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An Experimental Study to Investigate Strength of M25 Grade Concrete by Partial Replacement of Cement with Pulverised Scallop Shell

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ABSTRACT
The utilization of Scallop Shell Ash in concrete as partial replacement of cement is gaining huge importance these days, principally on account of the development within the future sturdiness of concrete combined with ecological advantages. Technological enhancements in thermal power station operations and fly-ash assortment systems have resulted in up the consistency of Scallop shell. To review the impact of partial replacement of cement by scallop shell ash studies are conducted on concrete mixes with 300 to 500 kg/cum Scallop Shell Ash materials at 15%, 20%, 25%,30% &35% scallop shell ash replacement levels. during this project the result of scallop shellashonworkability,settingtime,density,aircontent,compressivestrength,durability,size of aggregate, modulus of elasticity Slump test and Compaction test are studied based on this study compressive strength of different mixes v/s No of days curves are planned so concrete mixture of gradeM25 with distinction proportion of scallop shell ash are often directly designed.

I. INTRODUCTION

Concrete is the manmade material widely used for construction purposes. The usual ingredients in concrete are cement, fine aggregate, coarse aggregate, and water. It was recognized long time ago that the suitable mineral admixtures are mixed in optimum proportions with cement improves the many qualities in concrete. With increasing scarcity of river sand and natural aggregate across the country, researches began cheaply available material as an alternative for natural sand. Utilization of industrial waste or secondary material has increased in construction field for the concrete production because it contributes to reducing the consumption of natural resources. In India, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. But, now days it is very difficult problem for availability of fine aggregates. So researchers developed waste management strategies to apply for replacement offine aggregates for specific need. Natural resources are depleting worldwide while at the sametime the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

Scallop shell

The role of Scallop Shell Ash in concrete is primarily as a form of aggregate or decorative material, though its use can vary depending on the specific application. Scallop Shell Ash, as a natural material, can provide both functional and aesthetic benefits in concrete mixtures. Here’s how: Lightweight Aggregate: Scallop Shell Ash, being relatively lightweight compared to traditional aggregates like gravel or sand, can help reduce the overall density of concrete. This can be useful in applications where reducing weight is important, such as in the construction of lightweight structures or decorative elements.

Aesthetic Appeal: Scallop Shell Ash can be used in exposed aggregate finishes or decorative concrete applications. They can provide a unique and visually appealing texture to the surface, often used in decorative walkways, countertops, or architectural features. Their natural shape and colour add a distinctive, oceanic look to concrete.

Sustainability: Using Scallop Shell Ash in concrete can be an environmentally friendly approach, especially if the shells are sourced from waste material that would otherwise be discarded. This reduces waste and contributes to the sustainable use of materials.

Durability and Performance: When used as an aggregate, Scallop Shell Ash may contribute to the overall durability of concrete, depending on their composition. However, they may not always perform as well as traditional aggregates when it comes to strength, especially if they are not properly treated or if their calcium content is high, which can lead to issues in certain environmental conditions.

II. LITERATURE REVIEW

Aman Jatale, Kartiey Tiwari, Sahil Khandelwal (2013), “A study on Effects on Compressive Strength When Cement is Partially Replaced by Fly Ash”. The present paper deals with the effect on strength and mechanical properties of cement concrete by using fly ash. The utilization offly- ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvement in the long term durability of concrete combined with ecological benefits. Technological improvements in thermal power plant operations and fly-ash collection systems have resulted in improving the consistency of fly-ash. To study the effect of partial replacement of cement by fly-ash, studies have been conducted on concrete mixes with 300 to 500 kg/cum cementitious materials at 20%, 40%, 60% replacement levels. In this paper the effect offly-ash on workability, setting time, density, air content, compressive strength, modulus of elasticity are studied Based on this study compressive strength v/s W/C curves have been plotted so that concrete mix of grades M15, M20, M25 with difference percentage of fly-ash can be directly designed

Arivalagan. S (2013), A Study on Experimental Study on the Flexural Behavior of Reinforced Concrete Beams as Replacement of cement by fly ash". In this investigation replacement of cement by flyash was done to depict the compressive strength of cubes, flexural strength of beams and split tensile strength of cylinders. The fly ash added with cement to find out the results of concrete proportion ranging from 15%, 20%, 35%, 40%, 50%. The maximum (35.11Mpa) compressive strength was obtained in 40% replacement. The results also revealed the effect of fly ash on RCC concrete elements which shows increment in all compressive strength, split tensile, flexural strength and energy absorption characters. The results also depicts the value of slump which lies between 90 to 120 mm and the flexural strength of beam and also get increased by(21% to 51%) due to the replacement of fly ash.

