INVESTIGATING DETERIORATION OF CONCRETE SURFACE USING ABRASION TESTING MACHINE

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Abstract - One of the most common forms of deterioration imposed on concrete structures is surface abrasion. Rubbing, scraping, skidding, or sliding of objects on the concrete surface are the main reason for abrasion wear. Relative motion between the surfaces and moving objects creates wear on the pavement and floors surface due to forces applied. Compressive strength of concrete surface can be assessed effectively by measuring its abrasion resistance. The testing program involves 48 concrete testing specimens using different grades of concrete. Each specimen (size 300 X 300 X 100 mm) representing concrete surface is tested for abrasion on both sides, after curing for 56 and 90 days. As per ASTMC799/C799M-05 dressing wheel testing concept is used to fabricate machine and to measure abrasion resistance of varying compressive strength of concrete. Wear depth occur on concrete surface by dressing wheels will be count by using micro-meter with least count of 0.01mm .

I. INTRODUCTION

The abrasion resistance of concrete surfaces is of great importance, particularly for concrete pavement or floors in an industrial context where they are subjected to wear from a variety of sources such as impact loading and abrasion from heavily loaded, steel/rubber-wheeled vehicles. Failures can cause considerable disruption and high repair costs. The measurement of abrasion resistance is not straightforward and there is no standard test method. On concrete surface mostly deterioration occurs due to wears such as abrasion, cavitation, and erosion due to various exposures [1]. Relative motion between the surfaces and moving objects creates wear on the pavement and floors surface due to forces applied. Concrete abrasion resistance occurs by a number of factors including concrete strength, aggregate properties, surface finishing, and type of hardeners. A large number of previous studies have indicated that concrete abrasion resistance is dependent upon compressive strength of the concrete means more the compressive strength less will be the abrasion of concrete. The factors such as water cement ratio, air entrainment, type of aggregates and their properties, curing etc. that affect the concrete strength, therefore, should also influence abrasion resistance [2]. Data on the abrasion resistance of concrete is needed to determine appropriate mixture proportions in order to make abrasion resistant concrete. This project was undertaken to investigate abrasion resistance of concrete.

II. LITERATURE REVIEW

Benjamin D. Scott and Md. Safiuddin "Abrasion Resistance of Concrete – Design, Construction and Case Study" ISSR Journals, Vol.6 (3)-Sept. 2015.

- One of the most common forms of deterioration imposed on concrete structures is surface abrasion. This mechanical wearing can be a catalyst for other forms of deterioration such as cracking and corrosion of reinforcing steel.

- This paper is intended to discuss the key aspects of concrete abrasion. The common sources and mechanics of the abrasion of concrete have been identified. The effects of constituent materials, mix composition and strength, and construction practices on the abrasion resistance of concrete have been discussed.

● This paper also identifies the common test methods that are used to determine the abrasion resistance of concrete. Finally, this paper illuminates several key points for future work on the abrasion resistance of concrete.

Yasasvi Challapalli, K.Prudhvi "Strength And Abrasion Resistance Of High Volume Fly-Ash Concrete Pavements" IOSR Journal of Mechanical and Civil Engineering Volume 13, Issue 5 Ver. I (Sep. - Oct. 2016), PP 122-126.

● This paper is undertaken to evaluate the abrasion resistance and strength resistance of concrete proportioned to have five levels of cement replacements (30, 35, 40, 45, 50%) using fly ash. A reference concrete without fly ash was proportioned to have the 28-day compressive strength of 40 MPa are tested and the concrete specimens were subjected to abrasion according to the ASTM C- 944 test method. In this work , all the concretes made with and without fly ash passed the abrasion resistance requirements per ASTM C-779.

● The fly ash makes concrete more impermeable and denser as compared to Ordinary Portland Cement. From observations the long-term strength (90 days and above) of fly ash concrete is better compared to plain concrete .

III. OBJECTIVES

● To study the abrasion resistance of concrete and its evaluation methodology.

● To fabricate portable machine which can assess the pavement surface.

● To evaluate abrasion resistance with respect to compressive strength and ingredients for serviceability.

IV. THEORETICAL CONTENT

While concrete is designed primarily to withstand structural loads it must also contend an array of 'environmental forces'. The environmental loading can include extreme temperatures, wetting and drying , freezing and thawing, sulphate attack , chloride-laden sea water ingress and other forms of natural attack. Abrasion can also be a form of natural attacks on concrete. It mechanically induces friction and rubbing that cause significant damages on concrete surface . In the worst case, abrasion can completely wear away concrete from structural elements [3]. There are various factors which affects the abrasion of concrete like paste hardness, aggregate hardness, aggregate/paste bond but problem arises because this factors are not taken into consideration , so in this paper we will test the concrete casted of different grade by considering factors and by adding inclusive materials like steel slag and superplasticizer to improved abrasion resistance of concrete.

