mixes. The specimens were demoulded after about 24 h and then cured in clean water at room temperature till the desired testing age.

Curing conditions were similar for all mixtures, allowing for the influence of the replacement mixture to be compared more directly with the effect of the measured strength, rather than differing conditions.

D. Workability and Strength Testing

The workability of each fresh concrete mixture was determined using the slump-cone test according to IS 1199:2018. The measured slump decreased from 85 mm for the common mix to 80, 75, 70, and 65 mm for M1, M2, M3, and M4, respectively. This provided an indication of how increasing RHA and DP contents affected the fresh concrete before evaluating hardened strength.

The compressive strength was evaluated by compression testing machine (CTM) as per IS 516:2018. The cubes were loaded in compression until failure with the compressive strength determined by the following equation:

$$f_c = \frac{P}{A}$$

The failure load, P, is defined as the maximum load under compression applied to a cube of unit size, A.The failure load, P, is the maximum compressive force, under load, applied to a cube of unit size, A.

The compressive-strength values were found to increase as a function of curing age for all the mixtures. The common mix achieved 30.0 MPa at 28 days, whereas M1, M2, M3, and M4 achieved 31.5, 32.8, 33.4, and 32.4 MPa, respectively. M3 (15% RHA and 10% DP) had the maximum reported compressive strength of 33.4 MPa at 28 days, which increased further to 34.2 MPa at 56 days and 34.6 MPa at 90 days.

Hence, the experimental procedure was designed to keep all the other parameters of the base concrete, the batching method, specimen dimension, curing condition, and testing method same while altering the percentage of substitution

of RHA–DP. This gives first-hand experimental evidence upon which the relationship between material replacement and workability and strength development can be judged.

RESULTS AND DISCUSSION

The results obtained from the experiments were analyzed to see how the use of partial replacement of cement with Rice Husk Ash (RHA) and Dolomite Powder (DP) affects the fresh and hardened properties of M25 concrete. Concrete made with the common mix was used for the reference concrete, and the remaining concrete mixes M1, M2, M3 and M4 had different replacement levels.

The results were analyzed in terms of workability, compressive strength, flexural strength, split tensile strength and combined effect of RHA with dolomite powder. The details of the experimental data reported in the study are provided below.

A. Workability

The slump-cone test was conducted as per IS 1199:2018 to test the workability. Slump is a measure of the ease of mixing, placing and compacting fresh concrete. The same basic mix design procedure was used for all mixes but the amount of RHA and DP was adjusted for the present investigation.

The measured slump values were 85 mm, 80 mm, 75 mm, 70 mm and 65 mm for common mix, M1, M2, M3 and M4, respectively. Thus, the slump continuously decreased as the quantity of RHA and DP increased. The reduction in the common mix to M4 was 20 mm or about 23.5% in slump reduction.

Mix	RHA (%)	DP (%)	Total replacement (%)	Slump (mm)
Common Mix	0	0	0	85
M1	5	5	10	80
M2	10	10	20	75
M3	15	10	25	70
M4	15	15	30	65

Workability of the replaced materials can be correlated with the properties of replacement materials described in the report. RHA is a finely processed, relatively porous material with high surface area, and may require more water to coat the particles. Meanwhile, the amount of fine dolomite powder affects the particle-packing properties of the cementitious system. Thus, the more the replacement level was raised, the less workable the fresh concrete was.

One of the important observations is that M3 recorded the maximum reported strength with a slump of 70 mm, with the result being that the strength increase is not necessarily related to the same workability as the conventional concrete. But the reduction in the slump suggests that the workability should be taken into account when increasing the replacement level.

B. Compressive Strength

The hardened-concrete property of interest in the study was compressive strength. It was tested in a compression testing machine, as per IS 516:2018. The loading was gradually increased until failure for 150 mm × 150 mm × 150 mm cube specimens and compressive strength was determined by dividing the failure load by the area of the specimen under load.

Compressive strength is determined at various ages and is presented below.