Prof. JayeshkumarPitrod, Dr. L.B.Zala, Dr.F.S.Umrigar, (2012) A study on Experimental investigations on partial Replacement of cement with fly ash in design Mix concrete. In recent years, many researchers have established that the use of supplementary cementitions materials (SCMs) like fly ash (FA), blast furnace slag, silica fume, metakaolin, and rice husk ash (RHA), hypo sludge etc. can, not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs. This research work describes the feasibility of using the thermal industry waste in concrete production as partial replacement of Replacement of cement with flyash. The use offlyashin concrete formulations as a supplementary cementitious material was tested as an alternative to traditional concrete. The cement has been replaced by fly ash accordingly in the range of 0% (without fly ash), 10%,20%, 30% & 40% by weight of cement for M25 and M40 mix. Concrete mixtures were produced, tested and compared in terms of compressive and split strength with the conventional concrete. These tests were carried out to evaluate the mechanical properties for the test results for compressive strength up to 28 days and split strength for 56 days are taken.

RafatSiddique,(2004) A study on Effect of fine aggregate replacement with class F fly ash on the properties of concrete. This paper presents the results of an experimental investigations carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (sand) was partially replaced with class F Fly ash. Fine aggregate was replaced with five percentages (10%, 20%, 30%, 40%, 50%) of class F Fly ash by weight. Tests were performed for properties offresh concrete. Compressive strength, split tensile strength, flexural strength and modulus of elasticity were determined at 7, 14, 28, 56, 91, 365 days. Test results indicates significant improvements in the strength properties of plain concrete by the inclusion of fly ash as replacement of fine aggregates and can be effectively used in structural concrete.

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(2014), A study on Fly Ash as a Partial Replacement of Cement in Concrete and Durability Study of Fly Ash in Acidic (H2SO4) Environment. In this project report the results of the tests carried out on Sulphate attack on concrete cubes in water curing along with H2SO4 solution. Also, aiming the use of fly-ash as cement replacement. The present experimental investigation were carried on fly ash and has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 10%, 15%, 20% by weight of cement in concrete. Fresh concrete tests like compaction factor test was hardened concrete tests like compressive Strength at the age of 28 days, 60 days, 90days was obtained and also durability aspect of flyash concrete for sulphate attack was tested. The result indicates that flyash improves concrete durability.

III. MATERIALS AND METHODOLOG

HYDRATION REACTIONS WHEN SCALLOP SHELL ASH IS USEDIN OPC

OPC is made up of four principal mineralogical phases symbolically represented by C3S,C2S, C3A and C4AF. The hydration reactions of these chemical compounds as mentioned in the respective section are as follows:

2C3S + 6H —> C3S2H3+3Ca(OH)2

For C2S:

2C2S + 4H —> C3S2H3+Ca(OH)2

For C3A:

C3A+6H —>C3AH6

One of the primary benefits of scallop shell ash is its reaction with available lime and alkali in concrete, producing additional cementitious compounds. The following equations illustrate the pozzolanic reaction of fly ash with lime to produce additional calcium silicate hydrate (C-S-H) binder:

Cement Reaction : C3S/ C2S+ H→ C-S-H +Ca(OH)2

Pozzolanic Reaction: Ca(OH)2+S→ C-S-H

S—-Silica from scallop shell ash constituents

So, clearly from the above equation we can interpret that the excess lime content produced by the hydration reactions of cement, which weakens cement by leaching and other processes, is reduced by the use of silica. Also due to the formation of additional calcium silicate hydrate (C-S-H)binder, the strength of the mix as whole increases

Reduced heat of hydration

In concrete mix, cement and water come in contact, a chemical reaction initiates that produces binding material and consolidates the concrete mass. the process is exothermic and heat is released which increases temperature of the mass when as his present in the concrete mass, it plays dual role for the strength development. Scallop ash reacts with released lime and produces binder as explained above and render additional strength to the concrete. The unreactive portion of ash act as micro aggregates and fills up the matrix to render packing effect and results in increased strength. The large temperature rise of concrete mass exerts temperature stresses and can lead micro-cracking and improves the soundness of concrete mass. When scallop shellash is used as part of cementitious material, quantum of heat liberated is low and staggers through pozzolanic reactions and thus reduces micro concrete mass.

