Structural Strength Enhancement of Rigid Pavement Using Scrap Metal Fibre Reinforcement

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Abstract— Road construction with the use of steel fibers to improve the strength and reduce maintenance is an efficient technology established in current times by many researchers. In this study we will utilize this advantage of steel fibers but instead of buying typically available steel fibers we will utilize the locally generated metal scrap fibers in the construction of road pavements. The objective of present paper is to investigate the feasibility and performance of concrete when mixed with metal scrap For this the main aim is to develop a M40 grade mix design concrete with partial replacement of crush sand with metal scrap fibers in the percentage of 5%, 6% and 7% by weight of concrete. By conducting durability and compressive tests on this concrete the optimum percentage of metal scrap utilization in concrete will be presented. Comparisons are made with conventional concrete of M40.

Keywords: Metal Scrap, Compressive Strength, Concrete, Optimum Percentage of Metal Scrap

I. INTRODUCTION

Concrete pavement is a structure of highway pavement in India due to its increase in advantage, low maintenance, and long design life. These rigid pavements may sometimes experience pavement distress that results in too early failure. This research studies the application of fibers in concrete due to its improve counteraction to cracking. Now–a-days steel fibers in concrete increase effectively as an engineering requirement. From the present situation it is not only necessary to provide safe, economical and efficient design, but it also provide as equalize base for future practice. The energy exhaustion and cost consort with concrete pavements can be minimize through the reuse materials with more efficient construction techniques. In many advanced countries like India, anxiety over resource preservation, decrease material cost and waste generation have paying attention on recycling of materials.

Metal fibers have used in concrete early 1900s. The early fibers were circular and even and the wire was cut to the needed lengths. The use of straight, even fibers broad disappeared and advanced fibers have either harsh surface, undulated through their length. Advance effectively available steel fibers are manufactured from steel wire, by the melt-extraction method which produces fibers that have a curved-shape cross section.

As per IRC:SP:46-1997 metal fibers[14] have equivalent diameters (based on cross-sectional area) of from 0.15 mm to 2 mm and lengths from 7mm to 75 mm. Aspect ratios commonly range from 20 to 100. Metal fibers have strong tensile strength (0.5–2GPa) and modulus of elasticity (200GPa), a ductile stress-strain property and low creep. Concretes involve steel fiber have shown to have essentially enhanced resistance to impact and higher ductility of failure in compression, flexure and torsion.

An attempt has been built to investigate the mechanical properties of the waste metal scrap material which is available from the lathe is used as a metal fiber for pavement construction to improve the fiber content. The utilization of metal Fiber Reinforced Concrete (MFRC) as complex matrix is potentially beneficial from the point of view of its capacity to bear higher stresses. Under similar loading conditions pavement thickness can considerably be reduced in MFRC, hence reduction in material and cost. Sound MFRC pavement promises an appreciably higher life expectancy, reduced crack growth offer better serviceability and minimum corrosion.

II. OBJECTIVES OF THE STUDY

- Use of Metal scrap in concrete.
- To study effect of waste metal scrap in concrete.
- To check the feasibility of waste metal scrap in mix design concrete.
- To check feasibility by compressive strength test done on prepared concrete specimen.
- To compare test results with conventional concrete and decide optimum percentage of metal scrap for maximum strength of concrete.

III. LITERATURE REVIEW

1) Zeeshan Nissar Qureshi [1], have studied that, the strength properties of concrete were increasing by adding lathe machine scrap up to 1.5 % by weight in concrete after this negligible reduction in strength properties of concrete was observed. The compressive, split tensile and flexure strengths were increasing by 11.37 %, 18% and 30 % for optimum percentage of lathe machine scrap which was found to be 1.5%. The load carrying capability of beam at same percentage of lathe machine scrap was found to be 5.66kN and deflection which was also maximum among all percentages was 7mm. Lathe machine scrap was found to be powerful and environmental friendly material which can enhance structural strength of concrete, reduce steel reinforcements further, decreasing width of cracks when used as reinforced material in concrete.
2) Mr. Kolase Pramod K [2], have studied that, Early-age strength of concrete is the primary requirement of accelerated construction and rehabilitation. Road construction with the use of metal fibers to improve the strength and decrease maintenance is an impressive technology established in recent times. The paper reviews the studies, which determine the use of metal fiber in many effective ways developing the strength and an improvement in fatigue life of the pavement together with developing enhance resistance to crack.
3) Mrs. Nisha Thakur [3], have studied that, slag is the major by- product of steel industry and the current