Mix	7Days (MPa)	14Days (MPa)	28Days (MPa)	56Days (MPa)	90Days (MPa)
Common Mix	22.5	25.6	30.0	31.0	31.2
M1	23.4	26.8	31.5	32.0	32.0
M2	25.0	28.6	32.8	33.0	33.2
M3	**25.8**	**29.4**	**33.4**	**34.2**	**34.6**
M4	24.3	25.9	32.4	33.0	33.0

All the mixtures exhibited a progressive rise in their compressive strength with the curing age. The common mix increased from 22.5 MPa at 7 days to 30.0 MPa at 28 days and 31.2 MPa at 90 days. All modified mixtures exhibited the same pattern of strength development at the same ages.

The strength of M1 was raised from 30.0 MPa for the common mix to 31.5 MPa in 28 days, and for M2, it was raised from 30.0 MPa to 32.8

MPa. M3 had the greatest value of 33.4 MPa while M4 had 32.4 MPa. Thus, there was no linear increase in strength with increase replacement level. The strength was raised from M1 to M3, but was slightly reduced in M4 with the further increase in the replacement.

The 28-day strength of M3 was around 11.3% strong than the standard mix:

$$\frac{33.4 - 30.0}{30.0} \times 100 = 11.3\%$$

The same M3 mixture recorded the best reported results at the later ages – 34.2 MPa at 56 days and 34.6 MPa at 90 days. These are about 10.3% and 10.9% higher than the average blend.

Based on the suggested function of the two replacement materials, the higher strength obtained for M3 can be discussed. RHA may have a relatively large silica content and, if processed correctly, may be able to enter into pozzolanic reactions and create extra C–S–H formation. Due to its fine particle size, dolomite powder can add to the particle packing and filling of voids in the cementitious matrix. They may, therefore, help to create a denser matrix at a suitable replacement ratio.

It is also noteworthy that M4 is lower in strength than M3. The total replacement for M4 is 30% whereas for M3 it is 25%. The decrease in 33.4MPa to 32.4MPa at 28 days indicates that the strength does not necessarily improve with the increase of replacement quantity. The amount of the conventional cementitious material available for hydration and binding could become more important at higher replacement levels, where the decrease in the amount of cement could be greater. From the results of the experiments, the conclusion is therefore that the replacement level should be balanced, instead of maximized.

C. Flexural Strength

The flexural strength of concrete measures the resistance to flexural loading; it is important for understanding the behaviour of concrete under flexural loading. The report details the flexural-strength test which involves the bending of a concrete beam/prism until it cracks or fails. The results of the mixtures investigated are presented below after 28 days.

Mix	**28-Day Flexural Strength (MPa)**
Common Mix	4.1
M1	3.6
M2	3.8
M3	**4.2**
M4	3.8

The flexural strength of the M3 was about 2.4 % higher than the common mix. This means that the 15% RHA and 10% DP mix had the best flexural properties of the series reported. The result can be compared with the denser matrix suggested for M3 but it is not possible to test this mechanism directly from the available experimental data without undertaking microstructural testing.

D. Split-Tensile Strength

Split-tensile strength was tested for the indirect tensile strength of concrete. This test is performed on a cylindrical specimen under a compressive loading applied on the cross section of the cylinder, which causes tension load across the cross section of the specimen until it splits. The conventional test is described in the report and the equation is:

$$f_t = \frac{2P}{\pi LD}$$

f_t is the split-tensile strength, P is the maximum applied load, L is the cylinder length and Dis is the cylinder diameter.

The split-tensile strengths reported were

Mix	**28-Day Split-Tensile Strength (MPa)**
Common Mix	2.95
M1	2.70
M2	2.80
M3	**3.10**
M4	2.90

The split-tensile strength was highest with M3 at 3.10 MPa, while the common mix had a

strength of 2.95 MPa. This is up 5.1% from the previous year. The values of M1 and M2 were lower than the common mix, whereas M4 increased to 2.90 MPa, but was still a bit lower than the reference concrete.

The split-tensile results therefore generally follow the same trend as observed in the compressive and flexural tests—i.e., the best mechanical performance was measured for the M3 mixture. The Combined Effect of RHA and Dolomite Powder is interpreted.

