Comparative Study on Properties of High Strength Cement Concrete by Partial Replacement of Cement with Marble Powder & Silica Fume

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Abstract - The use of Marble Powder and Silica Fume in the present days is to increase the strength of cement concrete. In this research Compression of the two materials one is Marble Powder and another is Silica Fume. Is this study there are two content are involved, first is that The silica fume are replace by 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% and 25% and Marble Powder are replace by 10% common for all mixes as a partial replacement of cement for 7, 14 & 28 days for M30, and M40 grade of concrete. Second is that the Marble Powder are replace by 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% and 25% and Silica fume was replace by 10% common for all mixes as a partial replacement of cement for 7, 14 & 28 days for M30, and M40 grade of concrete. Casted 150 mm X 150 mm X 150 mm cubes for Compressive strength, 100 mm X 100 mm X 500 mm beams for Flexural Strength, and Slump cone for workability of concrete and other properties like compacting factor and slump were also determined for three mixes of concrete. The use of cement and production of cement creates much more environmental issues & costlier. To avoid such circumstances, the content of cement is reduced in concrete and replaced by silica fume which reduces cost & addition silica fume also increases strength. Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, Strength, Resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of admixtures, which improve the micro structure as well as decrease the calcium hydroxide concentration by consuming it through a pozzolanic reaction. The subsequent modification of the micro structure of cement composites improves the mechanical properties, durability and increases the service-life properties.

***Key Words*: Compressive Strength, Flexural Strength, Workability of Concrete, Marble Powder and Silica Fume.**

1. INTRODUCTION

Concrete is a most commonly used building material which is a mixture of cement, sand, coarse aggregate and water. It is used for construction of multi-storey buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of harden concrete is commonly considered to be an index of its extra properties depends upon a lot of factors e.g. worth and amount of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete prepared by the cost of materials plant and labour the variation in the cost of material begin from the information that the cement is numerous times costly than the aggregates thus the intent is to produce a mix as feasible from the practical point of view the rich mixes may lead to high shrinkage and crack in the structural concrete and to development of high heat of hydration is mass concrete which may cause cracking. The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength called characteristic strength that is specific by designer of the structures. This depends on the quality control measures but there is no doubt that quality control add to the cost of concrete. The level of quality control is often an inexpensive cooperation and depends on the size and type of job nowadays engineers and scientists are trying to enhance the strength of concrete by adding the several other economical and waste material as a partial substitute of cement or as a admixture fly ash, Marble Powder, steel slag etc. are the few examples of these types of materials. These materials are generally by-product from further industries for example fly ash is a waste product from power plants and Marble Powder is a by-product resulting from decrease of high purity quartz by coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys but nowadays Marble Powder is used in large amount because it enhances the property of concrete.

1.1 CEMENT

Ordinary Portland cement is used to prepare the mix design of M-30 & M40 grade. The cement used was fresh and without any lumps Water – cement ratio is 0.40 for this mix design using IS 456:2007.Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO_2), 3-8% Alumina (Al_2O_3), 0.5-6% Iron Oxide (Fe_2O_3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO_3), 0.5-3% Soda And Potash (Na_2O+K_2O).

1.2 SAND

Sand is a naturally occurring coarse material collected of finely separated rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand may also consign to a textural class of soil or soil type; i.e. a soil contain more than 85% sand-sized particle (by mass).In terms of particle size as used by geologists, sand particle range in diameter as of 0.0625 mm to 2 mm. An individual particle in this range size is termed a *sand grain*. Sand grains are among gravel (with particles ranging from 2 mm up to 64 mm) and silt (particles smaller than 0.0625 mm down to 0.004 mm). The dimension specification between sand and gravel has remained even for other than a century, but particle diameter as small as 0.02 mm be considered sand under the Albert Atterberg standard in utilize during the early on 20th century.