utilization of steel slag is less than 30%, far behind the developed countries. The biggest part of originated steel slag still ends on often non-regulated landfills as industrial waste in abutting areas. Dumping of steel slag as landfills contributes to serious pollution to the environment. The sustainable improvement concept requires a extra efficient management of waste materials and conservation of environment. Steel slag can be used potentially as a sustainable material in construction of pavements as India has world's second largest road network in terms of length with a total road length of 4.24 Million Km. Large scale highway construction in India, originating from rapid improvement has caused massive consumption of rare natural aggregate. This study provides an overview on the worldwide utilization of steel slag to resolve this problem and also the important routes and critical problems for large-scale utilization of steel slag were proposed.

4) G. Niranjana, Research Scholar [4] have studied that, to analyze the mechanical characteristics of the waste steel scrap material which is available from the lathe is used as a steel fibre for pavement construction and to increase the fiber content. The characteristics compressive strength and flexural strength of M30, M35, and M40 cement concrete for different proportions of steel scraps are experimentally search out. The steel scrap is added in various proportions by weight of the cement, and the experimental results show that the mechanical properties such as compressive strength, flexural strength, impact strength and abrasive resistance of concrete are setup to be expanded due to the addition of steel scrap fibre in the concrete. This paper focuses notice on the structural strength enhancement of rigid pavements by using the locally accessible Scrap Steel Fibre Reinforcement and it is comparision with the Plain Cement Concrete (PCC) specimens.
5) Ioanna Papayianni [5] have studied that, the properties in fresh and hardened state of concrete for pavements are described as well as a pilot application of steel slag concrete in road pavement. Based on the results it is visible that the use of steel slags in pavement application is very beneficial from technical point of view. Basic acceptible characteristics are increased or significantly enhanced, such as the compressive strength, ductility and resistance to abrasion. A comparison of conventional concrete pavement with steel slag concrete is made based on the cost and environmental footprint considerations, taking into account the maintenance cost during the service life of the pavement
6) Namrata M. Mannade [6] al, have studied that, waste scrap steel which are produced in different manufacturing processes of lathe machine works can be used as reinforcing material in concrete to enhance the various properties of concrete. The intension of the paper was to study the possibility of using steel scrap in concrete by scrutinize different concrete parameters like compressive strength, tensile strength and flexural strength. All the parameter scrutinized with varying percentage by 0%, 0.5%, 1%, 1.5%, 2% by weight of concrete. This paper display the current status and past studies in the area of reuse of waste materials in concrete
7) Tian Sing NG [7], presents an overview of the SFRC pavement design methodology using plastic analysis method and provides a guidance to practitioners on how to specify steel fibres. It also provides a brief review on the durability of steel fibre reinforced concrete. The situations of some steel fibre reinforced concrete pavements constructed some 20 years ago in Australia are also noted at this point.
8) Abdul Rahman [8], have studied that, the metal scrap waste material which is obtainable from the lathe can be used as steel fiber for the innovative construction industry and in pavement construction. It is originated by each lathe industries Disposing of these wastes contaminates the soil and groundwater, which creates a destructive environment. In addition, to get sustainable improvement and environmental advantages, lathe scrap with concrete is likely to be apply. In this project steel scrap concrete applying lathe waste is arranged and its properties are studied. Natural River sand due to consumption of resources and limitations due to environmental consideration has built concrete manufacturers look for suitable alternative fine aggregate. Though it has been in utilize in concrete manufacturing in India, the percentage of its contribution is still highly negligible in many parts of the country. The tests conducted were slump test, compressive strength test, split tensile strength test and. For this concrete cubes, beams and cylinders were cast and cured and tests were done at 3th day, 7th day and 28th day.
9) Keyvani [9], have studied that, a mixture of fibers fi-om steel cans were tested as reinforcing fibers in this study. By using these fibers, which are municipal and business waste products, as steel fibers for concrete reinforcement, not only is the concrete strength enhanced, but some areas of environmental pollution may also be reduced and the problems of disposal of waste steel cans may be minimized. This study proposes the idea of using steel cans bears for concrete reinforcement as a practical method of reclamation a solid waste material, Recycling waste steel cans to generate steel fibers for concrete pavements for car parks and pavement of the second degree path has visible cost advantage comparison to using industrially produced steel fibers.
10) Rashid Hameed [10], have studied the effect of fiber aspect ratio on the flexural properties of metallic fiber reinforced concrete (MFRC) the flexural properties, which have been studied, include maximum load bearing capacity (peak load), post-crack strength and flexural toughness. High performance metallic fibers of various aspect ratios were used. The application of fibers was kept 20 kg/m3 (0.25% by volume fraction) for all the fibered concrete mixtures. Three point bending tests were achieved on both control (without fibers) and fibered notched prismatic concrete specimens of cross section 100 x 100mm and clear span