E. Interpretation of the Combined Effect of RHA and Dolomite Powder

The results illustrate that the relative percentage of RHA and dolomite as well as total replacement percentage has a great influence on the concrete response. M1 with RHA and DP content of 5% exhibited a moderate rise in its compressive strength. The addition of a slight amount of DP to 10% RHA (M2) resulted in another increase. The highest compressive, flexural and split tensile strength were achieved with M3 containing 10% DP and 15% RHA. The strength was reduced if the dolomite content was increased to 15% in M4 with 15% RHA than M3.

This behaviour indicates that the behaviour of the two materials in combination is dependent on a proper balance between the two. The suggested explanation of the proposed mechanism is that RHA provides silica rich potentially pozzolanic material and dolomite powder provide fine mineral particles that may affect packing and the internal structure of the matrix. At the M3 composition these effects may have been conducive to an optimum combination and this gave the maximum measured strength.

The word “synergistic effect”, however, should be used with great caution in the journal paper. The following experiments show that the strength responses obtained from the combined RHA–DP mixtures were different and that the maximum strength response was obtained for M3. The results of the study do not provide quantitative chemical synergism as there is no microstructural or chemical analysis (SEM, XRD or TGA) included. Thus, the findings should be interpreted as showing potential synergy instead of proof of synergy, as there is a possibility that they are complementary effects.

The general trend of the experimental results is evident that there is a relationship between replacement level, workability and strength. More increase in RHA and DP led to a decrease in slump from 85 mm to 65 mm and the mechanical properties were increased with moderate combined replacement. The values reported in the series showed maximum values for M3 mixture with 33.4 MPa compressive strength, 4.2 MPa flexural strength and 3.1 MPa split-tensile strength at 28 days. It was not found that the strength would keep increasing at M4 with 30% total replacement.

There was one important correction you need to make to your paper; your conclusion of the report stated a 7.5% optimum of RHA + 7.5% dolomite, but this exact composition is not shown in the detailed table of the results for M1-M4. So the best possible statement you can make for the journal paper is that the measured strength of M3 (15% RHA + 10% DP) was the highest in the series of experiments reported here, unless you have the original laboratory records of the 7.5% + 7.5% mixture you can verify.

LIMITATIONS AND FUTURE SCOPE

The current study has been conducted on M25 grade of concrete and a specific percentage of RHA and dolomite powder replacement rates. The workability and mechanical properties such as compression, flexural and split tensile were the main attributes studied in the experimental study. No detailed durability properties like water absorption, permeability, chloride penetration, carbonation and sulfate resistance were studied. Furthermore, no microstructural analysis (SEM, XRD or TGA) was conducted, so the mechanisms proposed for pozzolanic and particle-packing were not directly confirmed. Detailed statistical analyses such as standard deviation and coefficient of variation are also not reported in the results.

A further study may be conducted with more proportions of RHA to dolomite to determine the optimum combination of the two. Durability tests, microstructural analysis and long-term performance studies can be performed to get into the behaviour of the blended system. Another study can also be conducted to see if a chemical admixture can be used to achieve better workability reduction at higher replacement levels. Further, the life-cycle assessment, cost analysis and environmental-impact evaluation can be undertaken to quantify the sustainability benefits of RHA and dolomite powder concrete.

CONCLUSION

The present experimental investigation aimed at finding the possibility of using Rice Husk Ash (RHA) in combination with Dolomite Powder (DP) as partial replacement for cement in M25 grade concrete. Various mixes of RHA and DP were tested and compared with the conventional concrete for workability and mechanical properties. The results indicated that the workability reduced gradually with the addition of RHA and DP in the mix and the slump was 65 mm for M4 while the slump of conventional mix was 85 mm, due to the fine and porous nature of RHA.

The compressive-strength outcomes presented that appropriate replacement degrees may be helpful to reach the adequate strength development. The tested mixes showed that M3 with 15 % RHA and 10 % DP gave 33.4 MPa as 28 days compressive strength as compared with 30.0 MPa for conventional mix. M3 also achieved 34.2 MPa at 56 days and 34.6 MPa at 90 days.

This blend exhibited the best flexural strength (4.2 MPa) and split tensile strength (3.1 MPa) after 28 days. Overall, the results prove that RHA and DP are viable to be used as partial cement replacement materials and can achieve satisfactory mechanical performance. The study thus shows that they could produce more sustainable concrete through the reduction of the amount of conventional cement used and the employment of alternative materials.

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