1.3 AGGREGATE

Aggregate are the essential constituent in concrete. They provide body to the concrete, decrease shrinkage and effect economy. Construction aggregate, or basically "Aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geosyenthetic aggregates. Aggregates are the mainly mine material in the world. Aggregates are an element of composite materials such as concrete and asphalt concrete; the aggregate serve as reinforcement to add strength to the overall combined material. Due to the comparatively high hydraulic conductivity value as compare to most soils, aggregates are generally used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates used as support material under foundations, roads, and railroads.

1.4 MARBLE POWDER

Marble dust is a waste product formed during the production of marble. A large quantity of powder is generated during the cutting process. Marble dust, a solid waste material generated from the marble processing can be used either as a filler material in cement or fine aggregates while preparing concrete.

1.5 SILICA FUME

Silica fume is a by-product in the decrease of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys. Micro silica consist of fine particle with a surface area on the order of 215,280 ft�/lb (20,000 m�/kg) when precise by nitrogen adsorption techniques, with particle just about one hundredth the size of the average cement Because of its excessive fineness and high silica content, micro silica is a very efficient pozzolanic material particle. Micro silica is added to Portland cement concrete to enhance its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvement stems from both the mechanical improvements resulting from addition of a extremely fine particle to the cement paste mix as well as from the pozzolanic reactions between the micro silica and liberated calcium hydroxide in the paste. Addition of silica fume also decrease the permeability of concrete to chloride ions, which protect the reinforcing steel of concrete from corrosion, especially in chloride-rich environment such as coastal region. While silica fume is incorporated, the rate of cement hydration increases at the early hours due to the liberate of OH �ions and alkalis into the pore fluid. It has been reported that the pozzolanic reaction of silica fume is very significant and the no evaporable water content decreases between 90 and 550 days at low water /binder ratios with the addition of silica fume.

2. LITERATURE REVIEW

Zhang etal (2018) Aim of their study was to investigate the effect of silica fume in paste, mortar and concrete by determining the non-evaporable water content of pastes, the compressive strengths of pastes, mortars and concretes containing 5% and 10% raw silica fume or dandified silica fume with water-to-binder ratios (W/B) of 0.29 and 0.24. Their results showed that silica fume can significantly increase the hydration degree of paste. It was shown that the addition of silica fume increase the compressive strengths of hardened pastes, mortars and concretes. It was also shown that the strength activity index of dandified silica fume in concrete is the highest while that in paste is the lowest. The agglomeration of silica fume has been found in blended paste which is hardly seen in concrete. The silica fume can improve the interface bond strength between hardened cement paste and aggregate. The crystalline orientation degree, the crystalline size and the content of calcium hydroxide at the interface are obviously decreased by adding silica fume. The different dispersion and the improvement of the interfacial transition zone are the main factors causing the different role of silica fume in paste, mortar and concrete.

Khan and Abbas (2017) evaluated the influence of hot weather conditions and subsequent curing requirements on the strength and durability of multi-cementations concrete. They considered five curing schemes using persistent moist curing for various ages followed by exposure to natural hot weather conditions. It was observed that curing in hot weather tended to increase the initial strength of ternary blended concrete for up to 28 days; however, the development of long-term strength had insignificant effect. Binary blended concrete with silica fume (SF) exposed to hot weather have higher early age strength development compared to those under standard curing. The compressive strength and permeability of concrete was more sensitive to hot weather curing at an early age as its fly ash (FA) content increased. However, the effects of curing age diminished with high FA content and the susceptibility of long-term strength to hot weathering decreased as SF content increased. The porosity of concrete cured with continuous moistening was lower compared to those under hot weathering. The chloride permeability of binary blended concrete containing SF was less affected by hot weather curing. Using numerical models, it was found that the optimized persistent moist curing age for concrete without SF was dependent on target strength and durability requirements.

Okoye etal(2017) In their paper, the effect of silica fume on durability properties of fly ash based geopolymer concrete have been investigated by immersing the cubes in 2% sulphuric acid and 5% sodium chloride solutions. The resistance of specimens to chemical attack was evaluated visually by measuring change in the weights and percent losses in compressive strength at different intervals of time. A control mix M40 was also cast with ordinary Portland cement concrete for comparison. Percent losses in compressive strengths in the case of control (M40) and MPC3 in 2% H2SO4 at 90 days were found 36% and 8%. Percent losses in compressive strengths in the case of control (M40) and MPC3 in 5%NaCl at 90 days were 18% and about 0%.Thus the resistance of geopolymer concrete incorporating silica fume in sulphuric acid and chloride solution was significantly higher than that of the control.

