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Comparative Study on the Effects of Steel Slag Aggregate over Blended Cement Concrete

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Abstract: Concrete is the most versatile construction material because it can bedesigned to withstand the harshest environments while taking on the most inspirational forms. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and alternative construction materials (ACM). Nowadays, most concrete mixture contains alternative construction materials which form part of the cementitious component. These materials are majority byproducts from other processes. The main benefits of ACM (alternative construction materials) are their ability to replace certain amount of cement or aggregates and still able to display major properties similarto concrete, thus reducing the cost of using traditional materials. The fast growthin industrialization has resulted in tons and tons of byproduct or waste materials, which can be used as ACMs (alternative construction materials) such as marble powder, silica fume, ground granulated blast furnace slag, steel slag etc. The use of these byproducts not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states. Most concrete produced today includes one or more ACM (alternative construction materials). For this reason, their properties are frequently compared to each other by mix designers seeking to optimize concrete mixtures. To design high strength concrete good quality aggregates is also required. Steel slag is an industrial byproduct obtained from the steel manufacturing industry. This can be used as aggregate in concrete. It has been usually used as aggregate in hot mix asphalt surface applications, but in the present work it has been used in conventional concrete mixture and performance is compared with normal aggregate concrete. Replacing all or some portion of natural aggregates with steel slag would lead to considerable environmental benefits. Steel slagaggregate generally exhibit a propensity to expand hence steel slag aggregates are generally not used in concrete making. However, use of blended cement concrete is reported to reduce the expansion of the concrete. In the present work a series of tests were carried out to make comparative studies of various mechanical properties of concrete mixes prepared by using normal cement concrete, marble powder and cement blend concrete (1:1 proportion) with or without use of steel slag. The ingredients are mixed in 1: 1.5: 3 proportions. The properties studied are 7 days, 14 days and 28 days compressive strengths, workability and surface hardness.
Keywords: Cement, Concrete, Steel Slag, Aggregates, Blended Cement,Marble Powder.

I. INTRODUCTION

Concrete is a fusion of cement, coarse aggregate, fine aggregates and water. Its success lies in its adaptability as can be designed to resist cruel environments although taking on the most inspirational forms. Scientists and Engineers are further aiming to enhance its limits with the help of novel chemical admixtures and various Alternative construction materials (ACMs).

Previously ACMs (Alternative construction materials) comprises of readily available materials, natural like diatomaceous earth or volcanic ash. The engineering marvels like Roman aqueducts, the Coliseum are examples of this practice used by Romans and Greeks. Currently, the majority concrete mixture consists ACMs (Alternative construction materials) which are mainly by-product or waste materials from other industrial processes.

A. Marble Powder as ACM

The development of concrete technology can decrease the use of natural resources and energy sources and lowers the load of pollutants on atmosphere. Currently huge amountof marble dust are produced in natural stone processing plants with a significant impact on environment and human beings. In building industry, Marble has been frequently used for different purposes like cladding, flooring, etc. The industrial removal of the marble powder material is in the form of a fine powder and constitutes as one of the atmospherically problems in the world. In India, marble dust is settled by sedimentation and then dumped away, results in environmental pollution. In addition to form dust in summer, threats both public health and agriculture. Therefore, consumption of the marble dust in various firms especially in construction, agriculture, paper and glass industries helps to protect the surroundings. Some measures have been taken to assess the chances of using waste marble powder in concrete and mortars and results of strength

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and workability were evaluated with control samples of traditional cement concrete. Some measures have been taken to assess the chances of using waste marble powder in concrete and mortars and results of strength and workability were evaluated with control samples of traditional cement concrete.