Workability of concrete:

Scallop shellash particles are generally spherical in shape and reduces the water requirement for a given slump. The spherical shape helps to reduce friction between aggregates and between concrete and pump line and thus increases workability and improve pumpability of concrete. Scallop shellash use in concrete increases fines volume and decreases water content and thus reduces bleeding of concrete.

Methodology Materials used:

The Raw materials that are used in the production of concrete are mentioned below.

Coarse aggregates
Fine aggregates
Cement
Metakaolin
Ceramic waste
Portable water

Coarse aggregate:

The material whose particles are of size are retained on IS sieve of size 4.75mm is termed as coarse aggregate and containing only so much finer material as is permitted for the various types described in IS: 383-1970 is considered as coarse aggregate. Aggregates are the major ingredients of concrete. They constitute 70-80% of the total volume, provide a rigid skeleton structure for concrete, and act as economical space fillers. Because at least three-quarters of the volume of the concrete is occupied by aggregate, it is not surprising that its quality is of considerable importance. The properties of aggregate greatly

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affect the durability and structural performance of concrete.

Aggregate was originally viewed as an inert material dispersed throughout the cement paste largely for economic reasons. It is possible, however, to take an opposite view and to look on aggregate as a building material connected in to a cohesive whole by means of the cement paste, in a manner physical, thermal and sometimes also 11 chemical properties influence the performance of concrete. Aggregate is cheaper than cement and it is, therefore, economical to put in to the mix as much of the former and as little of the later possible.

Fine aggregate:

The size of the fine aggregate is below 4.75mm. Fine aggregates can be natural or manufactured. The grade must be throughout the work. The moisture content or absorption characteristics must be closely monitored. The fine aggregate as shown in Figure 3.2 used is natural sand obtained from the river Godavari conforming to grading zone-II of Table 3 of IS 10262- 2009. The results of various tests on fine aggregate are given in Table 3.2. The fine aggregate shall consist of natural sand or, subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. The use of concrete is being constrained by urbanization, zoning regulations, increased cost and environmental concern

Fig2:Fine aggregate

Cement:

The cement is to be tested in the laboratory for its quality requirement limitations as per Indian Standards. The cement used was ordinary Portland cement of OPC 53 grade (KCP 53 grade) as shown in Figure. Confirming to IS: 12269-2013.n Various tests are conducted to know the physical properties of cement and the results are tabulated below in Table 3.1. All 16 the tests conducted are as per the norms of standard specifications given in IS 4031 and the results are tabulated.

Properties of cement

Scallop shellash

Scallop Shell Ash in concrete serve primarily as a lightweight and decorative aggregate. They offer an environmentally friendly alternative to traditional aggregates and can add aesthetic value to concrete surfaces. However, careful attention is required to ensure that the strength and durability of the concrete are not compromised, especially in structural applications. When used appropriately, Scallop Shell Ash can enhance both the appearance and sustainability of concrete in various applications.

Chemical composition of Scallopshellash

S.NO	Component	Composition(%)
1	$CaCO_3$	98.77
2	mg	0.0476
3	Na	0.9192
4	P	0.0813
5	K	0.0398
6	etc	0.1981

PREPARATION OF TEST SPECIMENS

Mixing was done in a laboratory by hand

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mixing. While preparation of concrete specimens, aggregates, cement and mineral admixtures were mixed with the showels and trowels. After proper mixing, mixture of water and plasticizer were added. The mixing was continued untila uniform mix was obtained. The concrete was then placed into the moulds which were properly oiled. After placing of concrete in moulds proper compaction was given using the tamping roads. Specimens were demoulded after 24 hours of casting and were kept in a curing tank for curing till the age of test

Preparation of specimen and mould

Curing of specimens

Details of Test Specimens

Standard moulds were used for casting 150mm cube specimen, 150mm diameter and 300mm height cylinders. A total of 51 specimens were cast and thedetails are given in Table 3.6.