There are different test methods to determine the abrasion resistance of concrete subjected to number of various types of abrasion. There are number of different tests used in various countries and it is clear that there is no single test that adequately measures the abrasion resistance of concrete under all conditions. For the purpose of this study, we have used concept of ASTM C779/779M-05, procedure-B, Revolving disk. The reasons for selection of this method are as given below.

1. Machine operates various abrasive forces.
2. Study the effects of abrasion resistance material used, curing and finishing procedure.
3. The number of revolution given is the representative of duration under traffic loading.
4. Used for quality acceptance of product [4].

The abrasion resistance of a concrete depends on its paste hardness, aggregate hardness and aggregate/paste bond. In general, the concrete's hardness, which is related to its strength determines how strong it will be to resist abrasion [3].

The concrete surface layer characteristics are directly associated with ability of the concrete to resist abrasion. The term of abrasion generally refers to dry attrition, floors, pavements, and hydraulic structures are subjected to abrasion; therefore, in these applications concrete must have a high abrasion resistance. Thus, all factors that affect compressive strength also affect abrasion resistance of concrete. The type of aggregate, mix proportion, workmanship, curing and surface finish or treatment used also have a strong influence on abrasion resistance [5].

V. MATERIAL USED FOR CASTING 48 CONCRETE SLABS OF 300 MM X 300 MM X 100 MM SIZE

• Cement : Ordinary Portland cement (53 grade) having specific gravity of 3.15.

• Coarse Aggregate : Nominal maximum size 20 mm.

• Fine Aggregate : River sand and Crush sand.

• Steel slag : Nominal maximum size 20 mm.

• Admixture : ASHTECH ASTROFLOW S – 46

• Flyash

Table No. 1 Properties of Material Used

Sr. No.	Material	Properties	Result
1.	Cement	Fineness Test	1.9 %
		Consistency Test	34 %
2.	Fine Aggregate	Sieve analysis	3.5
		Specific gravity	2.63
		Water absorption	4.87 %
3.	Coarse aggregate	Crushing value	12.69 %
		Abrasion value	6.3 %
		Specific gravity	2.63 %
		Water absorption	1.63 %

VI. MIX DESIGN FROM M20 TO M40 USED FOR CASTING 48 CONCRETE SLABS

Table No. 2 Concrete Mix Designs and Strength

Sr. No.	Designed Strength	Water-Cement ratio	Cement : Fine Aggregate : Coarse Aggregate	Average Compressive Strength of 28 days (N/mm^2)
1.	M 20	0.46	1 : 2.32 : 3.75	38.04
2.	M 20	0.46	1 : 2.1 : 3.97	42.54
3.	M 20	0.46	1 : 2.04 : 3.30	40.29
4.	M 20	0.46	2 : 2.04 : 3.30	39.22
5.	M 25	0.43	1 : 1.75 : 2.86	40.88
6.	M 30	0.48	1 : 1.75 : 2.86	42.66
7.	M 30	0.48	1 : 1.75 : 2.87	37.48
8.	M 30	0.48	1 : 1.75 : 2.88	41.33
9.	M 30	0.48	1 : 1.75 : 2.89	45.33
10	M 30	0.48	1 : 1.75 : 2.90	44.01
11.	M 35	0.44	1 : 2.4 : 3.02	49.55
12.	M 40	0.40	1 : 2.16 : 2.75	52.17

VII. PROJECT METHODOLOGY

The experimental work includes the study of abrasion resistance of concrete surface. For this 48 concrete slabs of size 300 X 300 X 100 mm will be cast according to different grades and proportions and abrasion testing machine will be fabricated according to ASTM C779 procedure B. Analysis of abrasion with respect to compressive strength will be carried out at the age of 56 days and 90 days.

Dimensions of machine which will be fabricated according to ASTM C779 procedure B to carry the experiment :

Rotating ram : 220 mm

Diameter of rotating wheel : 50 mm

Thickness of wheel : 25 mm

Diameter of vertical shaft : 15 mm

Electric motor : 90 W

Revolutions per minute (RPM) : 40

Weight : 25 kg

VIII. CONCLUSION

This study is concluded based on the literature review and experiments conducted till date. The following conclusions can be drawn on basis of the literature review:

1. Steel Slag can become a replacement for coarse aggregate in concrete production.

2. Concrete surface can be made more abrasion resistance by adding binder content, using superplasticizer, using hard aggregates, ensuring good curing.

3. Effect of compressive strength may vary the surface properties, life, hardening and abrasion of concrete.

4. Abrasion resistance of concrete increases as the compressive strength of concrete increases.

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