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Review Paper on A Study on Strength Properties of Rigid Pavement Concrete with Use of Steel Fibers and Marble Dust

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Abstract
This paper depicts ongoing researches about the study of rigid pavement concrete strength using steel fibre and Marble dust. Many analysis pertaining to steel fibre reinforced concrete and Marble dust were studied, and their effects were also laid down to a particular conclusion. The conclusion that was drawn out of these studies was that the compressive strength showed an immense increase on use of steel fibre and Marble dust in the rigid pavement concrete, where in marble dust was used as a partial replacement for cement. Also changes were found out in various cases of cube strength, split tensile strength and the flexural strength. It also showed the effect of use of a waste material in the form of waste marble dust being used as a partial replacement material for any cementious compound and ultimately acquiring a strength in particular more than that of a nominal mix.

Keywords
Steel fibre, marble dust, split tensile strength, compressive strength, flexural strength

I. Introduction

Concrete is without any doubt a prominent construction material. Initially it was discovered to be a protective shield of steel members, after that it was found out to be very durable, hence is revised and now a day's concrete is used as a structural material very efficiently and steel is installed in it to enhance its properties and provides better strength to the concrete. Concrete ultimately gives many benefits which include resistance to fire (fire proofing), almost zero permeability to water, can be easily mould into any shape and size as per desire, economy and readily availability of material on the job site. After use of concrete in many construction sectors, it was found out that normal concrete has some flaws or weaknesses. Hence to blow away such a weakness led to the development of High Strength Concrete (HSC). So with the help of admixtures these days, a strength double to that of normal concrete is almost achieved. Concrete is a durable material, enhancing its properties gives it a higher life expectancy, hence on addition of fibres can lead to a high life of concrete. Concrete also possesses an environmental friendly nature, recently is has been found out that various materials that go as a waste and pollute the environment have been used comprehensively with concrete in the form of admixtures or fibres and have been evaluated to possess a strength almost equal to or greater than the normal mix of concrete.

II. Materials

Materials used in this study are cement, coarse aggregates, fine aggregates, and super-plasticizer, in addition to marble dust and steel fibres. These materials were read in terms of various Indian practices. The detail of various materials which were used in this study is given below:

A. Cement

The physical properties of the cement as found out from various tests conforming to Indian Standard IS: 8112:1989 are listed in Table 1. Cement shoul be carefully stored to prevent reduction in its properties due to contact with the moisture.

Table 1 : Test Results of Cement Sample

S. No.	Characteristics	Requirements as per IS: 8112-1989
1.	Consistency (%)	-
2.	Specific gravity	3.15
3.	Initial setting time (min)	>30
4.	Final setting time (min)	<600
5.	Fineness (%)	10
6.	Soundness (mm)	<10
7. (i) (ii) (iii)	Compressive strength 3 days (MPa) 7 days (MPa) 28 days (MPa)	 ≥23 ≥33 ≥43

B. Aggregates

1. Coarse Aggregates

Coarse aggregates are present in the concrete mixture and hence it is important to study their properties. Physical properties of coarse aggregates are given in Table 2.

Table 2 : Physical properties of coarse aggregate

Particulars	Properties
Specific gravity	2.67
Fineness modulus	6.52
Bulk density(Loose),kg/m³	1460
Bulk density(compacted),kg/m³	1650
Maximum size, mm	20
FM (20mm)	7.01
FM (10mm)	6.66

2. Fine aggregates

The aggregates which pass through 4.75 mm IS sieve are termed as fine aggregates. The physical characteristics of fine aggregates are shown in table no. 3

Table 3 : Physical properties of fine aggregate

Particulars	Properties
Specific gravity	2.67
Fineness modulus	2.20
Bulk density (loose), Kg/m³	1590
Bulk density (compacted), Kg/m³	1780
FM	2.203

C. Marble Dust

Marble dust should be white in color and should be in particular air dried of all moisture content.

D. Steel fibres

Blended steel fibres which are corrugated and obtained through cutting of steel wires are used. The fibres have been cut by fibre cutting machine to a precise size.

E. Water

The potable water is a general recommendation for mixing and curing of concrete. Hence this potable water is used for manufacturing concrete. The water is considerably free from any dangerous toxins and hence is capable for use in the concrete mixture.

