The Study of Marble Dust as Replacement Material in Concrete

Er. Aarti Arora, Er. Praveen Kumar

Abstract— **This paper reveals the focus of the study of marble dust as replacement material in concrete. Marble has been commonly used as a building material since the ancient times, In building industry. The disposal of the marble powder material, consisting of very fine powder, constitutes one of the environmental problems around the world. Marble blocks are cut into smaller blocks in order to give them the desired smooth shape. In India, marble dust is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. 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 potentially candidates for use in the production of self-levelling mortars (SLMs) and self-compacting concretes (SCCs). They can be compacted under their self-weight, with no external action, providing a considerable saving in time and energy.**

Index Terms— **Key Words**: Concrete, Cement, Fly ash, Aggregates, Pavements.
Sub Area: Construction Technology & Management
Broad Area: Transportation Engineering (Civil Engineering)

I. INTRODUCTION

A pavement is a multi-layered structural part of the road which is subjected to stresses imposed by vehicular loading applied, as well as to deterioration from the effects of weather and the abrasive action of moving traffic. A satisfactory pavement design is one that is able to withstand these effects for a required period of time. A pavement consists of a multi-layer system, which is formed of a number of layers of compacted unbound aggregates or bound materials. Pavements, in general, can be classified in two major categories: concrete pavements and bituminous pavements. Concrete pavements are generally called rigid pavements and bituminous pavements as flexible pavements. There could be some other types of pavements which are neither rigid, nor flexible, for example, block pavement, composite pavements etc. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed $100 billion in revenue by 2015. In the United States alone, concrete production is a $30-billion-per-year industry, considering only the value of the ready-mixed concrete sold each year.

There are three main components of a road pavement:
1. Foundation
2. Base
3. Surfacing

The foundation comprises of sub grade soil (cut or fill), capping and sub-base. The foundation is designed to provide a certain standard quality of support for the higher layers.

The base is the main structural layer of the pavement. Meanwhile, an asphalt surfacing comprises of a surface course and a binder course. The function of the surfacing is to enable good ride quality to be combined with appropriate resistance to skidding and resistance to crack formation.

A concrete pavement, in general, consists of three layers, comprising of a sub-grade, base layer and the concrete slab. Generally bound base layers are used for concrete pavement construction. As per Indian specification, some example of such base layers are Dry Lean Concrete (DLC), Roller Compacted Concrete (RCC) (IRC:15-2002).The concrete slab is generally of M40 to M50 grade of concrete as per Indian specifications, and is called as paving quality concrete (PQC).

USE OF MARBLE DUST AS REPLACEMENT MATERIAL IN CONCRETE

The feasibility of the waste material recovery process is particularly influenced by the simultaneous satisfaction of the economic, technical and normative aspects for each field of use. Once the economic convenience has been assessed, the experimentation must verify that the physicochemical characteristics attained after treatment are suitable to the specific project solutions for which they are intended. In modern times, researchers have experimented with the addition of other materials, like water-based cross linking polymers, to create concrete with improved properties, such as higher strength, electrical conductivity, or resistance to damages through spillage.

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Table :Sieve analysis of coarse aggregate (20mm)

Weight of sample taken = 3000gm					
Sr. No	IS-Sieve (mm)	Wt. Retained(gm)	%age retained	%age passing	Cumulative % retained
1	80	0.00	0.00	100.00	0.00
2	40	0.00	0.00	100.00	0.00
3	20	53.00	1.77	98.23	1.77
4	10	2938.50	97.95	0.28	99.72
5	4.75	5.50	0.18	0.10	99.90
6	Pan	3.00	0.10	0.00	
	Total	3000.00	SUM	201.38 + 500 = 701.38	Total
				FM =	*7.01*

Table :Properties of Marble dust

Sl. No.	Test performed	Results
1.	Specific gravity	2.47
2.	Moisture content	1.5%
3.	Water absorption	2%
4.	Bulk density	1480
5.	Grading	Zone II
6.	Fineness modulus	1.5

Fig. -Marble Dust used in Experiment

SUPERPLASTICIZER

Table : Properties of Superplasticizer

Sr. No.	Characteristics	Value
1.	Type	Polycarboxylic ether (PCE)
2.	Form	Liquid
3.	Colour	Light Brown
4.	Specific Gravity	1.09
5.	Relative density	1.09 0.01 at 250C
6.	pH Content	>6
7.	Setting Time	There may be mild extension of initial or final

WATER

The potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used for making concrete available in Material Testing laboratory. This was free from any detrimental contaminants and was good potable quality.