S. No	**Specimen**	**Size(mm)**	**Numbers**
1.	Cube	150x150x150	36
2.	Cylinder	150x300	15

Specimen Identification:

Identification for cubes

Designation	Cement%	Scallop Shell Ash %	Fine aggregate %	Coarse aggregate %	No of cubes
N	100	0	100	100	6
S1	85	15	100	100	6
S2	80	20	100	100	6
S3	75	25	100	100	6
S4	70	30	100	100	6
S5	65	35	100	100	6

Identification of cylinders

Designation	Cement %	Scallop Shell Ash %	Fine aggregate %	Coarse aggregate%	No of cubes
N	100	0	100	100	3
S1	85	15	100	100	3
S2	80	20	100	100	3
S3	75	25	100	100	3
S4	70	30	100	100	3

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Mix Proportion for 1m³

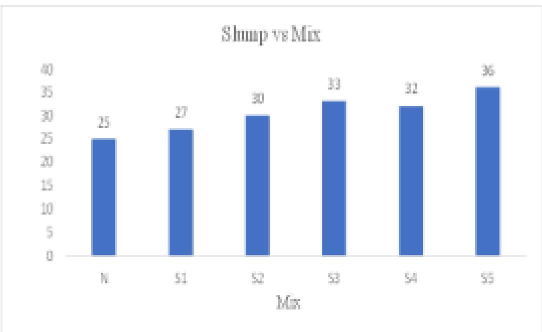
Mix designation	Water (liters)	Cement (kg/m³)	Scallop Shell Ash (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	Test specimen	
						cubes	cylinders
N	186	372	0	662	1107	6	3
S1	186	316.2	55.8	662	1107	6	3
S2	186	297.6	74.4	662	1107	6	3
S3	186	279	93	662	1107	6	3
S4	186	260.4	111.6	662	1107	6	3
S5	186	241.8	130.2	662	1107	6	---

Slump test

Slump test is used to determine the workability of fresh concrete. The apparatus used for doing slump test are Slump cone and Tamping rod. This is the most commonly used test of measuring the consistency of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing neither workability, nor it is always representative of the place ability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. It is performed with the help of a vessel, shaped in form of a frustum of a cone opened at both ends. Diameter of top end is 10 cm while that of the bottom end is 20cm. Height of the vessel is 30cm. A16mm diameter and 60cm long steel rod is used for tamping purposes.

Results of slump test

Mix	Slump(mm)
N	25
S1	27
S2	30
S3	33
S4	32
S5	36

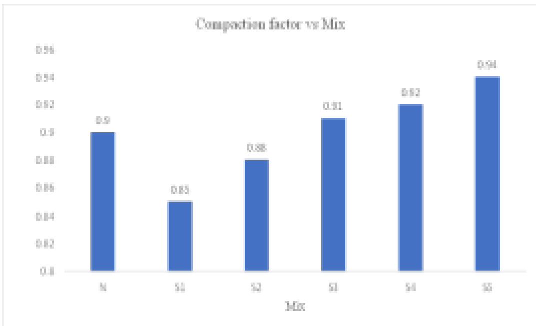


Compacting factor

Compacting factor of fresh concrete is done to determine the workability of fresh concrete. The compacting factor test is designed primarily for use in the laboratory but can also be used in the field. It is more precise and sensitive than the slump test. Such dry concrete are insensitive to slump test. The equipment used for conducting this experiment consists of three containers A, B and C. A and B are of truncated cone shaped vessels fixed to a stand and C is a detached cylinder, which can be opened downwards. The apparatus used is Compacting factor apparatus.

Results on compaction factor test

Mix	Compacting factor
N	0.9
S1	0.85
S2	0.88
S3	0.91
S4	0.92
S5	0.94



HARD CONCRETETESTS

Compressive strength tests

It can be seen that there is increase in strength with the increase in scallop shell ash percentages. The highest compressive strength was achieved by 25% replacement of Scallop Shell Ash, which was found about 33.6Mpa compared with 32.1Mpa for the control mixture at 28th day. The compressive strength of concrete is increased

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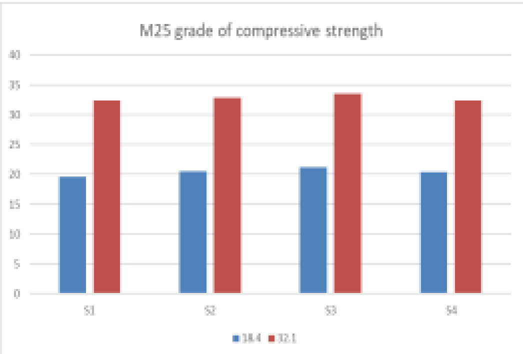
as Scallop Shell Ash content increases up to 30%, beyond that compressive strength was significant decreases due to increases free water content in the mixes. This means that there is an increase in the strength of 20% compared to the control mix.