Khodabakhshian etal (2017) Carried out an experimental investigation of durability properties carried out with 16 concrete mixes containing marble waste powder and silica fume as partial replacement of ordinary Portland cement. The latter was partially replaced at different ratios of silica fume (0%, 2.5%, 5%, and 10%) and marble waste powder (0%, 5%, 10%, and 20%). In all concrete mixes, constant water/binder ratio of 0.45 was kept with and target initial slump of S2 class (50e90 mm). Workability and bulk density tests were carried out on fresh concrete, while compressive strength, electrical resistivity, water absorption, durability to sodium sulphate, magnesium sulphate and sulphuric acid attack tests were performed to evaluate few relevant properties of concrete in the hardened state.

3. OBJECTIVE

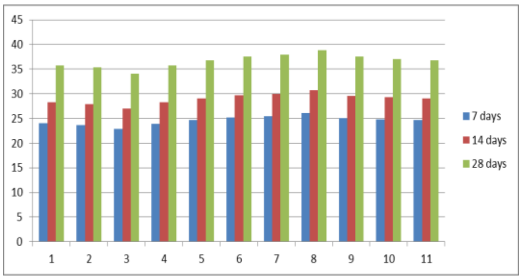
1) To determine the comparative study of marble powder and silica fume.
2) To determine the Workability of concrete with and without Silica fume and marble powder in different proportions at different grade.
3) To determine the Compressive Strength of concrete with and without Silica fume and marble powder in different proportions at different grade.
4) To determine the Split Tensile Strength of concrete with and without Silica fume and marble powder in different proportions at different grade.
5) To determine the Flexural Strength of concrete with and without Silica fume and marble powder in different proportions at different grade.
6) To find the optimum percentage of silica fume and marble powder for obtaining the maximum strength of concrete.
7) Comparative study of the behaviour of the concrete with & without silica fume and marble powder.

4. METHEDOLOGY AND RESULT

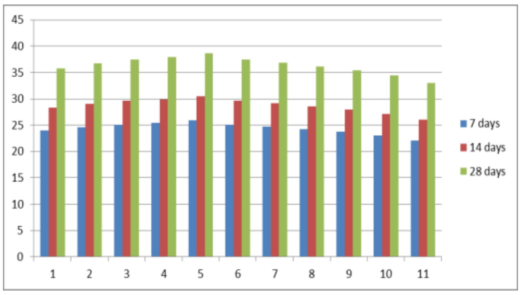
4.1 Compressive Strength Test

The test was conducted on cubes of size 150mm x 150mm x 150mm (for concrete and mortar) specimens were taken out from curing tank at the age of 7, 14, and 28, days of curing. Surface water was then allowed to drip down. Specimens were then tested on 200 tones capacity Compression Testing Machine (CTM). The position of cube while testing was at right angles to that of casting position. Axis of specimens was carefully aligned with the center of thrust of the spherically seated plates. The load was applied gradually without any shock and increased at constant rate of 3.5 N/mm^2/minute until failure of specimen takes place. The average of three samples was taken as the representative value of compression strength for each batch of concrete. The compressive strength was calculated by dividing the maximum compressive load by the cross sectional area of the cube specimens. Thus the compressive strength of different specimens was obtained.

