Study on Steel Fibre Reinforced Concrete With Partial Replacement of Marble Dust Powder As Fine Aggregate

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Abstract- *Concrete is the most important component used in the construction industry throughout the world, where the fine aggregate is generally natural sand. The use of sand in construction activities results in the excessive mining. Due to excessive mining, natural resources are getting exhausted. Thus, it is becoming inevitable to use alternative material in concrete. Marble is one of the important materials used in the construction industry. Disposal of the marble powder material from the marble industry is one of the environmental problems worldwide today. And also, Ordinary cement concrete possesses very low tensile strength, limited ductility and less resistance to cracking. It has been proved that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. As compared to other fibers it is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In this paper Past studies based on the Steel fiber concrete and utilization of Waste marble powder as replacement of fine aggregate in concrete were investigated.*

Keywords- Steel Fibre Concrete, Cement, Steel Fibres, Marble Dust Powder, Strength

I. INTRODUCTION

Concrete is the most commonly used construction material is developing towards high performance, i.e., high strength high toughness; high durability and good workability shrinkage and permeability resistance of concrete are two imp properties relating to durability. An important measure of improving concrete impermeability is to improve the capability of resisting shrinkage and cracking. Concrete can be modified to perform in a more ductility form by the addition of randomly distributed discrete fibres in the concrete matrix.

Fibre Reinforced Concrete (FRC):

Fibre reinforced cement and concrete materials (FRC) have been developed progressively since the early work by Romualdi and Batson in the 1960s. By the 1990s, a wide range of fibre composites and FRC products were commercially available and novel manufacturing techniques were developed for use with high fibre content. Fibre reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and fibres. In this composite material, short discrete fibres are randomly distributed throughout the concrete mass. The behavioural efficiency of this composite material is far superior to that of plain concrete and many other construction materials of equal cost. Due to this benefit, the use of FRC has steadily increased during the last two decades and its current field of application includes: airport and highway pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, rock-slope stabilization, etc.,

Steel Fibre:

Steel fibres are filaments of wire, deformed and cut to lengths, for reinforcement of concrete, mortar and other composite materials. It is a cold drawn wire fibre with corrugated and flatted shape. The addition of steel fibres helps in converting the brittle characteristics to ductile ones. To faster the compressive strength without sacrificing the ductility, a strategy adopted is to add discrete steel fibres as reinforcement in concrete.

Steel fibres are available in lengths between 6 and 80mm and with a cross sectional area between 0.1 and 1.5,2mm. The tensile strength is normally in the range between 300 and 2400Mpa. They are of circular or rectangular cross-sectional shape and are produced by cutting or chopping steel wires or by shearing sheets of flattened metal sheets and steel bars. The fibres are usually crimped or deformed with either a hook at each fibre end or a small head in order to improve the anchorage in the concrete matrix. It is obvious that the behaviour of HFRC depends on the orientations, distributions, aspect ratios, geometrical shapes and mechanical properties of fibres in concrete mixtures.

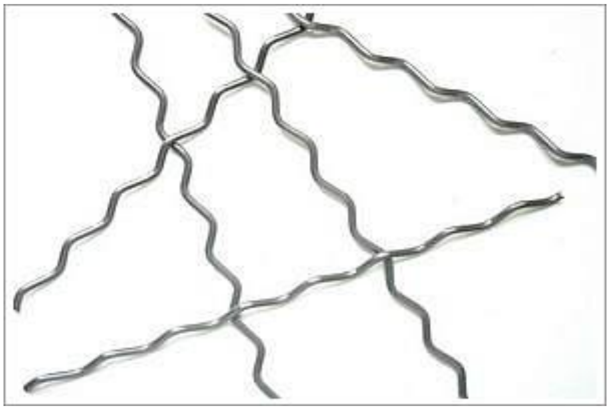

FIG 1.1 STEEL FIBRES

Marble Dust Powder:

Marble powder is one of the waste produces in marble industry. It is obtained during the processes of cutting, shaping and polishing. It is collected as slurry near the dumpsite of the industry. It mixes with the water and makes it unfit for reuse. During this process, about 20-25% of the process marble is turn into the powder form. Due to the presence of heavy metals, it affects the environment and also the human health. India being the topmost exporter of marble, every year million tons of marble waste form processing plants are released. The disposal of this waste marble on soils causes reduction in permeability and contaminates the over ground water when deposited along catchment area. Marble as a building material especially in palaces and monuments has been in use for ages. Thus, utilizing these marble waste in construction industry itself would help to protect the environment from dumpsites of marble and also limit the excessive mining of natural resources of sand.