Table :Composition of M-60 Grade Concrete

Mix Designation	C (kg/m^3)	MD (kg/m^3)	MD (%)	FA (kg/m^3)	CA (kg/m^3)	SP (L/m^3)	Water (L/m^3)	w/c ratio
M 1	480	0	0	660	1050	10.8	162	0.35
M 2	480	33	5	627	1050	10.8	162	0.35
M 3	480	66	10	594	1050	10.8	162	0.35
M 4	480	99	15	561	1050	10.8	162	0.35
M 5	480	132	20	528	1050	10.8	162	0.35

C - cement, MD – Marble Dust, FA – fine aggragates, CA – coarse aggregates , SP – super plasticizer

RESULTS AND DISCUSSION

STRENGTH PROPERTIES

The results of strength properties for marble dust mixes containing different percentages of marble dust are discussed below.

Compressive strength

The mix M_1 was used as control mix i.e MARBLE DUST content as 0% and compressive strength at 28 days was 68.50 MPa.

Table Compressive Strength Results

Mix	7 Days	28 Days	56 Days
M1 (MPa)	44.50	68.50	75.35
M2 (MPa)	48.10	76.72	84.00
M3 (MPa)	51.20	78.78	85.87

M4 (MPa)	51.70	78.40	85.45
M5 (MPa)	50.31	77.40	83.98

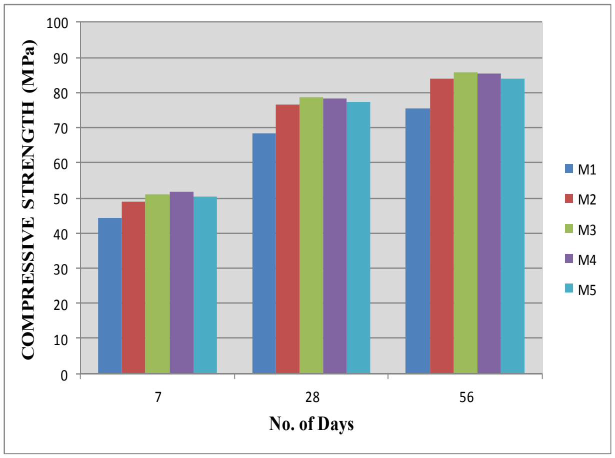


Fig- COMPRESSIVE STRENGTH TEST

Split tensile strength

Table -Split Tensile Strength Results

Mix	7 Days	28 Days	56 Days
M1 (MPa)	3.49	4.31	4.91
M2 (MPa)	4.70	5.53	6.30
M3 (MPa)	3.80	4.64	5.30
M4 (MPa)	3.77	4.61	5.24
M5 (MPa)	3.17	3.87	4.41

