# EFFECT OF STONE DUST AS A PARTIAL REPLACEMENT OF SAND ON THE ACID RESISTANCE OF TERNARY BLENDED CONCRETE

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**Abstract :** Concrete is most widely used construction material because of ease of construction and its properties like compressive strength and durability. It is difficult to point out another material of construction which is versatile as concrete. It is well known that plain concrete is very good in resisting compressive strength but possesses low specific modulus, limited ductility and little resistance to cracking. Internal micro cracks inherently present in the concrete and its poor tensile strength is due to propagation of such micro cracks eventually leading to brittle failure of concrete. An acute shortage of river sand which is generally used as a fine aggregate in concrete has been affecting the construction sector. The scarcity has led to the skyrocketing price of sand, escalating construction costs. The situation has dashed the dreams of many in the lower- and middle-income groups to own a house.There were studies about the depletion of river sand and the need for scientific management and exploitation of the available resource. Following the shortage of river sand, some research institutions are searching alternatives that can be used for construction.

Several admixtures have been developed to improve the strength and workability properties of concrete. Of all admixtures used in concrete, Micro Silica occupies a special position for quite a few reasons. The improvement of durability, resistance to chloride, sulphate, freezing and thawing, alkali silica reaction, frost attack, increase in compressive strength, reduces the permeability and bleeding. Micro Silica effectively improve the structure of interface eliminates the weakness of the interfacial zone.

The present experiment is carried out to investigate the compressive strength and acid attack resistance of normal as well as ternary blended concrete with 8% of micro silica and 15% of fly ash by weight of cement as partial replacement of cement and replacement of 0%, 10%,20%,30%,40%,50%,60%,70%,80%,90% of sand with Stone dust. Compressive strength of concrete is measured by testing standard cubes (150mmx150mmx150mm) at the age of 28 days, acid attack resistance of concrete is measured by observing the mass loss in specimens(100mm x100mm x100mm) over a period of 90 days.

Micro Silica and Fly Ash along with Stone dust in concrete has shown considerable improvement in the compressive strength of concrete. From the test results it is observed that concrete mixture with 8% Micro Silica and 15% Fly ash replacement of cement and 60% stone dust as replacement of sand has shown the maximum acid attack

resistance to the ternary concrete mix as well as normal concrete mix. Hence, ternary blended concrete with 8% micro silica and 15% fly ash with 60% replacement of sand with stone dust is a novel material having superior performance characteristics compared with conventional concrete.

**keywords :** Fly ash, micro silica, stone dust,workability, mechanical properties , etc,.

## I.INTRODUCTION

The word concrete comes from the Latin word Concretes (meaning compact or condensed).It provides superior fire resistance, compared with wooden construction and can gain strength over time. Structures made of concrete can have a long service life. It is also one of the most extensively use construction materials in the world, with about two billion tons of utilization worldwide each year. Concrete has relatively high compressive strength, but much lower tensile strength. For this reason its usually reinforced with materials that are strong in tension (often steel).

It is attractive in many applications because it offers considerable strength at a relatively low cost. Concrete can generally be produced of locally available constituents, can be cast in to wide variety of structural configurations, and requires minimal maintenance during service. However, environmental concerns, stemming from high-energy expense and $CO_2$ emission associated with cement manufacture, have brought pressures to reduce consumption through the use of supplementary materials.

Durability is one the most important properties to be considered in the design of reinforced concrete structures exposed to aggressive environments and they can be described by two stages: the initiation and the propagation period.

Pozzolonic materials are finely divided siliceous and aluminous materials and have little or no cementitious value and in the presence of moisture at ordinary temperature, chemically react with calcium hydroxide liberated during hydration, to form compounds possessing cementitious properties. The engineering benefits likely to be derived from the use of pozzolonas in concrete include improved resistance to thermal cracking because of lower heat of hydration, enhancement of ultimate strength and impermeability due to pore refinement, a better durability to chemical attacks such as acid, sulphate water and alkali-aggregate expansion.

**Fly Ash** : Past research proved better performance characteristics, in response of fly ash concrete, in terms of durability of concrete almost unanimously across the globe. The improvement in the gel structure caused by pozzalanic action of fly ash leads to a very impervious concrete. This factor improves the resistance of concrete against external aggression. Fly ash, an environmental hazard, can be consumed constructively and thus contribute to the ecological balance by effectively using it in concrete.