FIG 1.2 MARBLE DUST POWDER

Effects of cracks in concrete:

Concrete does not require much water to achieve maximum strength. But a wide majority of concrete used in residential work has too much water added to the concrete on the job site. This water is added to make the concrete easier to install. This excess water also greatly reduces the strength of the concrete.

Shrinkage is a main cause of cracking. As concrete hardens and dries it shrinks. This is due to the evaporation of excess mixing water. The wetter or soupier the concrete mix, the greater the shrinkage will be. Concrete slabs can shrink as much as 1/2 inch per 100 feet. This shrinkage causes forces in the concrete which literally pull the slab apart. Cracks are the end result of these forces. Also, rapid drying of the slab will significantly increase the possibility of cracking. The chemical reaction, which causes concrete to go from the liquid or plastic state to a solid state, requires water. This chemical reaction, or hydration, continues to occur for days and weeks after you pour the concrete. You can make sure that the necessary water is available for this reaction by adequately curing the slab.

Advantages of Steel Fibre:

Steel Fibre Reinforced Concrete (SFRC) has an untapped potential application in building frames due to its high seismic energy absorption capability and relatively simple construction technique.

By adding fibres made of steel to reinforced concrete the joint is toughened which enables the structure to be more durable.

Steel fibre reinforced concrete exhibits higher post-crack flexural strength, better crack resistance, improved fatigue strength, higher resistance to spalling, and higher firstcrack strength, Steel fibres strengthen concrete by resisting tensile cracking.

Steel fibres improve ductility, flexural strength and toughness of the concrete and also increase the ductility and the tensile strength.

II. LITERATURE REVIEW

General:

This chapter outlines some of the reports and results from journals, websites, books and etc., which are related to the Application of Steel Fibres and Marble Dust Powder (MDP)are detailed here in literature.

A.M. Shende, A.M. Pande, M.Gulfam Pathan at (2012) [1] on the work “Experimental Study on Steel Fiber Reinforced Concrete for M-40 Grade”.in this investigation for M-40 grade of concrete having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the compressive strength, flexural strength, split tensile strength of steel fibre reinforced concrete (SFRC) containing fibers of 0%, 1%, 2% and 3% volume fraction of hook tain. Steel fibers of 50, 60 and 67 aspect ratios were used. The compressive strength of Steel fibre reinforced concrete with 1% fibre and aspect ratio of 50, 60, 67 are 52.00 N/mm2, 50.37 N/mm2, 50.22 N/mm2. The compressive strength SFRC with 2% fibre with fibre aspect ratio of 50,60,67 are 53.33 N/mm2, 52.59 N/mm2, 51.41 N/mm2. The corresponding compressive strength of SFRC with 3% FIBRES with aspect ratio of 50,60 and 67 are 56.30 N/mm2, 54.07 N/mm2, 53.04 N/mm2. The flexural strength of sfrc with 1%,2% and 3% fibres and aspect ratio of 50 are 8.8 N/mm2, 9.47 N/mm2, 10.40 N/mm2. similarly, the flexural strength of sfrc with 1%,2% and 3% fibres and aspect ratio of 60 are 8.40 N/mm2, 9.20 N/mm2, 10.00 N/mm2 and the Flexural strength of SFRC with 1%, 2%, and 3% of fibre with aspect ratio of 67 are 8.27 N/mm2, 9.00 N/mm2, 9.73 N/mm2. The Split tensile strength of SFRC with 1%, 2% and 3% of fibre and aspect ratio of 50 are 3.30 N/mm2, 3.92 N/mm2, 4.34 N/mm2. The Split tensile strength of SFRC with 1%, 2% and 3% of fibre and aspect ratio of 60 are 3.21 N/mm2, 3.68 N/mm2, 4.25 N/mm2. The Split tensile strength of SFRC with 1%, 2% and 3% of fibre and aspect ratio of 67 are 3.16 N/mm2, 3.63 N/mm2, 4.20 N/mm2. From this result obtained they conclude that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibres as compared to that produced from 0%, 1% and 2% fibres, and strength property was high for aspect ratio of 50 as compared to those for aspect ratio 60 and 67. This study shows that the Steel fibre on the concrete increase the compressive strength, split tensile strength and flexural strength effectively.

