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Study on Partial Replacement of Cement and Coarse Aggregate by Egg Shell Powder and Steel Slag in Concrete

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Abstract: ***In this research, eggshell powder (ESP) was used as a partial substitute for cement in concrete to decrease the usage of cement in concrete production. The main objective of the study was to determine the workability and reinforcing properties including compression, tensile and flexural strength of concrete using various percentages (0, 10, 20,&10) of ESP by weight instead of cement. A total of 38 concrete samples were cast (12 cubic meters, 12 cylinders and 12 prisms) with a target strength of 28 N/mm2. The compressive strength of a cube sample (150 × 150 × 150 mm) was tested after 7, and 28 days, while tensile strength were also measured for 7 days and 28 days using a cylindrical specimen (200 × 100 mm). The bending strength of the specimen (100 x 100 x 500 mm), cast during 7, and 28 days of curing. The test results showed that during the. With ESP 20%, tensile strength increased by 30%, and a maximum strength of 20% was obtained using ESP 20% during 28-day cure. As the percentage of ESP increases, the workability of fresh concrete decreases. ESP is used in concrete to enhance the power of a concert.***

Natural aggregates are becoming scarce and their production and shipments is also becoming more difficult. The main objective of this study is to identify alternative source of good quality aggregates which is depleting very fast rate

due to the fast pace of construction activities in India and to improve the workability and durability of concrete. Use of steel slag as a waste industrial which is the by-Product of iron and steel production provides great opportunity to utilize it as an alternate to normally available coarse aggregates. In this study concrete of M30grade for a w/c ratio of 0.45 respectively for the replacement of 10%,20% and 30% of coarse aggregates by steel slag which is produced as a waste material in steel industry and has a negative impact on environment when disposed. The investigation reveals that the steel slag could be utilized as coarse aggregate in all the concrete applications and shows a considerable improvement in the compressive strength of concrete over the control mixes by 7 to 8%. Results show that the concrete incorporating steel slag has higher compressive strength and an increase in density and stability was clearly observed in the specimens replaced with steel slag as coarse aggregate.

Keywords: Eggshell Powder, cement, Steel Slag, coarse aggregate, grade-M30.

I. INTRODUCTION

A. General

The development of a country or a country depends not only on technology, but also on infrastructure. Concrete is called the pillar of infrastructure. Concrete is a mixture of materials such as cement, fine aggregates, coarse aggregates and water. Concrete is widely used throughout the world. Cement production ranges from 10% to 30% of the world's total carbon dioxide. Consequently, cement production is not environmentally friendly, and cement is the most expensive material in the composition of concrete and, therefore, uneconomical. Therefore, it is necessary to find alternative materials to make the construction industry environmentally friendly and sustainable. As a result, the construction industry is currently looking for suitable waste that will significantly reduce cement use and ultimately reduce construction costs. Waste from industrial and agricultural fields, such as copper, slag, quarry dust, rice husk ash, fly ash and eggshell, are a cause of recycling and environmental hazards. Calcium-enriched eggshells are poultry waste with almost the same chemical composition as limestone. Using eggshell waste instead of natural lime instead of cement in concrete can bring many benefits, such as minimizing the use of cement, protecting natural lime and using waste. Eggshell is a good accelerator for cement binders. The eggshell and lime stone are almost same in chemical nature. To this end, we can minimize the use of cement and waste disposal. Various researchers use eggshell powder as a substitute for cement. Present research analysed the fresh and hardened characteristics of concrete comprising of ESP.