FIG. 1 Marble Powder

B. Steel Slag

Steel slag is a derivative of steel manufacturing, is generated during the separation of molten steel from impurities in steel production furnaces. These can be utilized as aggregate in concrete. Steel slag aggregate usually shows a tendency to swell because of the existenceof magnesium oxides and free lime that have not reacted with the silicate structure and that can hydrated and swell in moist atmosphere. This potentially expansive nature (volume transforms up to 10 % or more attribute able to the hydration of calcium oxide and magnesium) might originates complexity with products including steel slag, and is one reason why steel slag aggregate are not used in concrete. Steel slag is presently used as aggregate in hot mix asphalt surface purposes, but there is a call for for some supplementary work to resolve the possibility of utilizing this industrial derivative more wisely as a substitute for both fine and coarse aggregates in a traditional concrete mixture. Maximum volume of concrete contains aggregates. Substituting all or some fraction of natural aggregates with steel slag would lead to substantial environmental benefits. Steel slag has more specific gravity, high abrasion value than normal aggregates apart from the disadvantages such as high-water absorption, high alkalis. Consequently, with appropriate treatments it can be utilized as coarse aggregate in concrete.

Fig 2 – Steel Slag

II. EXPERIMENTAL WORK

Table No. 1 – Result of sieve analysis of sand

Sieve size	Weight Retained in gm	% passing
4.75 mm	16 gm	98.4
2.36 mm	11 gm	97.3
1.18 mm	65 gm	90.8
600 micron	391 gm	51.6
300 micron	420 gm	9.4
150 micron	82 gm	1.2
Total	1000 gm	-

A. Physical Properties of Sand

Table No. 2 – Properties of sand

Fine aggregate	Specific gravity	Water absorption %
Sand	2.65	0.6

Table 3 Proportion of all the ingredients in prepared mix of 1:1.5:3 in Kg

Water	Cement/ Blended Cement (1:1)	Course aggregate	Sand
1.5	4	12	6

Table 4 Concrete mixes prepared with variation in Steel Slag Aggregates

Category of Mix	Mix no.	Ingredients (Kg)					
		Cement	Marble Powder	Sand	Coarse Aggregate	Steel Slag	% Steel Slag
C1 (Plain cement concrete)	C100	4	0	6	12	0	0
	C105	4	0	6	11.4	0.6	5
	C110	4	0	6	10.8	1.2	10
	C115	4	0	6	10.2	1.8	15
	C120	4	0	6	9.6	2.4	20
	C125	4	0	6	9.0	3.0	25
C2 (Blended cement concrete)	C200	2	2	6	12	0	0
	C205	2	2	6	11.4	0.6	5
	C210	2	2	6	10.8	1.2	10
	C215	2	2	6	10.2	1.8	15
	C220	2	2	6	9.6	2.4	20
	C225	2	2	6	9.0	3.0	25

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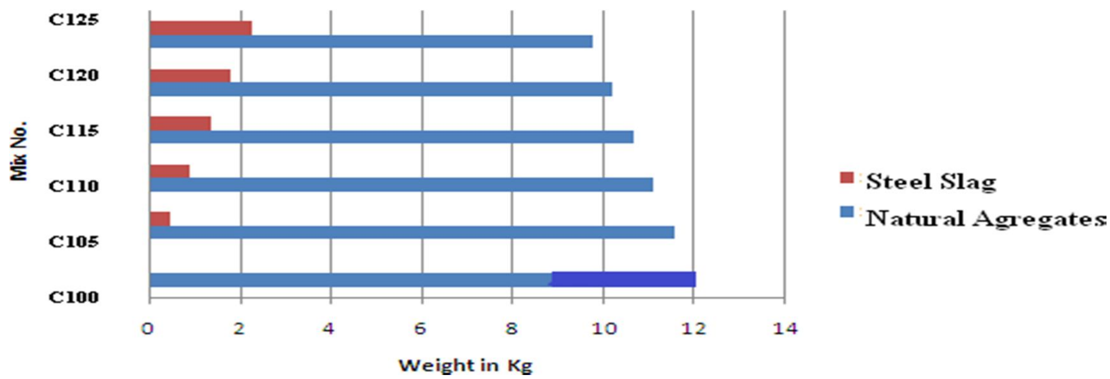