Vasudev R, Dr. B G Vishnuram at (2013) [2] on the "Studies on Steel Fibre Reinforced Concrete–A Sustainable Approach". In this paper they made a comparative study between ordinary reinforced concrete and steel fibre reinforced concrete. In this study the fibres which were used was the turn fibres. They were the scraps from the lathe shops. The concrete mix adopted were M20 and M30 with varying percentage of fibres ranging from 0, 0.25, 0.5, 0.75 & 1%. In this study the results are compared with the Available steel fibres and Turn steel fibres. Nominal concrete cubes (15 cm x 15 cm x 15 cm), concrete cylinders (15 cm diameter and 30 cm long). A mixture of irregular and crimped shaped fibres (3cm - 4cm length) were mixed with the aggregate while casting the specimens, it was made sure that fibres were uniformly distributed throughout the mix. For conducting the tests of compressive strength, two sets of ten cubes each of M20 & M30 mix were cast without fibres. The Compressive strength of M20 grade concrete cubes at 28 days of curing with turn steel fibre content ratio as 0%, 0.25%, 0.5% and 0.75%, are 25.84 N/mm2, 20.58 N/mm2, 24.84 N/mm2, 24.71 N/mm2, and the compressive strength of M30 cube with fibre content ratio as 0%, 0.25%, 0.5% and 0.75% after 28days of curing are 39.36 N/mm2,35.9 N/mm2, 37.57 N/mm2, 36.67 N/mm2,from this study it is clear that there is no significant increase in compressive strength by adding Turn steel fibres incase of both M20 & M30 grade of concrete. For testing of the split tensile strength, the cylinders were cast in the cylindrical mould of size 15 cm diameter and 30cm height. The split tensile strength with fibre content ratio as0%, 0.25%, 0.5%, 0.75% & 1% after 28 days of curing are 2.373 N/mm2,2.476 N/mm2,2.844 N/mm2,2.637 N/mm2,2.419 N/mm2.And forthe M30 mix the split tensile strength with fibre content ratio as 0%,0.25%, 0.5%, 0.75% & 1% after 28 days of curing are 2.6 N/mm2,2.87 N/mm2,3.17 N/mm2,2.8 N/mm2,2.68 N/mm2. In this the Split Tensile strength was increased by adding fibres of 0.5% on both the grades of concrete. From this study we conclude that the Significant increase in compressive strength was not obtained by the addition of turn steel fibres in concrete. The splitting tensile strength of plain concrete is improved by 20% for M20 concrete and 22% for M30 concrete by the addition of turn steel fibres. This study was a true example of sustainable development as the recycling of scraps. From this study it is clear that we can use Steel fibres instead of turned fibres for increasing Tensile strength compressive strength, Toughness of the concrete.

Aalok D.Sakalkal e, G. D. Dhawale, R. S. Kedar at (2014) [3]in their "Experimental Study on Use of Waste Marble Dust in Concrete analyzed the replacement of fine aggregate by marble dust at proportion 0%, 25%, 50% and 100% and its effect on properties of concrete were investigated. In order to determine the effect of the marble dust with respect to the curing age, standard mechanical properties of concrete are to be analyzed at the curing ages of 3, 7, 28 days. The Marble Dust Powder(MDP) was replaced accordingly to the weight of fine aggregate. In their study the compressive strength was compared with the proportion of marble dust powder the resultant values are mentioned on 3,7- and 28-days curing period. With the Marble dust at 0% the compressive strength was 31.73N/mm2 at28 days of curing. The compressive strength of 33.11N/mm2 was obtained at 25% of marble dust after 28 days curing. The compressive strength with 50% of MDP is 35.54N/mm2 after 28days curing period. For MDP of 100% the compressive strength was 21.32N/mm2. It is observed that 50 % MDP mix is the maximum optimum % of MDP and again further increasing the MDP% the compressive strength is gradually decreases. In case of split tensile strength, after 28 days curing, The maximum tensile strength is obtained at 0% MDP mix i.e., 8.12N/mm2.when compared to the mix of 25%-7.93N/mm2, for 50%-6.91N/mm2, and for 100%-3.82N/mm2. However, the tensile strength at 25% MDP mix is coming nearly equal to the tensile strength at 0% MDP. Thus, 25% MDP mix can also give better tensile strength. For the Flexural strength with MDP of 0%,25%,50% and 100% the corresponding Flexural strength are 4.43 N/mm2, 4.70 N/mm2, 5.10 N/mm2, 3.51 N/mm2 . The maximum flexural strength is achieved at 50% MDP mix, at all the curing ages. Thus, 50% MDP mix gives the optimum percentage of MDP. The compressive strength of concrete is increased with addition of waste marble powder up to 50% by weight in place of sand and further any addition of waste marble powder the compressive strength decreases. The split tensile strength of cylinders is decreased with addition of waste marble powder, from control mix to 100% replacement of sand. However, the tensile strength at 25% replacement of sand is coming nearly equal to the tensile strength at control mix. Thus, 25% sand replacement with MDP can also give better tensile strength. The flexural strength of beams is also increased with addition of waste marble powder up to 50% sand replacement and then gradually decreases. From their study we found out the optimum percentage for replacement of sand with marble powder in concrete is almost 50%, this proportion of replacement was added in concrete for better efficiency.