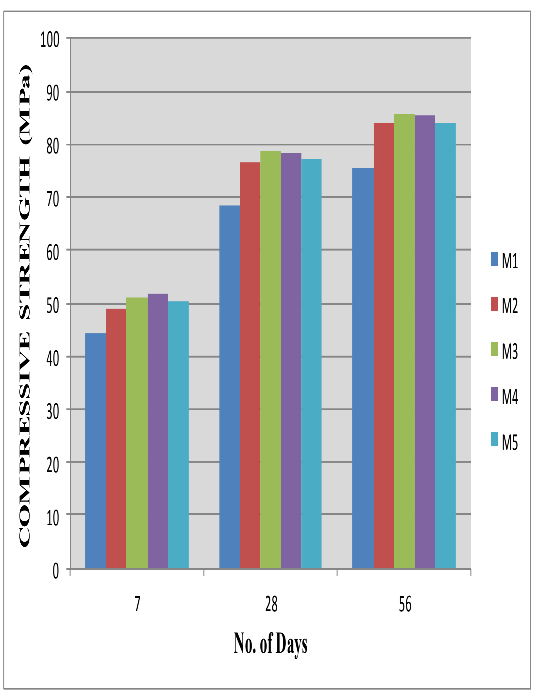


Fig 4.2 SPLIT TENSILE STRENGTH

TEST RESULTS

Flexural strength

Table - Flexural Strength Results

Mix	7 Days	28 Days
M1 (MPa)	2.20	3.55
M2 (MPa)	2.29	3.64
M3 (MPa)	2.38	3.90
M4 (MPa)	2.67	4.65
M5 (MPa)	2.62	4.58

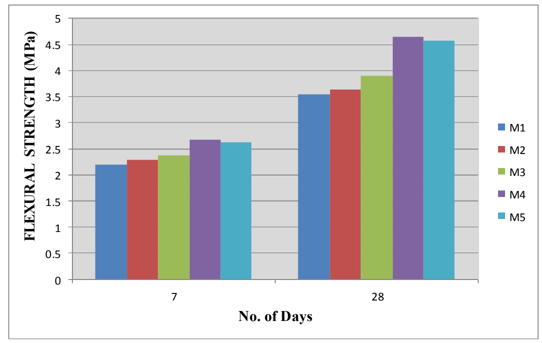


Fig - FLEXURAL STRENGTH TEST RESULTS

DURABILITY STUDIES

Durability of concrete means its resistance to deteriorating influences, which may reside inside the concrete itself, or to the aggressive environments. The ability of concrete to resist weathering action, chemical attack, and abrasion is known as durability. Factors affecting durability are surface wear, cracking due to crystallization of salts in pores, exposure to temperature extreme such as during frost action/ fire. Expansion reaction involving sulphate attack, alkali aggregate reaction and corrosion of embedded steel in concrete.

1% Solution

Table -Durability (1% solution) Results

Mix	28 Days	56 Days	56days/28days
M1 (MPa)	67.71	74.50	1.10
M2 (MPa)	75.13	83.25	1.11
M3 (MPa)	78.07	84.94	1.08
M4 (MPa)	77.52	84.44	1.09
M5 (MPa)	76.30	83.15	1.08

5% Solution

The ratio between compressive strength for mixes M_1, M_2, M_3 and M_4 at ages 56days-to-28days was found to be varying from 1.09-1.12 as shown in Table 4.5, when cured in 5% sodium chloride and sodium sulphate solution. The decrease in 56-day compressive strength of M_1, M_2, M_3 M4 and M_5, cured in 5% solution, was found to be 2.84%, 2.2%, 2.27%, 2.42% and 4.4%, when compared to specimen cured in water.

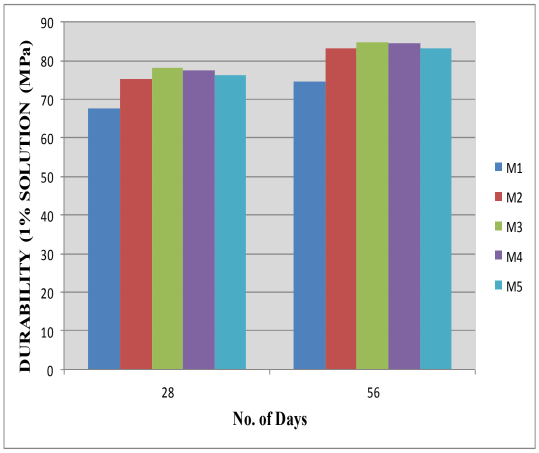
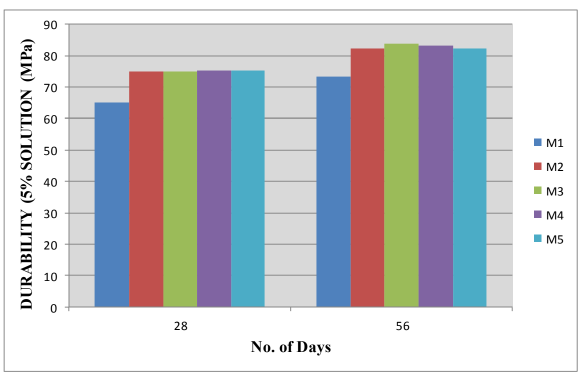