of 450mm. The results presented that the flexural properties of concrete matrix are significantly enhanced by the addition of high performance metallic fibers. Besides, it was found that the level of enhancement in flexural properties of MFRC varies with the aspect ratio of fibers. Out of the two various aspect ratios of metallic fibers used in this study, the fibers with maximum aspect ratio displayed better efficiency in improving the flexural response of MFR.

IV. MATERIALS USED

A. *Cement*

Ordinary Portland cement 53 grade cement was used in this project work. Cement satisfied all physical properties with in its limit as given IS 12269-1987. The weight of each bag is 50 kg. Cement is the expansive material among all ingredients of concrete [12]. Cement acts as a bonding material in concrete. Various test values obtained are described below.

Properties of cement		
Sr. No	Properties	Obtained values
1.	Fineness (%)	3.5
2.	Standard consistency (%)	30
3.	Initial setting time (min)	60
4.	Final setting time (min)	575
5.	Specific gravity	3.15
6.	Compressive strength at day 28 days (N/mm2)	53

B. *Fine Aggregate*

Crush sand passing through 4.75 mm IS sieve conforming to grading zone 2 was used. Sieve analysis was done to find grading zone [15]. The Properties like fineness modulus 3.38, specific gravity 2.5, bulk 1725 kg/m3 and satisfied the requirement of IS 383-1970. As shown in table.

Properties of Crush sand		
Sr. No	Properties	Obtained values
1.	Fineness Modulus (%)	3.38
2.	Specific gravity	2.5
3.	Bulk Density (kg/m3)	1725
4.	Grading	Zone- 2

C. *Coarse Aggregate*

The aggregate having size more than 4.75 mm is called as coarse aggregate. Generally, Aggregates are angular in shape. Flaky & elongated aggregates should not be used in concrete. It makes concrete porous & more permeable. The average size of 10mm and 20mm aggregate used in experimental work. The specific gravity of course aggregate is 2.95 and water absorption is 0.05%. Coarse aggregate obtained from grading zone 3.[15]

Properties of Coarse Aggregate		
Sr. No	Properties	Obtained values
1.	Fineness Modulus (%)	7.4
2.	Specific gravity	2.7
3.	Bulk Density (kg/m3)	1420
4.	Water Absorption (%)	0.05

D. *Water*

Water plays an important role in concrete and acts as a lubricant between ingredients of concrete. It helps in improving the workability of concrete. Water used for concrete mixing and curing shall be clean and free from injurious cause's reduction in strength of concrete. It pH value should be lies between 6 and 8.

E. *Metal scrap waste*

Processed scraps are crushed to fibers and obtained from workshops. Lathe scrap utilize as steel scrap and its sizes are average 1.5 mm thickness, average 25-30 mm length and 2 mm wide. The sizes of fiber varies from industry to industry. It is like a steel fiber but its properties are not same as steel fiber.

The shape of steel scrap may be rectangular or bend. Its shape depends upon type of work done by industry.

V. METHODOLOGY

A. *Concrete Mix Design:*

In this study M40 grade concrete is used as per IS: 10262-2009. Materials quantity required for 1m3 concrete for M40 grade concrete are as follows.