Bhupendra Singh Kalchuri, Dr. Rajeev Chandak, R.K.Yadav (2015) [4] on the "Study On Concrete Using Marble Powder Waste As Partial Replacement Of Sand", explore the possibility of using marble powder waste as partial replacement of fine aggregate in concrete. In the study, based on the Indian Standard (IS: 10262 – 1982), design mix for M30 grade of concrete was prepared by partially replacing fine aggregate with five different percentages by weight of marble powder (0%, 10%, 20%, 30%, and 40%,) and 150x150x150 mm concrete cubes were casting. The nine specimens of each mix were prepared. After 24hrs the specimens were removed from the mould subjected to water curing for 7, 28 and 90 days. After curing, the specimens were tested for compressive strength using a calibrated compression machine. The compressive strength of concrete with marble dust replacement of 0%, 10%, 20%, 30%, and 40%, at the curing period of 28 days correspondingly was 39.55N/mm2, 40.59 N/mm2, 41.04 N/mm2, 36.15 N/mm2, 33.48 N/mm2. From this we conclude that, The compressive strength of concrete is increased when the percentage of marble powder waste is increased up to 20% and by further increasing the percentage of marble powder waste compressive strength gets reduced. They also indicates that the waste marble powder can be successfully utilized as partial replacement of fine aggregate in concrete production. Their use in concrete will alleviate the problem of their disposal and environmental pollution.

Ali Amin and Stephen J. Foster (2016) [5], Despite the increased awareness of Steel Fibre Reinforced Concrete (SFRC) in practice and research, SFRC is yet to find common application in load bearing or shear critical building structural elements. Although the far majority of studies on SFRC have focused on members containing fibres only, in most practical applications of SFRC construction, structural members made of SFRC 824 | P a g e are also reinforced with conventional reinforcing steel for shear ligatures. In this paper, results are presented on shear tests which have been conducted on ten 5 m long by 0.3 m wide by 0.7 m high rectangular simply supported beams with varying transverse and steel fibre reinforcement ratios. The tests have been analyzed along with complete material characterization which quantifies the post-cracking behaviour of the SFRC.

Mr. L.SATISH KUMAR and Mr.M.SRINIVASA RAO (2017) [6] in their study on "PARTIAL REPLACEMENT OF FINE AGGEREGATE WITH MARBLE DUST IN CONCRETE "list out the possibilities of using Marble dust as a replacement for Fine aggregate. In this work, M25 grade concrete mix was developed using IS method of mix design. Specimens of dimension of 150 x 150 x 150mm cubes were cast for compressive strength of concrete specimens. The test results indicate that with the use of replacing Marble dust by fine aggregates in different percentages i.e., 0%, 5%, 10%, 15%, 20%, 25%, 30%, 30% and 40%. For evaluation of strength parameters each grade of concrete for each proportion in the form of cubes casted for testing at 3 days, 7days and 28 days periods. The compressive strength increases with the increase in percentage of Marble dust up to 30%. The maximum compressive strength of M25 grade concrete occurred at 30% replacement of fine aggregate was observed as 35.41 N/mm2 which is higher when compared to compressive strength of normal concrete without replacement of marble dust powder i, e.,25N/mm2. Based on this experimental investigation, it is found that Marble dust can be used as an alternative material to the natural river sand in future.