However, mixtures with 35% replacement offlyash gave the lowest compressive strength 31.6Mpa. It is recommended that up to 35% of Scallop Shell Ash can be use as replacement of cement.

Mix	**7thday (N/mm²)**	**28th day(N/mm²)**
N	18.4	32.1
S1	19.6	32.4
S2	20.5	32.9
S3	21.2	33.6
S4	20.4	32.4
S5	18.2	31.6

Results of compressive strength



Compressive strength of concrete at different stages

Split tensile strength

The highest split tensile strength was achieved by 25% replacement of scallop shell ash, which was found about 3.66N/mm² compared with2.73N/mm² for the control mix. This means that there is an increase in the strength of almost 35% compared to the control mix at 28 days.

Mix	**28thday**
N	2.73
S1	2.85
S2	2.98
S3	3.66
S4	2.61

Results of split tensile strength

IV. CONCLUSION

By our project, we conclude that the strength of concrete increased by the replacement of cement by Scallop Shell Ash. Scallop Shell Ash replaces Portland cement, save concrete materials costs. Here we using OPC of 53grade, class F fly ash, well graded coarse and fine aggregate.

35% Scallop Shell Ash replacement showed maximum workability. The workability of concrete had been found to decrease after 40% in concrete.

Among different mixes of concrete 25% showed maximum compressive strength at later ages.

Maximum split tensile strength is obtained for S3 mix which is 25% replacement of cement.

The cost analysis indicates that percent of cement reduction decrease the cost of concrete, but at the same time strength increases.

It has been shown that concrete containing Scallop Shell Ash is more economical than ordinary concrete. Concrete containing Scallop Shell Ash, delivered to the construction site, can be from 10 to 35% more economical than ordinary concrete. The main factor affecting the reduction in cost is the Scallop Shell Ash content of the mix. The user should be aware of concrete containing Scallop Shell Ash requiring a high dosage of air-entraining admixture for the development of a proper air-void system. In many cases, the increase in cost due to the admixture requirements may eliminate any savings in cost obtained by the use of Scallop Shell Ash.

Concrete containing Scallop Shell Ash having a slump in the range of 7.5 to 10.5cm.can be produced even when mixing temperatures are of the order of 1000 F and the total period of mixing does not exceed 60 minutes.

Improved workability. The spherical shaped particles of Scallop Shell Ash act as miniature ball bearings within the concrete mix, thus providing a lubricant effect. This same effect also improves concrete pump ability by reducing frictional losses during the pumping process and flat work finish ability.

Decreased water demand. The replacement of cement by Scallop Shell Ash reduces the water demand for a given slump. When Scallop Shell Ash is used at about 20 percent of the total cementitious, water demand is reduced by approximately 1 percent. Higher Scallop Shell Ash contents will yield higher water reductions. The decreased water demand has little or no effect on drying shrinkage/cracking. Some fly ash is known to reduce drying shrinkage in certain situations.

Reduced heat of hydration. Replacing

cement with the same amount of Scallop Shell Ash can reduce the heat of hydration of concrete. This reduction in the heat of hydration does not sacrifice long-term strength gain or durability. The reduced heat of hydration lessens heat rise problems in mass concrete placements.

Increased ultimate strength. The additional binder produced by the Scallop Shell Ash reaction with available lime allows Scallop Shell Ash concrete to continue to gain strength over time. Mixtures designed to produce equivalent strength at early ages (less than 90 days) will ultimately exceed the strength of straight cement concrete mixes.

Reduced permeability. The decrease in water content combined with the production of additional cementitious compounds reduces the pore interconnectivity of concrete, thus decreasing permeability. The reduced permeability results in improved long-term durability and resistance to various forms of deterioration.

Improved durability. The decrease in free lime and the resulting increase in cementitious compounds, combined with the reduction in permeability enhance concrete durability. This affords several benefits:

The observed slow set and low early strength obtained with Scallop Shell Ash has causeda reduction in the amount of this mineral admixture used in concrete. Although some flyash materials will reduce early strength and slow the setting time it does not have to be the case today. Some Scallop Shell Ash actually accelerates set. The addition of accelerators, plasticizers and/or a small amount of additional CSF, as well as the proper beneficiated fly ash, can mitigate this problem.

TheS3mixisthemosteconomicalandgiveshighstrengthcomparedtocontrolmix.Otheruses
Greater strength
Decreased permeability
Increased durability
Reduced alkali silicare activity
Reduced heat of hydration
Reduced efflorescence**.**

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