**Micro Silica** : Silica fume, also known as micro silica, is a byproduct of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica Fume is also collected as a byproduct in the production of other silicon alloys such as ferrochromium, ferromanganese, Ferro magnesium, and calcium silicon. Before the mid-1970s, nearly all Silica Fume was discharged into the atmosphere.

**Triple-Blends (Ternary Cement System) :**As the name suggests, ternary cement concrete consists of three main materials, added in select proportions within the percentage of concentration of the cement.It means micro silica or other cement replacement additives are to be used with OPC only. That is not strictly true and ternary mixtures comprise efficient -systems. The primary incentive of adding limited amount micro silica –for example 6 percent with fly-ash cement mixes was to ensure high early strength research has however, shown that ternary mixtures of OPC, micro silica and fly-ash result in synergic action to improve the micro structure and performance of concrete. When both micro silica and fly-ash are used, the resultant enhancement of strength or Pozzolanic activity was greater than super position of contributions of each, for the respective proportions. Such synergic effect results from strengthening the weak transition zone in aggregate cement interface, as well as segmentation and blocking of pores.

**Stone dust :** The spiraling costs of river sand used as fine aggregate in concrete have increased the cost of construction significantly in the past two decades. The increase in the cost of river sand is due to dwindling natural resources coupled with the restrictions imposed by several governments on sand quarrying, as well as the concern to prevent further environmental degradation and conserve ground water. These problems have led to the search for alternative materials for fine aggregates that are eco-friendly besides being in expensive. Stone crusher dust, available abundantly from crusher units at a low cost in many areas, provides a viable alternative for conventional river sand.

**Objectives of Present Investigation**

- To study the influence of stone dust in various percentages on compressive strength and acid attack resistance of ternary blended concrete and normal concrete, with the replacement of fine aggregate .
- The find the optimum value for replacement of fine aggregate by stone dust in a concrete mix.
- To study and compare the result values of ternary concrete containing 8% micro silica and 15% fly ash and partially replaced fine aggregate with stone dust to that of the normal concrete mix with partially replaced fine aggregate with stone dust.

**Scope of the Present Work**

The present experiment is carried out to investigate the compressive strength and acid attack resistance on M30 grade concrete with 8% and 15% replacement of cement by silica fume and fly ash respectively and 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% replacement of fine aggregate with stone dust.

## II.LITERATURE REVIEW

**M.G. Alexander, B.J. Magee(1999)** have conducted an experimental study on the durability performance of various condensed silica fume (CSF) concretes in comparison to portland cement (PC) and PC/ground granulated blast furnace slag (GGBS) controls up to the age of 28 days. Mix proportions were designed to provide 28-day strengths of 30, 40, and 50 MPa for the PC controls and these were used for all binder combinations considered. Concrete durability was inferred from a suite of durability index tests designed to measure concrete resistance to gas, liquid, and ion transport mechanisms. It is shown that concrete durability is dramatically improved through the use of CSF. Optimum performance was achieved through the use of CSF as a 10% addition by mass to the initial binder content. The work also confirms CSF's effectiveness when used in ternary binder blends with PC and GGBS, with these mixes out-performing the controls and selected binary blended PC/CSF mixes.

**A.K.Mullck(2007):** Described among the many factors that govern the durability and performance of concrete in service, type of cement receives greater attention. In his paper he describes the characteristics of cementitious systems required to meet the diverse requirements of strength and durability of concrete and highlights the advantages of part replacement of OPC by fly ash, granulated slag and silica fume- either singly or in combination in ternary blends.

**P. Murthi and V. Sivakumar (2008)** have conducted a detailed experimental investigation on the acid resistance of ternary blended concrete immersed up to 32 weeks in sulfuric acid (H2SO4) and hydrochloric acid(HCl) solutions. The results are compared with those of the control and binary blended concrete. ASTM class F fly ash was considered to develop the binary blended concrete at the replacement level of cement as 20% by weight. Then silica fume was considered to develop the ternary blended concrete and the replacement of cement in the ternary system by silica fume was suggested as 8% of total powder content by weight. The variable factors considered in this study were concrete grades (M20, M30 and M40) and curing periods (28 days and 90 days) of the concrete specimens. The parameter investigated was the time in days taken to cause 10% mass loss and strength deterioration factor of fully immersed concrete specimen in a 5% H2SO4 and 5% HCl solutions. The investigation indicated that the ternary blended concrete prepared by 20% fly ash and 8% silica fume performed better acid resistance than the ordinary plain concrete and binary blended concrete.