Akshit Mahajan, R. S. Bansal, Arjun Kumar and Kanav Mehta (2018) [7] on their study on "STRUCTURAL BEHAVIOUR OF PLAIN CEMENT CONCRETE WITH MARBLE DUST POWDER AND STEEL FIBRES". The aim of their study is to relatively improve the tensile and flexural strength of concrete along with its compressive strength using Marble Dust Powder (MDP) and steel fibers in standard concrete. In this the Marble dust powder was replaced by 5%, 10%, 15% and 20% to the weight of cement, and steel fibres was added in volume fraction of concrete at 0.5%, 1% and 1.5% volume of concrete. In this study the M25 grade concrete with w/c of 0.45 is used and controlled workability is observed without using any admixtures. the cube specimen of size (150X150X150) mm and cylindrical specimens of size (150X300) was made and tested in CTM to obtain the compressive strength of masses. the beam specimens of size (100X100X500) mm were made and tested under the two-point static flexural loading machine. 7- and 28-day strength to find the Flexural strength and admixture concrete mass. It is observed that when MDP is replaced with cement by 10% of its weight then it provides much better properties of concrete. This study also reveals that MDP and fiber mixed concrete provide much better properties in improving all strength as above and use of fibers provide better properties in controlling cracks and high strengths. Hence the optimum mix for this has been worked out to be MDP 15% and HE steel fibers 1% in concrete improving the properties of concrete. Further on increasing MDP beyond 15%, the strengths started to falling due to slight extra brittleness than using cement and also on increasing fiber beyond 1% the fall in strengths observed probably due to non-cohesiveness of concrete particles to each other. The maximum increase in compressive strength, split tensile strength and flexural strength at optimum has been worked out to be after 28 days is 36.9MPa, 4.24MPa, 5.46 respectively from initial values 32.8MPa, 3.24MPa, 4.34 MPa. From this they conclude that the MDP was replaced upto 15% with Hooked End steel fibres proportion of 1%of concrete volume, to enhance the overall performance of concrete.

Birbal Kumar, Prof. Kapil Soni (2019) [8] on their work "EXPERIMENTAL STUDY OF WASTE MARBLE POWDER AND STEEL FIBRES FOR CEMENT CONCRETE MIXES", they utilized Waste marble powder and steel fibers in this study and analyzed the strength of concrete.For achieve this objective they partially replaced the cement with waste marble powder as partial replacement of cement incorporating with steel fibers. In this research, steel binding wires were used as steel fibers which are locally available at very cheap cost. Steel fibers were added in different percentage i.e. 0 %,0.5 %, 1 %, 1.5 % and 2 %, with addition to waste marble powder. In this work M20 grade with mix ratio of 1:1.5:3 and w/c ratio of 0.45 was adopted. In this with Marble dust replacement at range of 0%, 5%, 10%, 15%, 20%, the corresponding compressive strength after 28days of curing are 24.80 N/mm2, 25.45 N/mm2 ,26.10 N/mm2, 28.95 N/mm2, 24.30 N/mm2.This shows further increasing at 20% of marble dust the compressive strength was decreased so it is safe to adopt marble dust replacement as 15%. The result of compressive strength of different mix with 15% marble powder corresponding to the different percentage of Steel fibre at 0%, 0.5%, 1.0%, 1.5% ,2.0% was 28.95 N/mm2, 29.65 N/mm2, 30.90 N/mm2, 28.80 N/mm2, 28.65 N/mm2.Similarly the corresponding Split tensile strength with 15% of marble dust and 1% of steel fibre 2.98 N/mm2 was higher than other proportions, 0%- 2.69 N/mm2, 0.5%-2.78 N/mm2, 1.5%-2.63 N/mm2, 2.0%-2.55 N/mm2. The flexural strength of concrete with 15% of marble dust in addition with 1% of steel fibre 6.67 N/mm2, was higher when compared to other proportional values 0%- 6.35 N/mm2, 0.5%- 6.41N/mm2, 1.5%- 6.31N/mm2, 2.0%-6.28N/mm2. On the basis of those result obtained that 1% steel fibre in addition with partial replacement of 15 % marble powder shows better results in all the aspects. Concrete mix with 15 percent marble dust as replacement of cement is the optimum level as it has been observed to show a significant increase in compressive strength, Flexural strength and Split tensile strength at 28 days when compared with nominal mix. From this study we conclude that the marble dust in addition to steel fibres on concrete increase the properties of the concrete and also marble dust was suitable replacement for the Cement as well as Fine aggregate.

SCOPE OF THE PROJECT:

The Scope of the project is to find an alternative for River sand without affecting the Mechanical properties of concrete.

Marble dust powder MDP was waste product from marble industry, without proper disposal that'll affect the environment. The scope of this project is to Use the Marble Dust Powder as a replacement of Fine aggregate.

Marble Dust Powder was added to concrete in manner without affecting the Mechanical properties of concrete.

In addition to that, Steel Fibres was added to increase the Mechanical properties of concrete.

III. CONCLUSION

From the study the following conclusions are described as follows:

1. Marble Dust Powder was an suitable replacement for Fine aggregate at range of 20% to 30% for better strength characteristics of concrete.
2. With the increase in steel fiber content, the mechanical properties such as compression strength, flexural strength, and splitting tensile strength improves gradually.
3. Further tests are carried on to derive the strength characteristics for various concrete mix proportions.

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