



Strength of Concrete using waste products-A Literature

Altaf Ahmad Reshi
(M.Tech,CT &M)

Gurukul Vidyapeeth IET, Civil Engg Deptt. Banur, Panjab, India

Sameer Malhotra
Assistant Professor

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ABSTRACT

Due to high strength, durability, economy and better serviceability there is a growing interest in the construction of concrete structures such as pavements. The main concentration nowadays is towards the production of thinner and green pavements of good quality which can sustain much heavier loads. High strength steel fibre concrete is a concrete that possesses strength greater than 40 MPa and is made of hydraulic cement, fine and coarse aggregates and unconnected, discontinuous, randomly distributed steel fibres.

The aim of this study was to develop pavement quality control mixture including marble dust as a partial replacement of cement as well as admixtures. In this study, the flexural, compressive and split tensile strength for pavement quality concrete mixture for different percentage of steel fibre and replacement of cement with marble dust were reported. For 1% steel fibre and 0% marble dust, increase in compressive strength, flexural strength and split tensile strength is maximum. Also it has been made possible to achieve savings in cement by its replacement with marble dust and additional fibres.

This study also reveals that in view of higher values of split tensile strength, flexural strength, compressive strength, higher life expectancy and higher load carrying capacity, the combination of 20% marble dust with addition of 0.5%-1% steel fibre is ideal for a rigid pavement that has the above mentioned characteristics.

1. INTRODUCTION

The word concrete originated from the Latin word "concretus" (meaning condensed or compact). In the times of Roman Empire, roman concrete was manufactured using pozzolana, quicklime, and an aggregate of pumice. Concrete is a construction material composed primarily of cement, aggregate, and water. These are the properties which vary according to different formulations. The aggregate is in general coarse gravel or crushed rocks as, granite or limestone along with sand as fine aggregate.

The cement, generally Portland Pozzolana cement and other cementitious materials such as slag cement and fly ash serve as a binder for the aggregate. To achieve varied properties, various chemical admixtures are also added. Mixing of this dry composite with water enables it to be shaped (typically poured) and then harden and solidify into rock-hard strength through a chemical phenomenon known as hydration. The water reacts with the cement and bonds the other components together, eventually creating a rigid stone like material. Concrete has generally high compressive strength. For this reason it is mainly reinforced with materials that are strong in tension (for example steel).

1.1 DEFINITION OF HIGH STRENGTH CONCRETE

The definition of high strength concrete (HSC) varies on the basis of geography. In general, HSC may be defined as concrete which enhances the compressive strength properties which may not be easily obtained with the use of local materials and practices. However, the ACI (American Concrete Institute) Committee defines HSC of normal weight aggregates having 28 days cylinder compressive strength equal to 41MPa or greater in un-axial test (ACI 363 R-84). High strength concrete is a relative term which can be defined accordingly to, contemporary, requirement and technology.

1.2 MATERIALS

Effective production of high strength concrete should be achieved by carefully selecting, inspecting, controlling and proportioning of all concrete making materials.

1.2.1 Cement

The production and enhancement of HSC requires the utilisation of a Portland cement of optimum quality from strength and workability point of view. Any Variation in cement causes the concrete's compressive strength to change or alter more than any other single material. Following are the physical properties that are required for cement to be used in HSC:

Maximum Blaine fineness: 4000cm²/gm

Minimum 7 days mortar cube strength: 28.959 MPa

Mortar air content: 7 to 10 %

1.2.2 Other Cementitious Materials

The cementitious materials other than Ordinary Portland cement, commonly consists of fly ash or silica fume, which have been considered as the auxiliary components in the production of High Strength concrete (HSC) because as per the need high cementitious materials content and low W/(C+P) ratio (W = water content, C = cement content, P = pozzolona cement). These materials can help resist the temperature rise in concrete at early stages and can reduce the water requirement for given workability. On the other hand the early strength gain of concrete may reduce in this case considerably.

1.2.3 Water- cement ratio

The acceptability of water for High Strength Concrete (HSC) is not major problem if potable type water is used. The evolution of High Strength concrete (HSC) requires a w/c (water-cement) ratio in the range of 0.30 to 0.40 as per IS guidelines for rigid pavement. The following are the maximum w/c (water-cement) ratio is necessary to produce the High Strength Cement (HSC) in the range of 41.38MPa to 62.07MPa.

Strength Specified Max. W/c ratio

41.38MPa 0.38

51.78MPa 0.36

62.07MPa 0.34

1.2.4 Coarse Aggregate

Coarse aggregates make up the major proportion of a concrete mixture. Sand natural gravel and crushed stone are used mainly for this purpose. Careful consideration should be adopted at the time of giving proper size, shape, mineralogy and surface texture of aggregates. High strength aggregates are not suitable for concrete because of their very high modulus of elasticity as compared with the modulus of a cement paste, due to this contrary stress concentrations occur which damages the concrete in mechanical behavior. The presence of aggregate greatly increases the robustness of concrete above that of cement, which otherwise is a breakable material and thus concrete is a true composite material.