## IV.COLLECTION OF MATERIALS AND MIX DESIGN

**Cement :** Ordinary Portland cement (Ultra tech cement) of 53 grade confirming to IS: 12269-1987 [8] was used. It was tested for its physical properties as per IS 4031 (part II)-1988 and chemical properties as per IS: 12269.

**Fine Aggregate :** The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963[9]. The fine aggregate is conforming to standard specifications.

**Coarse Aggregate :** Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The physical properties of coarse aggregate were investigated in accordance with IS 2386 -1963.

**Water :** Locally available water used for mixing and curing which is potable and is free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

**Fly Ash :** The fly ash obtained from Hyderabad Industries, Andhra Pradesh is used in the present experimental work.

Fly ash

**Micro Silica :** Micro Silica was procured from a local dealer at Hyderabad.

**Stone dust :** Standard stone dust, obtained locally from one of the numerous quarries around Hyderabad .The physical properties and the typical oxide combination of stone dust used.

**Acid (H2SO4) :** Standard H2SO4 acid having specific gravity 1.840, molecular weight 98.06 obtained locally from premier traders, Hyderabad.

**Super Plasticizer :** Super plasticizer by trade name Conplast SP 430 manufactured by Fosroc Chemicals (India) limited obtained from United Engineering Rani Ganj Hyderabad was used as a water reducing agent to achieve the required workability.

**Mix Design** :Using the properties of cement aggregate concrete mix of $M_{30}$ grade was designed as per IS 10262-1982. the mix design procedure and calculations are presented in Appendix A the following proportions by weight were obtained.

| Cement | Fine Aggregates | coarse aggregate |
|---|---|---|
| 1 | 1.57 | 3.32 |

Water cement ratio = 0.46 ,The same proportion of mix was used throughout the experimental programme.

**Test Arrangement**

The specimens are removed from the curing pond after 28 days and they cleaned to wipe off the surface water. After thorough drying, the cube specimen is immersed into the tubs that contain the solution for testing the acid attack resistance. Here, the solution represents 5% acidic solution of H2SO4 acid. The cubes are so placed that they must completely be immersed in the acid solution, from all the sides. It is better to have the cubes suspended in the solution, so as to have complete contact between the cube and the solution. After immersing the cubes in the concerned tubs, the apparatus is left for the required time at room temperature.

Acid attack setup

## V.RESULTS AND ANALYSIS

**Physical Properties of Ordinary Portland Cement**

| S.No. | Property | Test Method | Test Result |
|---|---|---|---|
| 1 | Specific Gravity | Specific gravity bottle (IS 4031-Part 11) | 3.14 |
| 2 | Initial Setting time | Vicat apparatus(IS 4031-Part 5) | 40 min |
| 3 | Normal Consistency | Vicat apparatus(IS 4031-Part 4) | 32 % |
| 4 | Fineness | Sieve test on sieve no.9 (IS 4031-part 11) | 3% |

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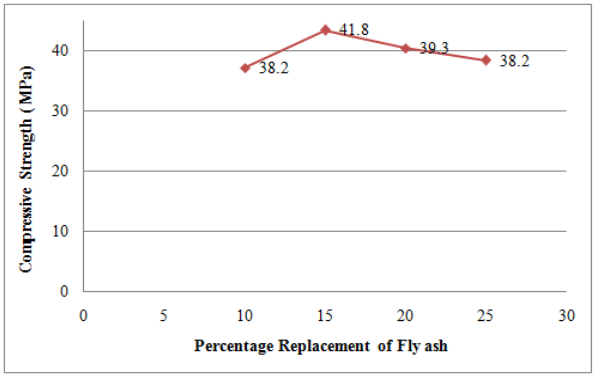
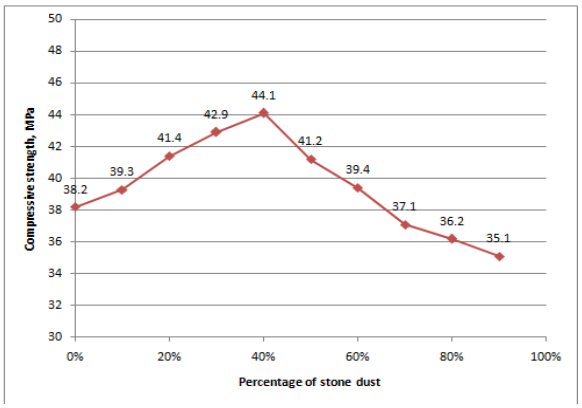
**Compressive Strength of Various Concrete Mixtures with Constant Micro Silica and Different Percentage of Fly Ash at Different Ages**