Fig. 3 – weight of ingredients in C1 category mix

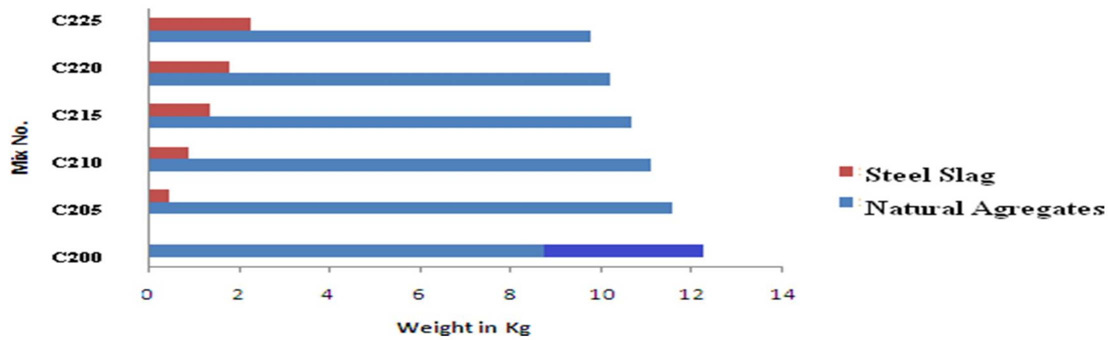

Fig. 4 – weight of ingredients in C2 category mix

From collection of materials to analysis of results presents the methodology of the present work. This research has been divided in separate steps. Following Flow chart will presentthe methodology involved in the present work.

Collection of waste materials

↓

Replacement of aggregate with steel slag in blended cement concrete in different percentage by weight

↓

Evaluation of strength, and workability of normal and steel slag concrete with blended and non blended cement

↓

Comparison of results for all the materials on each selected parameter

Fig. 5 – Flow chart of Methodology

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III. RESULTS AND DISCUSSION

A. Results of 7 days Compressive Strength

After testing of cubes in 7,14 and 28 days by Universal testing machine and resultsshows in table

Table 5– Results of 7 days Compressive strength

S. No.	Mix no.	Cube 1	Cube 2	Cube 3	Average
1	C100	13.2	13.3	13.2	13.23
2	C105	13.5	13.6	13.6	13.57
3	C110	13.9	14.2	14.1	14.07
4	C115	14.8	15	15.1	14.97
5	C120	15.1	15.4	15.2	15.23
6	C125	15.4	15.4	15.5	15.43
7	C200	13.8	13.9	14.2	13.97
8	C205	14.3	14.5	14.6	14.47
9	C210	15.1	15.3	15.1	15.17
10	C215	15.6	15.9	15.8	15.77
11	C220	16.6	16.8	16.8	16.73
12	C225	17.1	17.2	17.1	17.13