It was observed that the size of coarse aggregate control the concrete strength apart from W/c ratio. For a given W/c ratio, the strength of concrete decreases as the maximum size of coarse aggregates increases. It was also observed that for optimum compressive strength with high cement contents and low water cement ratio, the maximum size of coarse aggregate should be kept minimal at the rate of 12.5 mm or 9.5 mm. "It was suggested that ideal aggregate should be cubical, angular, clean 100 % crushed and continuously graded with a minimum of elongated and flat particles".

1.2.5 Fine Aggregate

The grading of fine aggregate regulate the workability of concrete at a particular water content of the concrete mix as the surface of these fine aggregates is relatively much higher than that of coarse aggregates. Sand which has fineness modulus below 2.5 produces concrete to sticky consistency due to this sticky behavior it is very difficult to compact. However Sand which has fineness modulus of about 3.0 gave the optimum compressive strength and workability. Fine aggregate with fineness modulus in the range of 2.5 to 3.2 is suitable for production of High Strength concrete (HSC).

1.2.6 Admixtures

An admixture is a material added to the particular batch of concrete before or during its mixing to modify its fresh, setting, mixed or hardened properties. About 80.00% of concrete produced in North America have one or more admixtures. About 40.00 % of ready-mix producers use fly ash. About 70.00% of concrete produced contains a water-reducer admixture. One or more admixtures can be added to a mix to achieve the desired results. The main reasons for using admixtures are as enumerated below:

- Increases workability and slump;
- Retards or accelerate initial setting time;
- Reduces or prevents shrinkage;
- Modifies the rate or capacity of bleeding;
- Foaming as Coagulation; and
- Produces colored concrete.

2. PROBLEM IN PRODUCING HIGH STRENGTH CONCRETE

(a) Superplasticizers are used to attain necessary slump keeping water/cement ratio low. But due to diffusive action of superplasticizers, more surface area of cement comes in contact with water. Hence hydration of cement can take place more rapidly, resulting in higher slump loss. Due to this reason, some amount of superplasticizers is added at the mixing plant and remaining portion is added just before concreting at the site.

(b) There is some difficulty in entraining 5 to 7% air in concrete with high cement contents and incorporating 20 to 30% silica fume.

(c) Higher cement contents and lower water contents have produced concrete of higher strengths. By proportioning water demand in the mixture increases due to large amount of cement in the concrete mix. A high percentage of cement could give rise to massive heat by pozzolona (silica fume, fly ash etc.) to control heat of hydration.

3. APPLICATION OF HIGH STRENGTH CONCRETE

All over the world Engineers, Architects and Designers have considered the use of higher strength of concrete in their structure from time to time. HSC is very well known for its properties like corrosion resisting property and durable property than the normal concrete.

Higher Compressive Strength of concrete gives a higher modulus of elasticity. It maintains a higher tensile stress and reduces specific creep. HSC is used for casting of columns in high rise buildings which is now used for wider range of member types like

- (a) Bridges
- (b) Monorail piers
- (c) Concrete launch pad
- (d) Chimney
- (e) Pre-stressed concrete sleeper
- (f) Shear walls of high rise building and High-rise building column

4. STEEL FIBRE REINFORCED CONCRETE

4.1 Definition

Fibre reinforced concrete is represented by combination of four different phases, like cement, water, coarse aggregate, fine aggregate and a dispersion of discontinuous steel fibres. It can also contain admixtures and pozzolans which are commonly used with the conservative concrete. All admixtures under the ASTM specifications for use in concrete are desirable for use in Steel Fibre Reinforced Concrete (SFRC).

4.2 Fibre Content

Various amount of fibre is added in concrete which is generally measured as a fraction of total volume of mortar.

4.3 Properties of Fibre Reinforced Concrete

a) Workability: An increase in the fibre content or the aspect ratio of the fibres, the workability decreases. The balling effect of fibres, segregation of the mix and bleeding during placing a compaction affects the strength and other properties of the concrete. The workability of steel fibre reinforced concrete will totally depend on the percentage of the fibres, size and volume of the aggregates and at last but not least the aspect ratio of fibres.

b) Effect on the size and volume of the aggregate: It has been observed that uniform distribution of fibre is more difficult as the size of aggregate increases from 5 to 10 mm. Fibre interaction will be more if the size and volume of the coarse aggregate is more. A satisfactory fibre concrete should contain a mortar volume of about 70 percent with only about 30 percent consisting of particles between 5 mm to 10 mm.

c) Effect of Aspect Ratio: It is determined that the workability of fibre loading is affected which is directly related to the aspect ratio of the fibres. With increase in the aspect ratio of the fibres, the workability decrease for a given fibre content. Normally aspect ratio i.e. l/d ratio ranges from about 20 to 100, while dimension of length ranges from 6.4 to 76 mm.

d) Compressive Strength: Due to the addition of fibre content, the compressive strength increases varying ranging from negligible to 20 percent and ranging from 0 to 15 percent for up to 1.5 percent by volume of fibres.

e) Flexural strength: It is determined that it is considerable increase with the use of short, small diameter of the steel fibre in the first crack ultimate flexural strength and flexural strength of plain concrete. With the use of steel fibre, the ultimate strength can be increased up to 3 times the strength of plain concrete. It is found that in the normal third-point bending test, the flexural strength of SFRC is about 50 to 70 percent more than that of the plain concrete mix.

f) Flexural Toughness (energy absorption): The advantage of adding fibre in fibre reinforced concrete (FRC) is that it improves its flexural toughness i.e. the total energy absorbed in breaking a specimen. It is examined that with the addition of 0.5 percent volume fraction of steel fibres in concrete mix, it increases 3.5 times in the number of blows to failure at 28 days as comparison with plain cement specimens.