| S.No. | Mix ID | Compressive Strength (MPa) | |
|---|---|---|---|
| | | 7 days | 28 days |
| 1 | FASF00 | 22.0 | 37.3 |
| 2 | FASF108 | 22.2 | 38.2 |
| 3 | FASF158 | 25.8 | 41.8 |
| 4 | FASF208 | 24.4 | 39.3 |
| 5 | FASF258 | 23.1 | 38.2 |




**Compressive Strength of Normal Concrete Mix with different percentages of Stone Dust at Age of 28 Days**

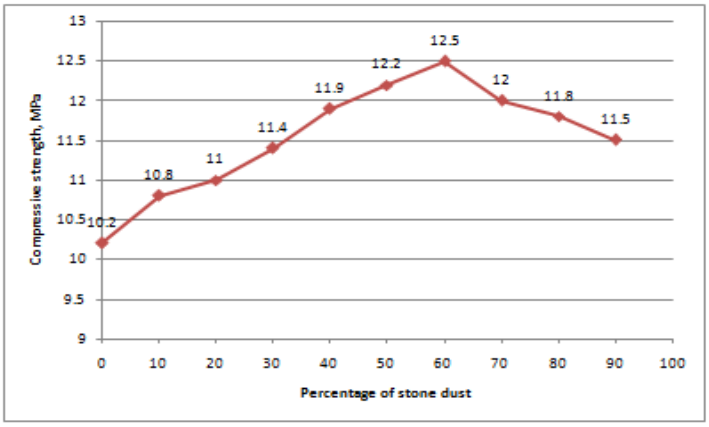
| No. | Mix Name | Cement % | Stone Dust % | Fine Aggregate (Sand) % | 28 Day Compressive Strength ( N/mm2) |
|---|---|---|---|---|---|
| 1 | FASF000 | 100 % | 0% | 100% | 38.2 |
| 2 | FASF0010 | 100 % | 10% | 90% | 39.3 |
| 3 | FASF0020 | 100 % | 20% | 80% | 41.4 |
| 4 | FASF0030 | 100 % | 30% | 70% | 42.9 |
| 5 | FASF0040 | 100 % | 40% | 60% | 44.1 |
| 6 | FASF0050 | 100 % | 50% | 50% | 41.2 |
| 7 | FASF0060 | 100 % | 60% | 40% | 39.4 |
| 8 | FASF0070 | 100 % | 70% | 30% | 37.1 |
| 9 | FASF0080 | 100 % | 80% | 20% | 36.2 |
| 10 | FASF0090 | 100 % | 90% | 10% | 35.1 |



**Weight Loss and Compressive Strength of Plain Concrete with different percentages of Stone Dust after dipping in 5% H2SO4 acid solution for 90 days**

| Mix Name | Sample No. | Cement % | Stone Dust % | Initial Weight Kg | Final Weight Kg | Average Weight Loss Kg | Average 90 Day Compressive Strength N/mm2 | % Weight Loss |
|---|---|---|---|---|---|---|---|---|
| FASF000 | 1 | 100 % | 0% | 2.400 | 1.30 | 1.100 | 10.2 | 45.66% |
| | 2 | | | 2.449 | 1.348 | | | |
| | 3 | | | 2.378 | 1.279 | | | |
| FASF0010 | 1 | 100% | 10% | 2.430 | 1.370 | 1.060 | 10.8 | 43.44% |
| | 2 | | | 2.441 | 1.382 | | | |
| | 3 | | | 2.450 | 1.389 | | | |
| FASF0020 | 1 | 100% | 20% | 2.465 | 1.471 | 0.994 | 11 | 40.29% |
| | 2 | | | 2.46 | 1.466 | | | |
| | 3 | | | 2.476 | 1.482 | | | |
| FASF0030 | 1 | 100% | 30% | 2.475 | 1.555 | 0.920 | 11.4 | 37.76% |
| | 2 | | | 2.415 | 1.495 | | | |
| | 3 | | | 2.420 | 1.500 | | | |
| FASF0040 | 1 | 100% | 40% | 2.486 | 1.594 | 0.892 | 11.9 | 35.72% |
| | 2 | | | 2.546 | 1.66 | | | |
| | 3 | | | 2.459 | 1.564 | | | |