Fig. 4.4 DURABILITY RESULTS (1%SOLUTION)

Table 4.5 Durability(5% solution) results of CFRC mixes

Mix	28 Days	56 Days	56days/28days
M1 (MPa)	65.12	73.21	1.12
M2 (MPa)	74.87	82.14	1.10
M3 (MPa)	75.07	83.92	1.11
M4 (MPa)	75.32	83.38	1.10
M5 (MPa)	75.14	82.17	1.09



CONCLUSIONS

From the experimental results, the following conclusion can be drawn:
Compressive Strength

The fresh properties of all mixes satisfied the ranges specified by IS Code.
The 7-day compressive strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 8.08%, 15.05%, 16.17% and 13.05% respectively, when compared to strength at 0% marble dust content.
The 28-day compressive strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 12%, 15%, 14.04% and 12.9% respectively, when compared to strength at 0% marble dust content.
The 56-day compressive strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 11.4%, 13.9%, 13.40% and 11.40% respectively, when compared to strength at 0% marble dust content.
It is concluded that the concrete mix with 10 percent marble dust as replacement of sand is the optimum level as it has been observed to show a significant increase in compressive strength at 7, 28 and 56 days when compared with nominal mix.

Split Tensile Strength
The 7-day Split Tensile strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 13.46%, 8.88%, 8.02%, and decreased by 10% respectively, when compared to strength at 0% Marble dust content.
The 28-day split tensile strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 23.66%, 7.65%, 6.73% and decreased by 11.3% respectively, when compared to strength at 0% Marble dust content.
The 56-day split tenslie strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 28.83%, 8.00%, 6.70% and decreased by 11.40% when compared to strength at 0% Marble dust content.
It is concluded that the concrete mix with 5 percent marble dust as replacement of sand is the optimum level as it has been observed to show a significant increase in split tensile strength at 7, 28 and 56 days when compared with nominal mix.
Flexural Strength
The 7-day flexural strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 4%, 8%, 21% and 19% respectively, when compared to strength at 0% Marble dust content.
The 28-day flexural strength of mixes with marble dust content of 5%, 10%, 15% and 20%, were found to be increased by 2%, 10%, 31% and 28% when compared to strength at 0% Marble dust content.
It is concluded that the concrete mix with 15 percent marble dust as replacement of sand is the optimum level as it has been observed to show a significant increase in flexural strength at 7 and 28 days when compared with nominal mix.
Durability
The 56-day durability (1% solution) of mixes with marble dust content of 0%, 5%, 10%, 15% and 20%, were found to be decreased by 1.1%, 0.89%, 1.08% 1.18% and 3.29% respectively.
The 56-day durability (5% solution) of mixes with marble dust content of 0%, 5%, 10%, 15% and 20%, were found to be by 2.84%, 2.2%, 2.27% 2.42% and 4.4% respectively.
It is concluded that the concrete mix with different percentage marble dust as replacement of cement is the optimum level as it has been observed to show a significant decrease in compressive strength at 28 and 56 days when compared with nominal mix. It means the marble dust does not give good results in case of durability.
Further study can be made by increasing the percentage of marble content. Different types of waste materials like plastic waste, foundry sand, rubber waste, rice husk, glass powder waste, furnace slag etc. may be used for future investigation.In durability properties, concrete mixes

containing marble dust exposed to freezing and thawing cycles, can be investigated.Further study can be done on concrete mixes containing marble dust subjected to elevated temperatures.

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