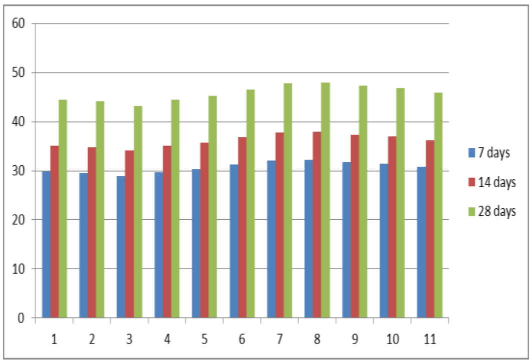
Graph: For all curing days of M30 with replacement of SF & Constant MP



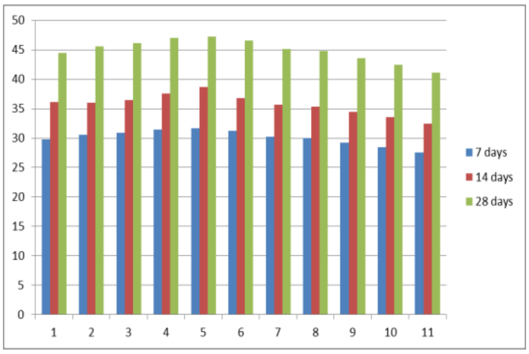
Graph: For all curing days of M30 with replacement of MP & Constant SF



Graph: For all curing days of M40 with replacement of SF & Constant MP



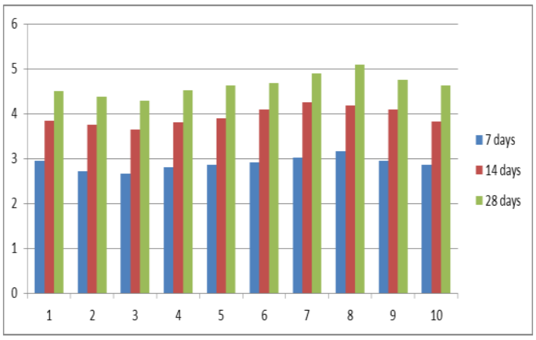
Graph: For all curing days of M40 with replacement of MP & Constant SF



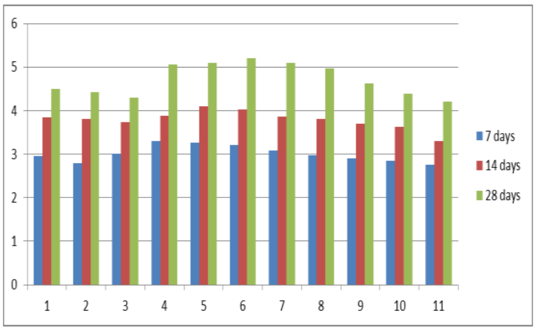
4.2 Split Tensile Strength Test

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7,14 &28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in Table below. Variation of splitting tensile strength of all the mixes cured at 7,14 &28 days is also shown in Fig. Shows the variation of splitting tensile strength of concrete mixes w.r Table 4.3 Splitting tensile strength (MPa) results of all mixes at different curing ages.

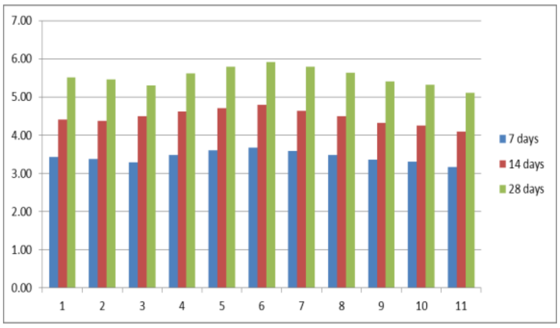
Graph: For all curing days of M30 with replacement of SF & Constant MP



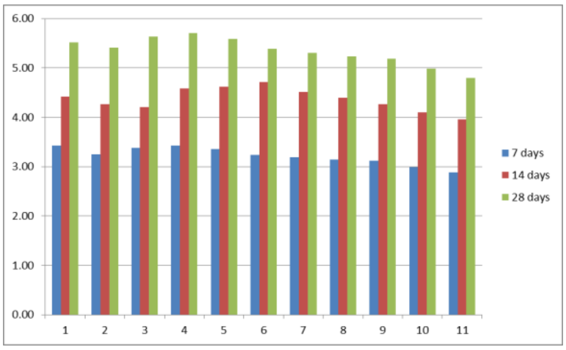
Graph: For all curing days of M30 with replacement of MP & Constant SF