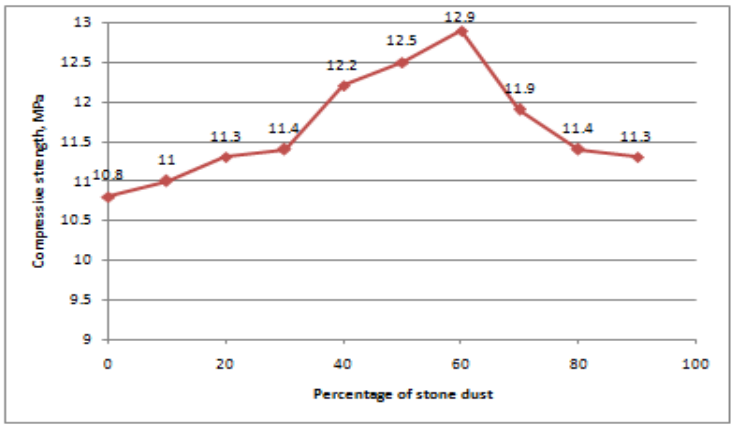
| Mix Name | Sample No. | Cement % | Stone Dust % | Initial Weight Kg | Final Weight Kg | Average Weight Loss Kg | Average 90 Day Compressive Strength N/mm2 | Weight Loss % |
|---|---|---|---|---|---|---|---|---|
| FASF0050 | 1 | 100 % | 50% | 2.435 | 1.585 | 0.850 | 12.2 | 33.62% |
| | 2 | | | 2.555 | 1.70 | | | |
| | 3 | | | 2.595 | 1.744 | | | |
| FASF0060 | 1 | 100 % | 60% | 2.415 | 1.595 | 0.820 | 12.5 | 33.22% |
| | 2 | | | 2.450 | 1.630 | | | |
| | 3 | | | 2.540 | 1.720 | | | |
| FASF0070 | 1 | 100 % | 70% | 2.565 | 1.705 | 0.860 | 12.0 | 34.15% |
| | 2 | | | 2.435 | 1.575 | | | |
| | 3 | | | 2.555 | 1.695 | | | |
| FASF0080 | 1 | 100 % | 80% | 2.495 | 1.605 | 0.890 | 11.8 | 36.28% |
| | 2 | | | 2.415 | 1.524 | | | |
| | 3 | | | 2.450 | 1.560 | | | |
| FASF0090 | 1 | 100 % | 90% | 2.486 | 1.586 | 0.900 | 11.5 | 36.54% |
| | 2 | | | 2.446 | 1.545 | | | |
| | 3 | | | 2.459 | 1.560 | | | |



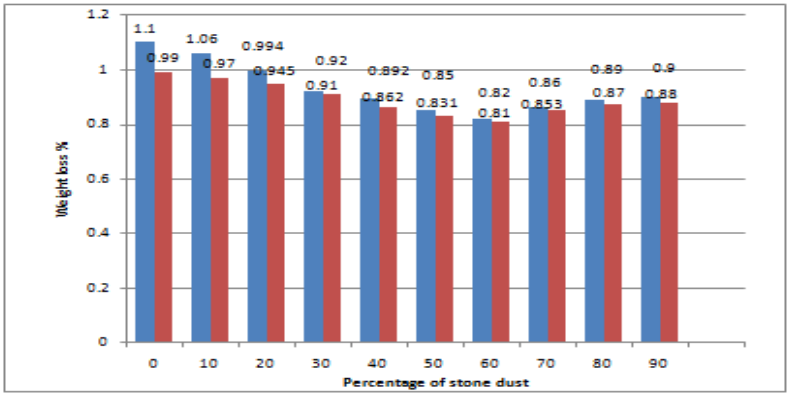
**Weight Loss and Compressive Strength of Ternary Concrete with various percentages of Stone Dust after dipping in 5% H2SO4 acid solution for 90 days.**