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Conventionally concrete is proper mixture of cement, sand and aggregate. The aggregates occupy the almost 10-20 percent of the total volume of concrete. To meet the global demand of concrete in the future life, it is necessary to use a for alternative material in construction which can fully or partially replaced for the natural aggregate without affecting the property of fresh and harden concrete. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river sand. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere there is large demand for alternative materials from industrial waste. Hence an alternative material like utilization of quarry rock dust which can be called as manufactured sand has been accepted as a building material in the industrial construction. Also, steel slag could be used as a partial replacement for coarse aggregate. Good environmental conditions by effective utilization of these by-products will occur which will otherwise remain as a waste material. Steel slag aggregates are already being used as aggregates in asphalt paving road mixes due to their mechanical strength, stiffness, porosity, wear resistance and water absorption capacity. The feasibility of the usage of quarry rock dust and steel slag as substitutes for conventional concrete are investigated. The test results of workability levels and strength are also same when compared to the conventional concrete. The improvement of the concrete mixture properties by addition of steel slag in concrete is observed. The waste material can be replaced by natural aggregates in concrete. The strength of plain concrete and CFSTs with partial replacement of natural aggregates by waste materials in concrete strength is same. The strength by partial replacement of quarry dust as fine aggregate and C& D debris as the coarse aggregate is more than of plain concrete. The investigation of property of concrete by replacing fine and coarse aggregate by steel slag shows that the strength increased and workability decreased. Also, concrete density is decreased. Compressive strength, split tensile strength, flexural strength is higher when M sand is used as 50% replacement as fine aggregate. The properties of concrete by replacing natural sand by manufacturing sand is higher. The higher level of fines in manufactured sand increases the workability decrease water content in concrete. The steel slag when used as a replacement for coarse aggregate increases the strength and workability.

II. LITERATURE REVIEW

Amarnath Yerramala studied the Properties of concrete with eggshell powder as cement replacement. This paper describes research into use of poultry waste in concrete through the development of concrete incorporating eggshell powder (ESP). Different ESP concretes were developed by replacing 10-30% of ESP for cement. The results indicated that ESP can successfully be used as partial replacement of cement in concrete production. The data presented cover strength development and transport properties. With respect to the results, at 10% ESP replacement the strengths were higher than control concrete and indicate that 10% ESP is an optimum content for maximum strength. In order to investigate properties of ESP concretes, five mixes were employed in this study. Several laboratory trial mixes were carried out with 300kg/m3 cement. Water to cementitious ratio, coarse and fine aggregate quantities was arrived for concretes to be tested from the trial mixes. In this study, Compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 KN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516.1959. The test was conducted on 150mm cube specimens at 1, 7 and 28 days. Compressive strength was higher than control concrete for 5 % ESP replacement at 7 and 28 days of curing ages. ESP replacements greater than 10 % had lower strength than control concrete. Addition of fly ash improved compressive strength of ESP concrete.

D.Gowsika et al experimentally investigated the Egg Shell Powder as Partial Replacement with Cement in Concrete. This paper reports the results of experiments evaluating the use of egg shell powder from egg production industry as partial replacement for ordinary Portland cement in cement mortar. The chemical composition of the egg shell powder and compressive strength of the cement mortar was determined. The cement mortar of mix proportion 1:3 in which cement is partially replaced with egg shell powder as 5%, 10%, 15%, 20%, 25%, 30% by weight of cement. The compressive strength was determined at curing ages 28 days. There was a sharp decrease in compressive strength beyond 5% egg shell powder substitution. The admixtures used are Saw Dust ash, Fly Ash and Micro silica to enhance the strength of the concrete mix with 5% egg shell powder as partial replacement for cement. In this direction, an experimental investigation of compressive strength, split tensile strength, and Flexural strength was undertaken to use egg shell powder and admixtures as partial replacement for cement in concrete.

Praveen Kumar R et al experimentally investigated the Partial Replacement of Cement with Egg Shell Powder. The aim of this study is to study the chemical composition of the egg shell to find its suitability of replacement in the concrete. To examine the feasibility of utilizing the egg shell and silica fume as cement replacement material. To study the strength parameters of the egg shell powder mixed specimens and to compare it with conventional specimens.