Graph: For all curing days of M40 with replacement of SF & Constant MP



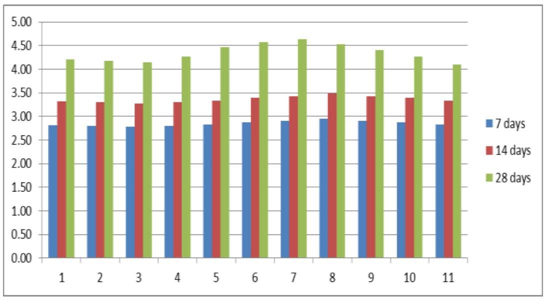
Graph: For all curing days of M40 with replacement of MP & Constant SF



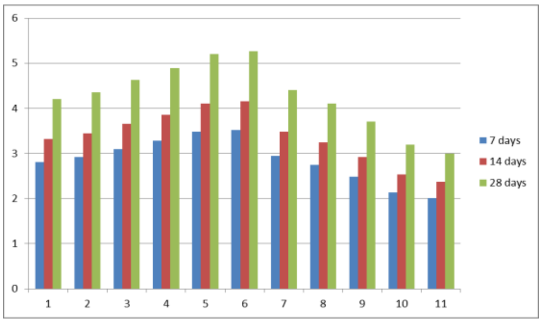
4.3 Flexural Strength Test

The results of the Flexural strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The Flexural strength tests were conducted at curing ages of 7, 14, and 28, days. The Flexural strength test results of all the mixes at different curing ages are given in Table. Variation of Flexural strength of all the mixes cured at 7, 14, and 28, days are also shown in Graph. Shows the variation of Flexural strength of concrete mixes w.r.t control mix (100%OPC+0%SF) after 7, 14, and 28, days respectively.

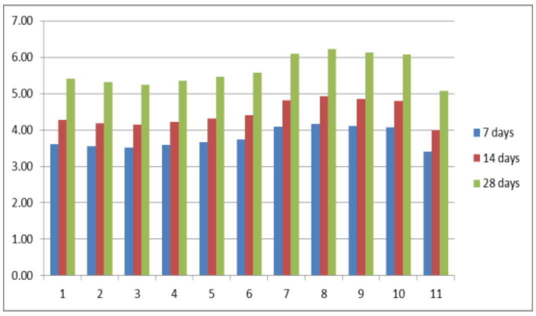
Graph: For all curing days of M30 with replacement of SF & Constant MP



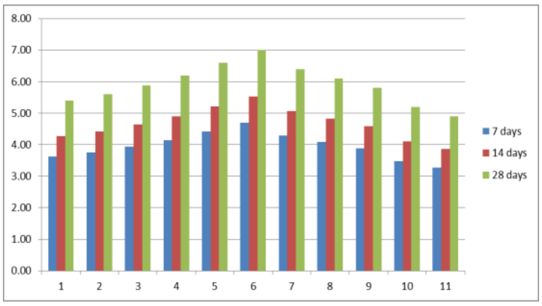
Graph: For all curing days of M30 with replacement of MP & Constant SF



Graph: For all curing days of M40 with replacement of SF & Constant MP



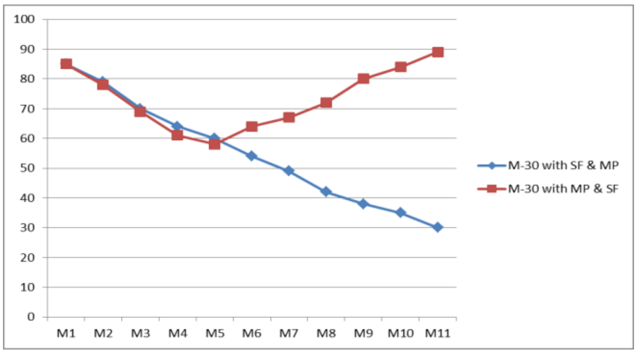
Graph: For all curing days of M40 with replacement of MP & Constant SF