III. Literature Review

Steel Fibre Reinforced Concrete

Steel fibre reinforced concrete (SFRC) contains blown steel fibres with concrete. The most important arrangement of steel fibres in concrete is to retard and control the tensile cracking of the concrete material. The steel fibre reinforced concrete improves the strength characteristics like flexural strength, , strain capacity, flexural toughness, split tensile strength, compressive strength and crack arrest properties which lead to their use in airfield pavements and highway, overlays and bridge deck slabs.

In 1996, it was explored the fibre reinforced beams of concrete under impact loading. Impact tests were carried out on small beams reinforced with concrete of different volumes of both steel fibres and polypropylene. The drop height of the instrumented drop weight impact machine was so selected that Some test samples failed completely under one drop of the hammer, while others required two or more blows to bring about complete failure. It was found that, at volume less than 0.5%, polypropylene fibres gave only a small increase in fracture energy. Steel fibres could bring about much greater improvement in fracture energy, with a passage in failure modes occurring between steel fibre volumes of 0.50% and 0.750%. Below 0.50%, fibre breaking was the main failure mechanism and the increase in fracture energy was also very less; above 0.750% fibre pull-out was the primary mechanism with increase in fracture energy.[1]

In 1997 it was evaluated the influence of fibres on the structural performance of shear reinforcement in situations of different ratios, some aspects of the properties of hardened and of fresh concrete are introduced. The main conversions (Alterations) resulting from the use of fibres were increased stiffness (particularly after first cracking stage), shear strength and ductility. Other parameters used in monitoring performance were the stresses in the stirrups ,properties of the hardened concrete (tensile strength, compressive strength and modulus of elasticity), and in the concrete and the longitudinal reinforcement (at the compression zone and at web). [2]

In 1998 it was studied on the Properties of high-strength steel fibre-reinforced concrete beams in bending. They reviewed that the flexural rigidity before yield stage and the displacement at 80% ultimate load in the descending curve are improved and length at comparable loads and crack number is reduced after the addition of steel fibres. The descending part of the load-displacement curve of the concrete beams without steel fibres is much steeper than that with steel fibres, which shows that the addition of steel fibres makes the high strength concrete beams more ductile. The research results of ten high-strength reinforced concrete beams and steel fibre-reinforced high strength concrete beams, with steel fibre content of 1% by volume. The enlarged ends of mild carbon steel fibres with three different dimensions were selected. [3]

In 2005 out investigation on steel fibre reinforced concrete for road pavement applications was carried out. In this paper, they established that the use of SFRC for road pavements and compare its execution with plain concrete under traffic loading. The determining of SFRC properties on performance and design aspects of concrete roads are discussed. Results coming out from road trial sections, tested under in-service traffic, are used to validate the use of the material in roads. Accordingly a 25% thickness reduction was possible by incorporating steel fibres hooked at 30kg/m^3 [4]

In 2011 studies on the influences of fly ash on behaviour of fibre reinforced concrete structures were made. The aim of this study was to measure the tensile and compressive strength of concrete with different steel fibre and fly ash percentage. Concrete specimens with different fibre contents like 0.50%, 1% and 1.5% by volume were tested. Fly ash contents in mixes ranged b/w 0 and 30% by weight. Sixteen concrete mixes were prepared. The result of this study confirmed that the addition of steel fibre improves the flexural strength but has a negligible effect on the compressive strength of concrete [5]

In 2011,studies on the proportioning of steel fibre reinforced concrete mixes for pavement construction and their impact on environment and cost were carried out. The new concept of the project is the use of recycled steel tyre-cord wire as concrete fibre reinforcement, which provides enhanced environmental benefits for tyre recycling over landfilling. Within the project framework an experiment of a steel-fibre-reinforced roller-compacted concrete (SFR-RCC) pavement was constructed in a rural area in Cyprus.. The main outcome of the studies is that SFR-RCC is more economically and environmentally sustainable than others. The suggested SFR-RCC pavement design is well feasible alternative to SFRC for use in road construction industry both in economic and environmental terms. Present available design methods, current laying and material production equipment, a new approach like SFR-RCC pavement may ideal in road construction. However, further new work can be done towards a more environmental and economic pavement pattern. Most importantly, the life cycle studies depicted that the steel fibre type and dosage can intensely influence