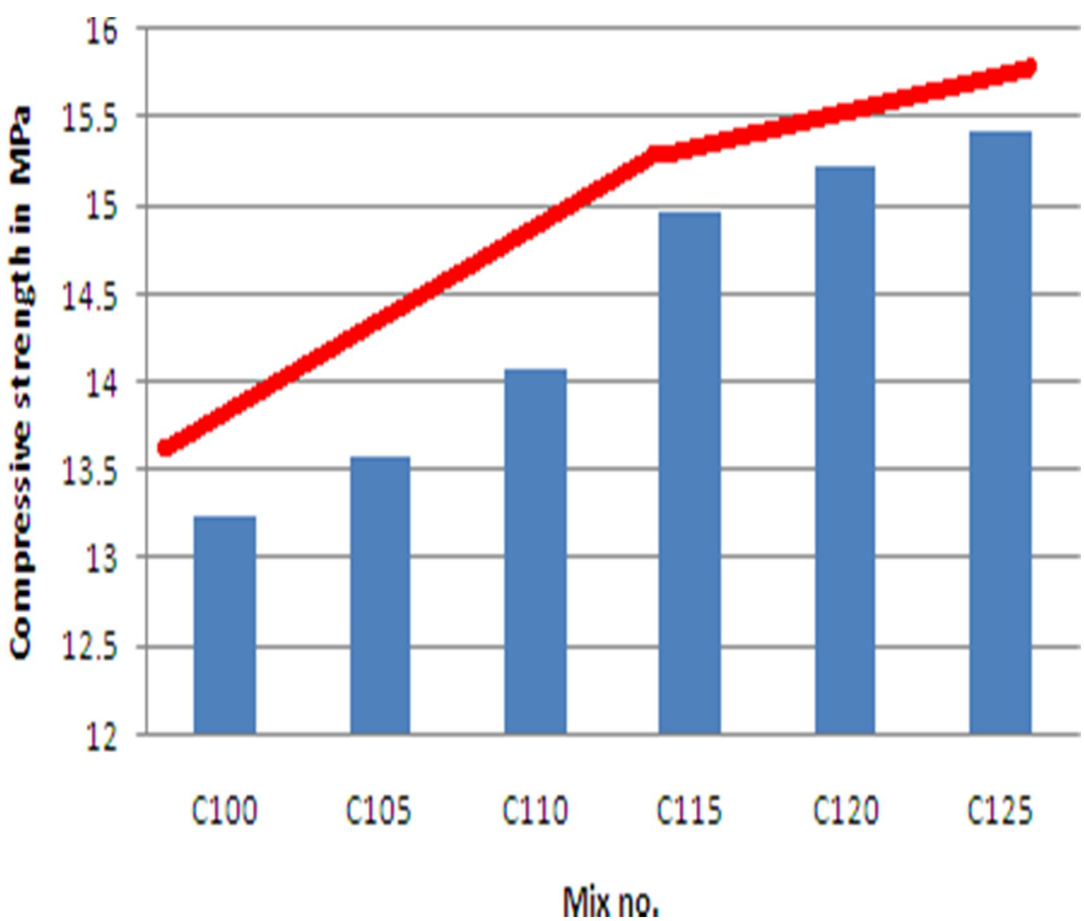

Fig. 6– 7 days compressive strength of C1(ordinary portland cement) category mix

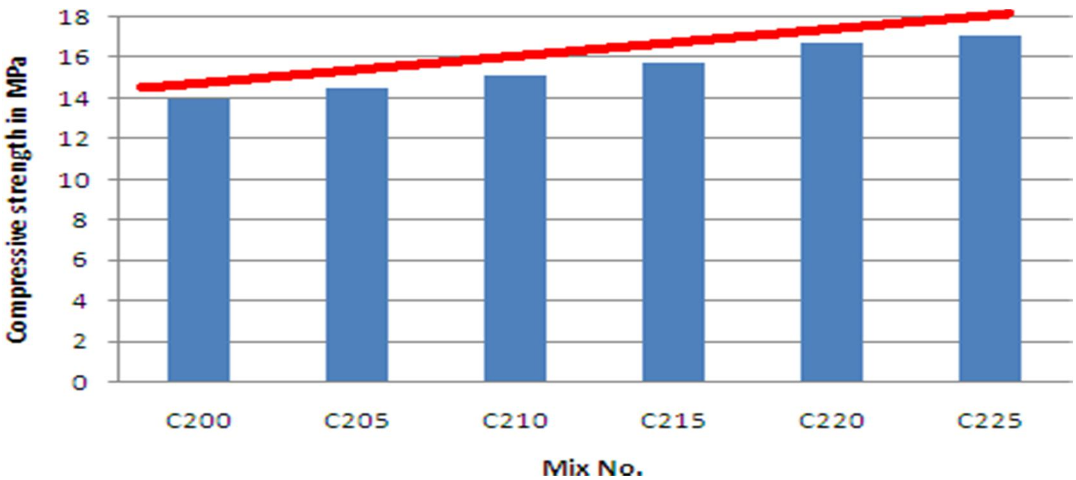

Fig. 7 – 7 days compressive strength of C2(Blended cement) category mix

B. Results of 14 days Compressive Strength

Table 6 – Results of 14 days Compressive strength

S. No.	Mix no.	Cube 1	Cube 2	Cube 3	Average
1	C100	15.8	15.7	15.9	15.80
2	C105	16.6	16.4	16.6	16.53
3	C110	16.9	17	16.7	16.87
4	C115	17.4	17.6	17.6	17.53
5	C120	17.8	18.2	18.1	18.03
6	C125	18.4	18.7	18.4	18.50
7	C200	16.5	16.3	16.5	16.43
8	C205	17.1	16.9	17.3	17.10
9	C210	17.6	17.5	17.7	17.60
10	C215	18.1	18.3	18	18.13
11	C220	18.9	18.8	18.7	18.80
12	C225	19.6	19.4	19.8	19.60