Materials and its quantity

Material	Quantity (kg/m3)
Cement	440
Fine Aggregate (Crush Sand)	880
Coarse Aggregate (10 mm)	400
Coarse Aggregate (20 mm)	660
Water	195
Admixtures	4.40

B. *Casting and Testing:*

For mixing concrete, mixer machine is used. First of all calculated quantity of dry coarse aggregate & then fine aggregate added in the mixer machine drum and rotating it about 2 minutes. Then, estimated amount of cement added into the drum. Calculated quantity of water added into the drum. At the last calculated quantity of fibre into the drum. Mixing is done till constant homogeneous mix achieved.

Total 24 cubes will casted & final compressive strength will tested for 7 and 28 days curing [16]. The 6 moulds stuffed with conventional concrete mix proportion, 6 moulds filled with 5% metal scrap fibre, 6 moulds filled with 6% metal scrap fibre. If strength will increase by this percentage then we will increase percentage of metal scrap

fibre & if strength will decreases we will decrease percentage of metal scrap fibre.

VI. RECOMMENDATIONS FOR FUTURE STUDIES

Further investigations can be carried out in this field by utilizing other types of scraps from industry or with steel powder. The work can be extended by adopting other mixes like M45, M50 etc. with varying percentages of scraps either by weight of concrete or by volume of concrete or any kind of replacement. Several other parameters can also be tested like Split tensile, Flexure, Impact resistance, Abrasion, Fatigue resistance, Crack propagation etc.

REFERENCES

[1] Zeeshan Nissar Qureshi, Yawar Mushtaq Raina, Syed Mohd Asgar Rufaie – "Strength Characteristics Analysis of Concrete Reinforced With Lathe Machine Scrap" - Volume 4, Issue 4, July-August, 2016
[2] Mr. Kolase Pramod K, Dr. Atul K. Desai, Mr. Shivamanth , Mr. Randhavane Shrikant B - "Metal Fiber Reinforced Concrete Pavement" -International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 10 | March 2015
[3] Mrs. Nisha Thakur, Dr. P.P.Saklecha – "review of slag utilization in pavements" – International Journal of Latest Trends in Engineering and Technology Vol. (10) Issue (2), pp.314-319
[4] G.Niranjana, Research scholar, Dr.Samson Mathew Assistance Professor, NIT, Tiruchippali -"Structural Strength enhancement of rigid pavement using steel fibre reinforcement" International Journal of Latest Trends in Engineering and Technology. March 2019.
[5] Ioanna Papayianni , Eleftherios Anastasiou , Michael Papachristoforou , Alexandros Liapis - Steel Slag Concrete for Pavement Construction - International Balkans Conference on Challenges of Civil Engineering, 3-BCCCE, 19-21 May 2016
[6] Namrata M. Mannade , Prof. A.P.Khatri ,- experimental investigation on use of lathe scrap steel fibers in rigid pavement - International Journal of Technical Research and Applications , Volume 6, Issue 4 (july-august 2018)
[7] Giedrius Girskas, Džigita Nagrockienė - The Use of Steel Cord Scrap in Concrete - October 2016, vol. 18, pp. 22–26
[8] Pooja Shrivastava, Y.p. Joshi - Innovative Use of Waste Steel Scrap in Rigid Pavements - Civil Enviornmental Research Vol 6, No 7 (2014)
[9] Abdul Rahman, Syed Mustafa Ali, Syed Azeemuddin - Performance Analysis of Steel Scrap in Structural Concrete - Journal of Mechanical and Civil Engineering, Volume 14, Issue 2 Ver. VII (Mar. - Apr. 2017), PP 42-47
[10] A. Keyvani - Road pavement constructing using recycled steel cans – Waste Management And the Environment, Azerbaijan University of Tarbiat Moallem, Tabriz, Iran.2002
[11] "Concrete Technology-Theory & Practice"- M.S. Shetty
[12] IS: 10262-2009, "Recommended guidelines for concrete mix design, Bureau of Indian standard" New Delhi.
[13] IS 12269-1987,"Specification for 53 Grade Ordinary Portland Cement".
[14] IRC-SP: 46-1997, "Steel fibre reinforcement concrete for pavement".
[15] IS: 383-1970, Specification for coarse and fine aggregate from natural source of concrete, Bureau of Indian Standard New Delhi.
[16] IS: 516-1959, Method of Testing Strength of concrete, Bureau of Indian Standard New Delhi.