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the environmental and economic indicators of concrete pavement layer. The reason being the pavement layer depth, required to support the traffic load, is affected by the mechanical properties of SFRC. On the other hand, natural aggregates may be replaced by concrete in concrete mix, achieving only a negligible amount of reduction in air emissions. But, it is more environmentally sustainable to recycle wastes than to extract natural resources. [6]

In 2011 investigation was carried out on effect of fibre geometry and volume fraction on the flexural behaviour of steel fibre reinforced concrete. In this paper the effect of fibre geometry and fibre volume fraction has been investigated for steel fibre reinforced concretes. Specifically the compression strength, the flexural strength and toughness were read as a function of the above parameters in comparison to unreinforced concrete. The effect of the fibre addition on the slump and air content properties of fresh concrete has also been determined. The test results led to the conclusion that the fibres play an important role, not only in its fresh state , but also in the mechanical properties of hardened concrete test specicemens. Concerning fresh concrete, the inclusion of steel fibres in the concrete mixture reduced the slump in the range of 65.0–90.0 mm, compared to normal concrete. The air content showed increasing effect with the raising of fibre volume fraction. Samples with high fibre volume fraction (1.0 and 1.50% by concrete volume) presented larger air content than samples with lesser fibre volume fraction (0.50% by concrete volume). Plain concrete specimens failed comprehensively by a single crack, and separated into two pieces. On the negative side, the fibre-reinforced concrete samples, even those with small fibre volume fraction (0.50%), retained post-cracking ability to carry out loads. [7]

In 2012, laboratory investigations were carried out on the influence of steel fibre on concrete at a dose of 0.80% volume of concrete. Experimental investigation was done using M20 mix and tests were carried out as per specified procedures by relevant codes. The analytical parameters of this investigation included compressive strength, split tensile strength and of conventional and fibre reinforced concrete. The results indicated that the flexural strength , compressive, split tensile strength of fibre reinforced concrete is increased by 12.680%, 32.140%, 52.380% respectively when compared to the conventional concrete. [8]

In 2012 evaluation was made that the shear strength of Steel Fibre Reinforced Concrete (SFRC) moderate deep beams without stirrups having span to depth ratio 2, 2.4, 3, 4. The 12 numbers of beams were specifically tested. The beams were tested to failure under two point symmetrical loading. A full shear deformational behaviour along with load-deflection response, crack patterns and modes of failure is analysed experimentally. Shear strength is evaluated using empirical equations scheduled here in this work for evaluation of ultimate shear strength of these beams without stirrups. Experimental outcomes of ultimate shear strength are put side by side with theoretical results calculated from the equation proposed. The comparison shows that the equation proposed here gives the most accurate estimates of shear strength. In addition to concrete strength, the effect of other variation such as, span to depth ratio, fibre factor longitudinal steel ratio and size effect is considered. [9]

In 2013 case studies were made on steel fibres to increase the load carrying capacity of concrete members. Fibres substantially reduce the breakability of concrete and improve its engineering properties such as tensile, flexural, impact resistance, fatigue, load bearing capacity after cracking and toughness. It shows a study of research performed on Steel Fibre reinforced concrete. The performance of the Steel Fibre Reinforced Concrete (SFRC) has shown a immense improvement in flexural strength and overall toughness in comparison against Conventional Reinforced Concrete.[10]

Marble Dust

It is white in colour, in powdered form and air dried. Different percentages of marble dust are replaced with concrete which is discussed as follows:

In 2009, studies concluded that the marble sludge is very useful in house building materials. The main objectives of using marble sludge are to save natural resources and to reduce the dumping problem of industrial waste materials quantity. The experimental outcomes and their theoretical interpretation shows suitable incorporation of marble sludge results in building blocks of 15.0 cm with superior properties in terms of water absorption (7.0%). The compressive strength at age of 28 days curing only to a maximum of 7.80N/mm^2. [11]