5. APPLICATION OF FIBRE REINFORCED CONCRETE

Steel fibre reinforced concrete (SFRC) is a concrete that contains diffused steel fibres. The most important regulation of steel fibres in concrete is to control and retard the tensile cracking of the composite material. The steel fibre reinforced concrete improves the strength characteristics like flexural strength, split tensile strength, strain capacity, flexural toughness, compressive strength and crack arrest properties which lead to use in highway and airfield pavements, overlays and bridge deck slabs. Some of the practical applications of steel fibre reinforced concrete include usage in thin shells and walls, concrete pipes, highway pavements, partially pre-stressed composite concrete beams, airport runways, high velocity passages, blast resistance structures, water retaining structures, marine structures etc.

6. REPLACEMENT MATERIAL IN CONCRETE

In building industry, Marble has been used very commonly as a building material since the olden times. The disposal of the marble powder or dust material, consisting of very fine powder, constitutes one of major environmental problems around the world. Marble blocks are blended into smaller blocks in order to give them the required fine shape.

In India, marble dust is settled by process of sedimentation and then is dumped away, which results in environmental deterioration, in addition to forming dust in summers and giving threats to both agriculture and public health. Therefore, use of the marble dust in various industrial sectors especially the, agriculture, construction, glass and paper industries would help to secure the environment. Considering for instance, certain residues such as marble sludge from stony material manufacturing and cement kiln dust are characterized by an average diameter. This important characteristic makes them potential candidates for use in the production of self-compacting concretes (SCCs) and self-leveling mortars (SLMs). These can be compacted under their own sustained self-weight, with no external act, providing a considerable saving in energy and time.

The utility of the waste material recovery process is particularly controlled by the simultaneous satisfaction of the technical, economic and normative aspects for each field of use. Once the economic convenience has been assessed, it is necessary that the experimentation must verify that the physicochemical characteristics attained after treatment are applicable to the specific project solutions for which they are intended.

7. OBJECTIVE OF THE STUDY

In this study an attempt is made to find the effect of various additives on paving concrete. The objectives of the proposed work can be summarized as follows:

- The main objective of the proposed work is to read the effect of steel fibres on strength characteristics like compressive strength, split tensile strength and flexural strength of Rigid Pavement Quality Concrete.
- Additionally, the effect of partial replacement of cement by marble dust has also been proposed to be studied in this dissertation.
- Moreover, the behavior on addition of both Marble Dust and Steel Fibre in Concrete for various conditions and cases has also to be studied.

8. CONCLUSIONS

Cement was partially replaced by marble dust at three different levels of replacement i.e. 0%, 10% and 20% by weight of cement and steel fibre is added in by the volume of the concrete mix at different percentage i.e. 0%, 0.5% and 1%. Tests were performed after 28 days of curing of concrete. Various samples of reference mix i.e. with 0% marble dust and 0% steel fibre and samples of marble dust and steel fibre in concrete with different percentage were prepared for determining flexure strength, compressive strength and split tensile strength of concrete with different water-cement ratio as 0.30 for 5.5 N/mm², 0.35 for 5 N/mm² and 0.40 for 4.5N/mm² (Target Mean Flexure Strength).

Super-plasticizer was used in all the mixes at 1% level by weight of cementious

material. From the experimental results carried out with different samples and with varying ratios of contents the following conclusion can be drawn:

Strength Characteristics

- Concrete mix similar to grade M20, with 10 percent marble dust as replacement of cement by weight in its composition is the optimum level as it has been observed to show a significant increase in compressive strength up to 10% at water cement ratio 0.40 at 28 days curing when compared with nominal mix without marble dust and Concrete mix prepared in the study that is nearly similar to grade M20 when reinforced with steel fibre up to 1% shows an increased compressive strength of 53.2% at water cement ratio of 0.30 as compared to nominal mix without the steel fibres.
- The split tensile strength also tends to increase with increase percentages of steel fibres in the mix up to 50% with use of 1% steel fibres for water/cement ratio of 0.30 and also tends to increase up to 10% when 10 percent of marble dust as replacement of cement by weight is induced in the concrete mix. On increasing the percentage replacement of cement with marble dust beyond 10%, there is a slight reduction in split tensile strength.
- The flexure strength also tends to increase up to 25% with the increase percentages of steel fibres up to 1%, a phenomenon similar to increase in split tensile strength and compressive strength, whereas in case of marble dust when added to concrete mix, the percentage flexure strength reduces.

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