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The scope of the study is to cast the concrete specimens and conduct the compressive strength test, split tensile strength test and flexural strength test at 7th & 28thday, with the specified combinations of egg shell powder and compare it with the controlled concrete specimens. In this project M30 Concrete is designed for various combinations. A combination of Egg shell with silica fumes are used in different combinations to find the feasibility of using the Egg shells as an alternate to cement Egg shell powder replaces 10%, 20% and 30% in addition with the silica fume by 5%, 10%, 15% of weight of cement. Concrete is cast and Compressive test, Tensile and Flexural tests were carried out to find the best combination which results in optimum percentage of strength.

Freire et al carried out the investigation on egg shell waste and found out its use in a ceramic wall tile paste. Based on the presence of CaCO3 in egg shell it can be used as a alternative raw material in the production of wall tile materials they also found that egg shell can be used as an excellent alternative for material reuse and waste recycling practices.

Lau yih bling conducted the investigation in egg albumen and reported that foamed concrete were prepared by egg albumen which has reduce the cost and time of project. 1 per cent and 5 per cent egg albumen were used. From the investigation it is concluded that 10 per cent of EAFC consists of unstable compressive strength and higher flexural strength with increase density when compared with control foamed concrete which was 64 per cent and 35 per cent. In this study it is proved that Egg Albumen Foamed Concrete (EAFC) can produce light weight concrete which is more environment friendly and improved properties.

Harsh Gupta et al (2017) The purpose of this study was to study the effect of steel slag such as changing the positive part by 0%, 10%, 20%, 30%, and 40% testing the concrete level of M25 & M30 after 7, 14, 28 and Days 50 water treatments. A rough amount of 20mm is selected and trained with a 10mm filter, a good amount of more than 4.75mm with a filter and stored in a filter of 600 microns used, compressive strength test, solid separation test, flexible test, steel slag was tested. The result shows that the maximum energy exchange rate combined is a slag metal for 7, 14, 28 days and 50 days for water healing.

Comparison of compression strength, flexibility and strength to separate ordinary concrete and concrete with Slag Steel as part replacement Results show that normal concrete strength is slightly lower than steel replaced Slag.

An increase in depressive strength is approximately 31.47% in 7 days treatment 20% in 14 days cures 18% 28 days and 40% slight decrease in 4.2% noted in 7 days and 3.4 days % 28 days of treatment compared to 30%.

Increased M 30 concrete pressure increase of approximately 24.9% 7 days of healing 17.5% 14 days of healing and 15.5% 28 days of healing while 40% slight decrease of 3.6% noted 7 days and 2.5%. 28 days of treatment compared to 30%. The strength of the separated slag increases by increasing the percentage of iron slag to 30% by weight of fine aggregate. Increased tensile strength was approximately 16.7% in 28 days healing M25 concrete range and increased by 15.6% in 28 days of M2 treatment. 30th level concrete. Flexural strength increases within the percentage of iron slag up to 30% by weight of fine aggregate. Increased flexibility strength test approximately 36.7% with 28 days healing M 25 grade concrete and 24.7% 28 days treatment M M concrete floor.

Rosales.j et al (2017) in this document entitled effect of stainless-steel slag waste as a replacement for cement in mortars. In these studies, replacing cement by stainless steel slag waste and improving the mechanical properties of the slag waste by using different types of treatment. The cement was replaced with different substitution percentage of untreated stainless-steel slag and waste slag that was proceed to the crushing, burning, and both treatments to determine the optimum replacement ratio according to the mechanical properties. In this case based on multivariate factor analysis was developed to compare these proceed waste according to their mechanical behavior. A mortar sample with a mix proportion of 0.5:1:3(water; cement; sand) was designed as the control mix.

To compare SW with cement made using common addition, three sets of cement with FA were manufactured with different substitution percentages (10%,20%, and 30%). samples with different substitution percentages for the manufacture of cement mortar were created to analyze the cement capacity of the stainless-steel slag waste.