| Mix Name | Sample No. | Cement % | Stone Dust % | Initial Weight Kg | Final Weight Kg | Average Weight Loss Kg | Average 90 Day Compressive Strength N/mm2 | % Weight Loss |
|---|---|---|---|---|---|---|---|---|
| FASF1580 | 1 | 77 % | 0% | 2.430 | 1.441 | 0.99 | 10.8 | 40.16% |
| | 2 | | | 2.489 | 1.499 | | | |
| | 3 | | | 2.478 | 1.488 | | | |
| FASF15810 | 1 | 77% | 10% | 2.435 | 1.465 | 0.970 | 11 | 39.39% |
| | 2 | | | 2.441 | 1.471 | | | |
| | 3 | | | 2.510 | 1.540 | | | |
| FASF15820 | 1 | 77 % | 20% | 2.454 | 1.509 | 0.945 | 11.3 | 38.63% |
| | 2 | | | 2.405 | 1.460 | | | |
| | 3 | | | 2.479 | 1.534 | | | |
| FASF15830 | 1 | 77 % | 30% | 2.443 | 1.533 | 0.910 | 11.4 | 37.38% |
| | 2 | | | 2.454 | 1.544 | | | |
| | 3 | | | 2.406 | 1.496 | | | |
| FASF15840 | 1 | 77 % | 40% | 2.449 | 1.587 | 0.862 | 12.2 | 34.57% |
| | 2 | | | 2.556 | 1.694 | | | |
| | 3 | | | 2.474 | 1.612 | | | |

| Mix Name | Sample No. | Cement % | Stone Dust % | Initial Weight Kg | Final Weight Kg | Average Weight Loss Kg | Average 90 Day Compressive Strength N/mm2 | % Weight Loss |
|---|---|---|---|---|---|---|---|---|
| FASF15850 | 1 | 77 % | 50% | 2.510 | 1.678 | 0.831 | 12.5 | 33.66% |
| | 2 | | | 2.464 | 1.633 | | | |
| | 3 | | | 2.432 | 1.601 | | | |
| FASF15860 | 1 | 77% | 60% | 2.530 | 1.72 | 0.810 | 12.9 | 32.3% |
| | 2 | | | 2.541 | 1.73 | | | |
| | 3 | | | 2.450 | 1.639 | | | |
| FASF15870 | 1 | 77 % | 70% | 2.365 | 1.512 | 0.853 | 11.9 | 35.23% |
| | 2 | | | 2.443 | 1.589 | | | |
| | 3 | | | 2.454 | 1.601 | | | |
| FASF15880 | 1 | 77 % | 80% | 2.499 | 1.629 | 0.870 | 11.4 | 35.46% |
| | 2 | | | 2.421 | 1.551 | | | |
| | 3 | | | 2.439 | 1.569 | | | |
| FASF15890 | 1 | 77 % | 90% | 2.532 | 1.653 | 0.88 | 11.3 | 36.2% |
| | 2 | | | 2.546 | 1.666 | | | |
| | 3 | | | 2.459 | 1.579 | | | |




**A Comparative account of the difference of weight loss in both Plain as well as Ternary cement concrete ; having different percentages of stone dust after 90 Days in 5% H2SO4 solution.**



## VI.CONCLUSIONS

From the experimental investigations on compressive strength of concrete containing stone dust, micro silica and fly ash the following conclusions are drawn.

- Optimum percentage of concrete mix containing micro silica and fly ash as partial replacement of cement was found to be 8% and 15% respectively.
- Using stone dust as 40% replacement of fine aggregate in a Plain concrete mix, the compressive strength increases by around 13.37%.
- The optimum value of Stone dust for Ternary concrete containing 15% fly ash and 8% silica fume is 50%, with respect to the compressive strength. It was observed here that using this percentage of Stone Dust increases the compressive strength by around 12.61% over Plain concrete containing 100% cement.
- Also, 60% replacement of sand by stone dust provides for the best acid attack resistance for both Plain as well as Ternary concrete containing 15% fly ash and 8% silica fume.

**Inferring statement**

- From the above conclusions it is observed that optimum combination of micro silica, fly ash and stone dust marginally improves compressive strength and acid attack resistance.

**Scope for Further Investigations**

- Further research can be carried out to study the compressive strength and acid attack of concrete with partial replacement of different mineral admixtures like GGBS, rice husk etc, in different proportions or in tandem, thereby making the mix binary, ternary or quaternary.

- The investigation on compressive strength and acid attack of concrete with various admixtures, in addition to different types of fibres.

- The investigation on other aspects like permeability, shear strength, acid resistance for different concentrations of acids, etc of ternary blended concrete can be carried out.

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