In 2009, case studies were carried out on the properties of green concrete containing rock quarry dust and marble sludge powder as fine aggregate. In this , they accomplished that feasibility of the usage of quarry rock dust and marble sludge powder as almost 100% substitutes for natural sand in concrete. An attempt has been put forward to enhance durability of green concrete in comparison to the natural sand concrete. It is evaluated and found that the compressive, split tensile strength and durability studies of concrete made of rock quarry dust are nearly 14.0 % greater than the traditional concrete. The concrete resistance to sulphate attack was improved. Introduction of green concrete is an efficient way to downturn environment pollution and upgrade durability of concrete under harsh circumstances. [12]

In 2010, the effects of using waste marble dust (WMD) as a fine material on the mechanical characteristics of the concrete were studied. Four distinguished series of concrete-mixtures were prepared by changing the fine sand (passing 0.250 mm sieve) with WMD at proportions of 0, 25.0, 50.0 and 100.0% by weight. The consequence of the WMD on the compressive strength with respect to the, compressive strengths, curing age of the samples were recorded at the curing ages of 3, 7, 28 and 90 days. The porosity values, ultrasonic pulse velocity (UPV), dynamic modulus of elasticity (Edin) and the unit weights of the series were calculated in addition and all data were compared with each other. It was observed that the inclusion of WMD such that would change the fine material passing through a 0.250 mm sieve at particular proportions has depicted an increasing effect on compressive strength. Marble dust is an outcome of marble production facilities and also creates large scale environmental pollution. Therefore, it could be feasible to prevent the pollution of environment especially in the regions with enormous marble production and to consume lesser natural resources as well through its use in normal strength concretes as a replacement for the very fine aggregate. [13]

In 2010, investigation on characterization of marble powder for its use in mortar and concrete was carried out. In this paper, they established that with the replacement of 10% of marble powder with sand gives a maximum compressive strength at about the same workability, comparable to that of the reference mixture after 28 days of curing. Mixtures were checked out based upon cement or sand substitution by the marble powder. [14]

In 2010, investigations were carried out on stone dust and ceramic scrap as aggregate replacement in concrete. In this research paper, he authenticated that stone dust has been tried as fine aggregate in spite of sand and ceramic scrap has been used as limited/ full substitute to conventional coarse aggregate in concrete making. Cylinders, cubes and prisms were cast and checked for compressive, split tensile strength and modulus of rupture after a curing period of 28 days. The outcomes indicated effectiveness of stone dust as fine aggregate and partial replacement of traditional coarse aggregate by ceramic scrap up to 20 %, without affecting the design strength. [15]

In 2011 investigation was carried out on the properties of concrete paving blocks made with waste marble. In this research paper, they concluded that the cement type turns out to be an important factor. Mechanical strength reduces with increasing marble content while freeze- melt durability and wear resistance increase. Waste marble is well usable in spite of the usual aggregate in the concrete paving block production. Inclusion of marble waste provides concrete paving blocks of sufficient quality and strength. [16]

In 2011, it was concluded that the effect of using marble powder and granules as ingredients of fines in mortar or concrete by limited reducing quantities of cement as well as other conventional fines has been probed in terms of the relative workability & flexural as well as compressive strengths. Very less change of cement and usual fine aggregates by changing a percentage of marble powder and marble granules reveals that increased waste marble powder (WMP) or waste marble granule (WMG) ratio conclude in enhanced workability and compressive strengths of the mortar and concrete. [17]

In 2012**,** probe on the Partial replacement of cement with marble dust powder was conducted. In this research, they resulted that with the replacement of 10% of marble dust with cement, the compressive strength increases and further any replacement of marble dust with concrete the compressive strength decreases. Same case in the split tensile strength of cylinder, As 10% replacement of marble dust with cement the split tensile strength increases and further any replacement of marble dust the split tensile strength decreases. Thus they evaluated that the optimum percentage for replacement of marble powder with cement and it is almost 10.0% cement for both cubes and cylinders. [18]

IV. Conclusion

Considering all these researches, I conclude that use of steel fibres, marble dust and other additives in concrete lead to considerable amount of increase in strength of concrete and gives a higher life expectancy. The additives are left unused in many of the situations, considering these are just the byproducts and are treated as a waste, but their effective use results in the increase of compressive strength, flexural strength, cube strengths of concrete. I also conclude that these materials give immense durability on mixing with concrete. The use of marble dust in place of cement partially has lead to much more savings in cement and hence giving an economic mix. Also, I conclude 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.

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