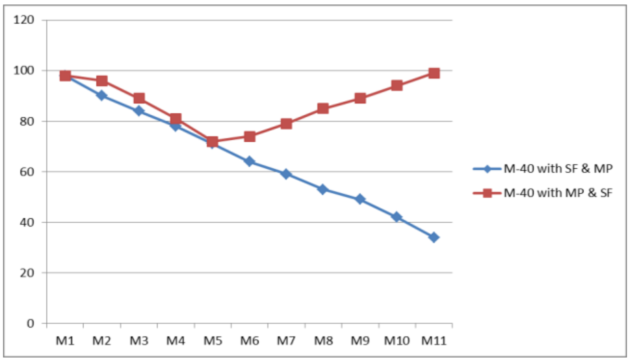
4.4 Workability of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure given in chapter 3. Water cement ratio (W/c) was kept constant 0.4 for all the concrete mixes. The workability results of different concrete mixes were shown in graph.

Graph: Combined Workability of M30 grades concrete



Graph: Combined Workability of M40 grades concrete



i) above results strength is varying due to composition of **Silicon** dioxide (SiO_2).

ii) In ordinary Portland cement the percentage of SiO_2 is less as compare to silica fume.

iii) In SF the percentage of SiO_2 is more than 85% so the compressive strength will increase at BM(8) when we add (72.50%OPC + 17.50%SF +10%MP) after that strength will start decreasing due to low composition of calcium oxide in OPC.

iv) In MP SiO_2 content is less as compare to SF when we replacement MP and constant SF the strength should start decreasing at BM (6) (77.50%OPC + 12.50% MP +10%SF) due to low content of SiO_2 the graph falling downward.

v) When equal and require percentage are not matched at each level the strength should be decreasing & when equal and require percentage are matched at particular level the strength should be increasing.

vi) SF is much finer than MP this is another reason to increase strength.

5. CONCLUSIONS

Compressive strength, and Flexural strength test of concrete Mixes made with and without silica fume and marble powder has been determined at 7, 14, & 28 days of curing. The strength gained has been determined of silica fume added concrete with addition of 2.50%, 5%, 7.5%, 10%, 12.5% 15%, 17.50%, 20%, 22.50%,&25% and Marble Powder 10% replaced common for all mixes of M30, and M40 grade as a partial replacement of cement in conventional concrete. From the results it is conclude that the silica fume and Marble powder are a superior replacement of cement. The rate of strength increase in silica fume concrete is high. After performing all the tests and analyzing their result, the following conclusions have been derived:

Stage-1

- The results achieved from the existing study shows that silica fume is great potential for the utilizationin concrete as replacement of cement as compare to marble powder.
- Workability of concrete decreases as proportion of silica fumes increases. But we increase MP % increase workability.
- Maximum compressive strength was observed when silica fume replacement is about 17.50% (BM-8) and Marble powder is 10%, (constant amount) M-30&M-40
- Maximum Flexural strength was observed when silica fume replacement is about 15.50% (BM-7) and Marble powder is 10%. (constant amount) M-30 & M-40
- Maximum Split Tensile strength was observed when silica fume replacement is about 17.50% (BM-8) and Marble powder is 10%, (constant amount) M-30&M-40

Stage-2

- Maximum compressive strength was observed when Marble powder replacement is about 10% (BM-5) and silica fume is 10%, (constant amount) M-30 & M-40.
- Maximum Flexural strength was observed when Marble powder replacement is about 12.50% (BM-6) and silica fume is 10%. (constant amount) M-30 & M-40.
- Maximum Split Tensile strength was observed when Marble powder replacement is about 12.50% (BM-6) and silica fume is 10%, (constant amount) M-30&M-40.

6. FUTURE SCOPE

From this research, there are few recommendations to develop, to extend and to explore the usage of silica fume in concrete:

i.) Define the effect of silica fume and Marble powder on concrete with the replacement of mixture of coarse and fine aggregate.

ii.) Replacement of cement with silica fume and Marble powder in different water cement ratio.

iii.) Selected few samples of concrete with different percentage of using silica fume and conclude the most suitable percentage of usage to achieve the optimum compressive strength and Flexural Strength.

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