Liwu mo et al (2017) in their studies entitled Accelerated carbonation and the use of steel slag concrete as binding materials and aggregates. Experimental study, 60% of slag metal powders containing high free CaO content, 20% Portland cement up to 20% active magnesia and lime mixed to fix binding compounds. Binding mixtures were then used to cast concrete, when up to 100% of the natural composite material (limestone and river sand) was replaced with steel slag aggregates. Concrete was exposed to carbonation healing with a concentration of 99.9% CO2 and a pressure of 0.10 MPa at different times (1d, 3d, and 14d). Carbonation front, carbonate products, compressive strength, microstructure, and strength of concrete volume were investigated. The effects of CO2 treatment on carbonation depth, compressive strength, and volume stability of steel slag concrete as binding materials and aggregates were investigated.

Ramesh et al. (2017) in this investigation entitled use of furnace slag (FS) and welding slag (WS) as a replacement of coarse aggregates in concrete. The aim of this study is to examine the behavior of the WSA in HPC. For mixtures containing WS, the 7-d compressive strength of concrete cubes increased from 10 to 15% and 28 d compressive strength increased from 5 to 15%.

It was concluded that 5% of WS and 10% FS replacement with fine aggregates is effective for practical purpose. On the basis of the above literature, weld slag was potentially used in the manufacture of bricks and as a replacement of fine aggregate in concrete. Six mixture proportions were made. Control mixture (CM) without weld slag was prepared and for other five mixtures, weld slag was replaced to fine aggregates at 10, 20, 30, 40 and 50%, respectively. To recognize the mixtures, each mixture was titled as CM, WSA 10, WSA 20, WSA 30, WSA 40 and WSA 50. WSA 20 denotes that the HPC mixture made with 20% WSA replacing the fine aggregate.

Gaayathri Priya et al Natural aggregates are becoming scarce and their production and shipments is also becoming more difficult. The main objective of this study is to identify alternative source of good quality aggregates which is depleting very fast rate due to the fast pace of construction activities in India and to improve the workability and durability of concrete. Use of steel slag as a waste industrial which is the by-Product of iron and steel production provides great opportunity to utilize it as an alternate to normally available coarse aggregates. In this study concrete of M25 grade for a w/c ratio of 0.45 respectively for the replacement of 60%,70% and 80% of coarse aggregates by steel slag which is produced as a waste material in steel industry and has a negative impact on environment when disposed. The investigation reveals that the steel slag could be utilized as coarse aggregate in all the concrete applications and shows a considerable improvement in the compressive strength of concrete over the control mixes by 7 to 8%. Results show that the concrete incorporating steel slag has higher compressive strength and an increase in density and stability was clearly observed in the specimens replaced with steel slag as coarse aggregate.

III. MATERIAL AND METHODS

This experimental procedure covers all preliminary tests, including analysis of aggregates, specific gravity and water absorption of the cement to ensure the quality of the material and its limitations within the technical specifications.