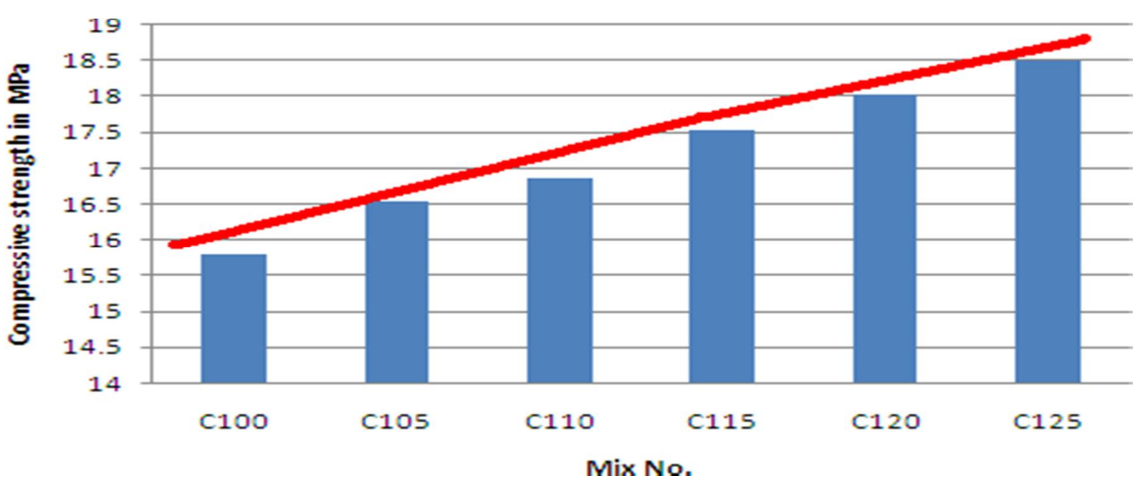

Fig. 8 – 14 days compressive strength of C1 (ordinary Portland cement)category mix

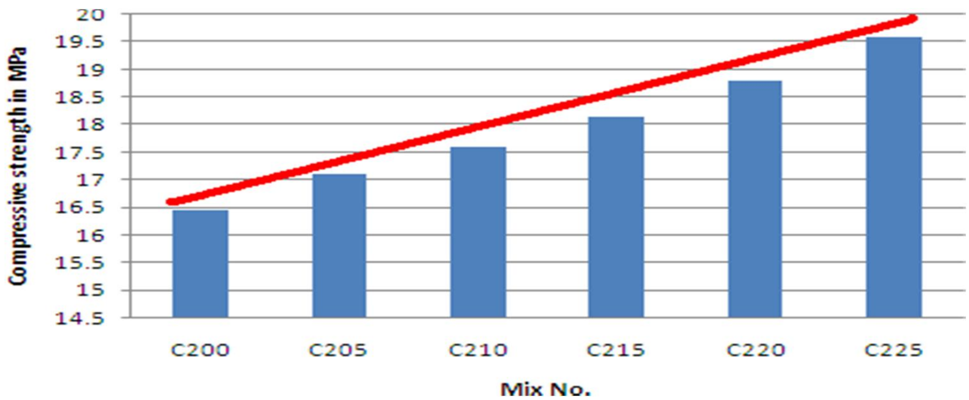

Fig. 9 – 14 days compressive strength of C2(Blended cement) category mix

C. *Results of 28 days Compressive Strength*

Table 7 – Results of 28 days Compressive strength

S. No.	Mix no.	Cube 1	Cube 2	Cube 3	Average
1	C100	19.2	19.3	19.2	19.23
2	C105	19.7	19.5	19.4	19.53
3	C110	20.2	20.4	20.3	20.30
4	C115	20.8	20.7	20.8	20.77
5	C120	21.1	21.3	21.4	21.27
6	C125	21.6	21.6	21.8	21.67
7	C200	19.6	19.7	19.9	19.73
8	C205	20.3	20.4	20.4	20.37
9	C210	20.8	20.9	20.8	20.83
10	C215	21.5	21.7	21.6	21.60
11	C220	21.9	21.8	22.1	21.93
12	C225	22.4	22.7	22.5	22.53