1) *Cement:* Cement is a powdery substance consisting of limestone and clay, it is mixed with water, sand and large stones to produce concrete. Cement is a binder that hardens and hardens, and can also bind other substances into aggregates. Cement acquires strength through a chemical reaction with water. This process is called hydration.As a rule, cement loses 10% of its strength within one month from the date of manufacture. The fineness of cement was measured through standard determination of fineness of cement (IS: 4031 - Part - 3) method.
   specific gravity: 3.1
   Consistency: 32%
   Initial setting time: 40min
   Final setting time: 300min
2) *Coarse Aggregate:* Collected coarse aggregates from local stores. It was produced in a place near Naziabad, which has a good reputation when it comes to rough aggregates of the Pakistani construction industry. The sample of a 20 mm size coarse aggregate were analysed for various tests including specific gravity, water absorption and fineness modulus.
3) *Fine Aggregates:* The fine aggregate is called the material that will pass through the No. 4 sieve and will remain on the No. 200 sieve. The main purpose of the fine aggregate is to ensure that the concrete works, so it must have a round shape. Another goal is to fill the voids caused by a large population. Although all small aggregates have similar sizes, they differ in many ways. Small units come from local stores. It is derived under the name Bolari sand, which is commonly used in local buildings. This quarry is considered the best in Sindi career. Many experiments have been conducted to detect the various properties of small aggregates, such as specific gravity, modulus of fineness and water absorption.
   Specific gravity of sand: 2.65
   Fines modulus of sand: 3.45
   Sand confirming Zone as per IS 383-1970: Zone III
   Water absorption: 0.6%
4) *Eggshell:* The eggshell is the hard outer shell of the egg. It mainly consists of calcium carbonate, normal calcium. The rest is made up of proteins and other minerals. Calcium is an essential mineral and is found in many foods, including dairy products. Egg shell chopper is used to process egg shell into egg shell powder. As for the production of egg shell powder, this process: washing egg eggshell, drying egg shells and grinding egg shells. Eggshell before chopping is broken into small pieces. Throughout the process, three machines are required: a dryer for eggshell, a mill for eggshell, and a sieve for eggshell. For eggshell washing machines, it can be customized to suit your needs.

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Fig:1 eggshell powder sample

5) *Steel Slag:* Steel slag is an industrial by-product obtained from the steel manufacturing industry. It is produced in large quantities during the steel-making operations Steel slag can be used in the construction industry as aggregates in concrete by replacing natural aggregates. Fig.2 shows the induction furnace steel slag sample and table.1 shows the properties of steel slag.



Fig:2 steel slag sample.

Chemical composition of steel slag
Carbon 1.40%
Oxygen 54.05%
Sodium 0.58%
Aluminium 4.49%
Silicon 18.28%
Potassium 0.33%
Calcium 1.46%
Titanium 0.49%
Chromium 0.32%
Manganese 3.67%
Zinc 0.32%
Iron 14.52%

IV. METHODOLOGY

It is the method followed to perform the experiment. In this section we have made step wise procedure to perform experiment which is briefly described as follows:

1) Mix designed
2) Batching
3) Experimental programmed of casting
4) Mixing
5) Compaction
6) Curing
7) Testing

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V. CONCLUSION

A number of experiments were conducted to determine the use of egg-shell powder as a cement substitute material by making concrete cubes, cylinders and prisms. Based on the results of experimental work, we can draw the following conclusions.

The compressive strength of concrete using eggshell powder as a substitute for cement is reduced by 20%. The tensile strength of concrete from eggshells decreases with the addition of egg shells powder. This can be added if concrete is used with steel rods. The flexural strength of an egg-shell mixture increases with an increase in the amount of eggshell egg powder added by 10%. The eggshell powder surrounding the surface of the mixture can increase the carbonization process and can reduce permeability over a long period of time. Therefore, a detailed study of the carbonization process in the mixture is required.

The increase in strength for the replacement of coarse aggregate by steel slag up to 40 percent may be due to shape, size and surface texture of steel slag aggregates, which provide better adhesion between the particles and cement matrix.

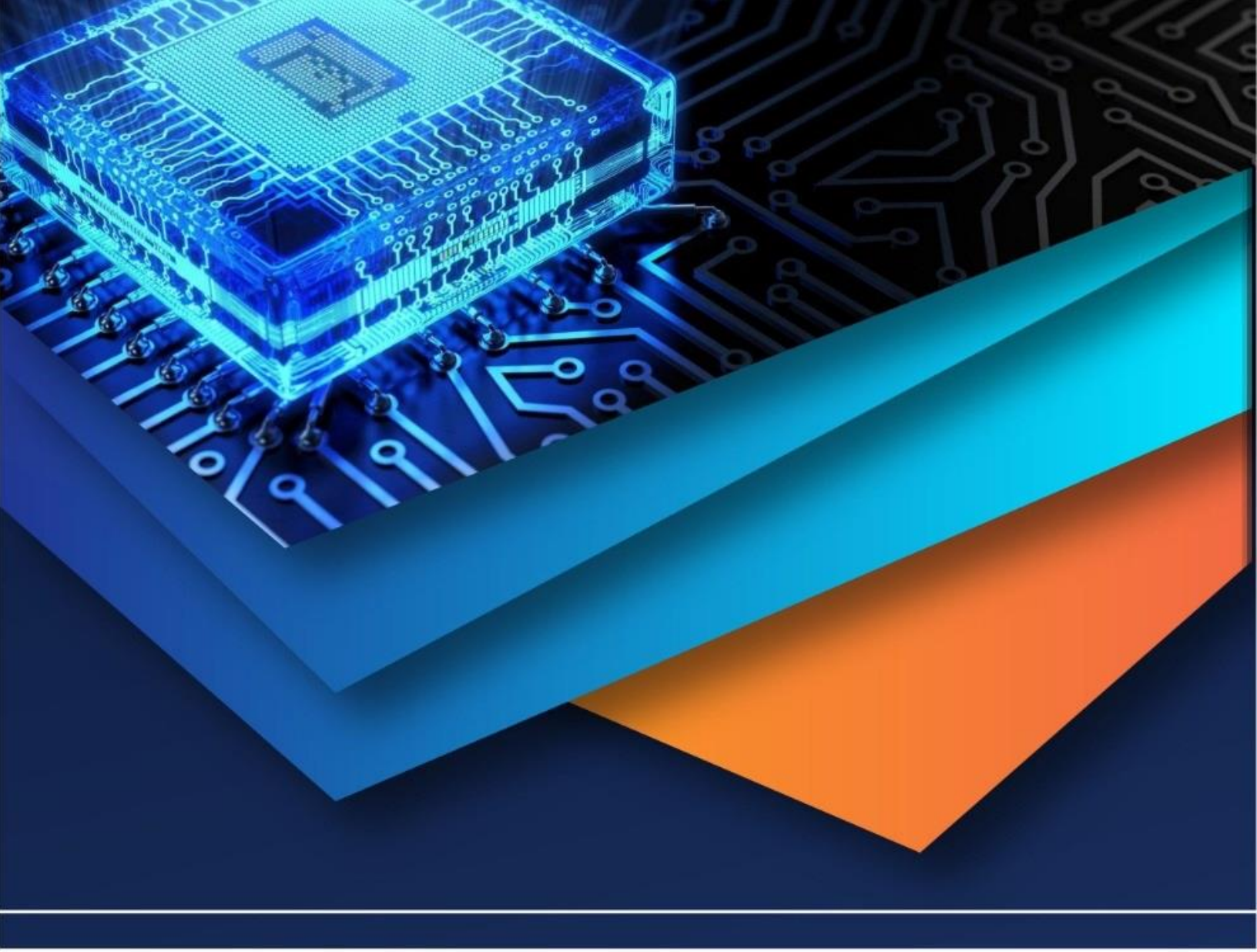
Optimum level of replacement for steel slag is found as 40%. Increase in strength initially is attributed to shape effect and decrease in strength beyond 40% is attributed to porosity of steel slag.

Optimum level of replacement for M sand is found as 25%. Increase in strength initially is attributed to particle size effect and decrease in strength beyond 25% is attributed to water absorption capacity of M sand. The combination 25 percent replacement of M Sand and 40 percent replacement of steel slag gave compressive strength of above 48.7 Mpa. Also split tensile strength flexural strength and water absorbing results showed maximum values for the same percentage. From the test results obtained it may be concluded that replacement of river sand by 25% M Sand and coarse aggregate by 40% steel slag is the optimum and most suitable for areas not exposed to marine conditions.

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