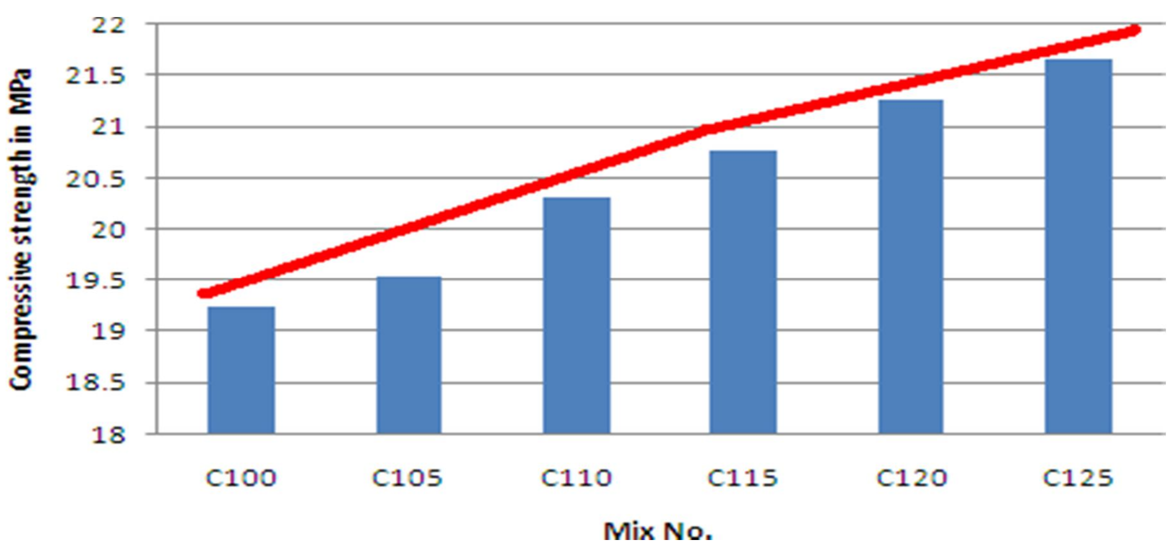

Fig. 10 – 28 days compressive strength of C1 (ordinary portland cement) category mix

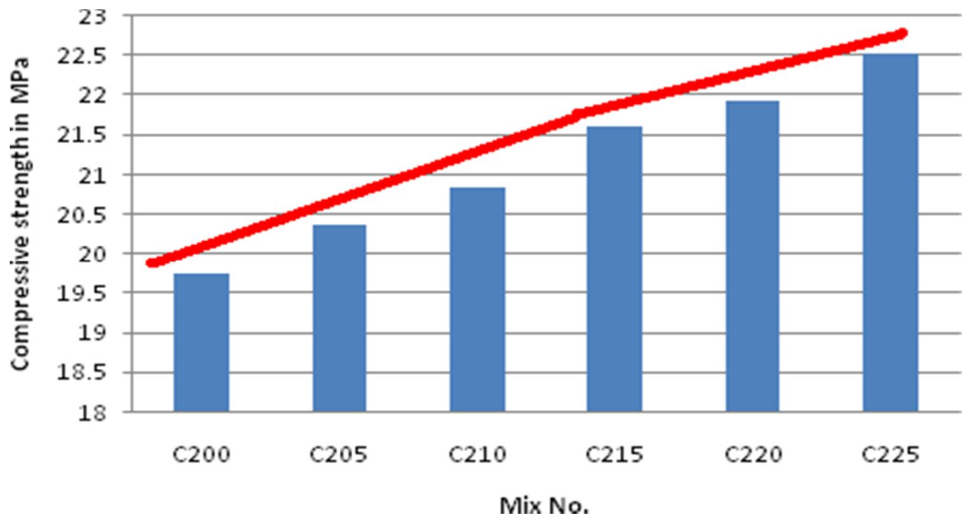

Fig. 11– 28 days compressive strength of C2(Blended cement)category mix

D. Results of Slump Cone Test

Table 8 – Results of Slump Cone Test

S. No.	Mix no.	Slump Value(mm)
1	C100	97
2	C105	92
3	C110	86
4	C115	78
5	C120	74
6	C125	68
7	C200	108
8	C205	102
9	C210	94
10	C215	87
11	C220	81
12	C225	73

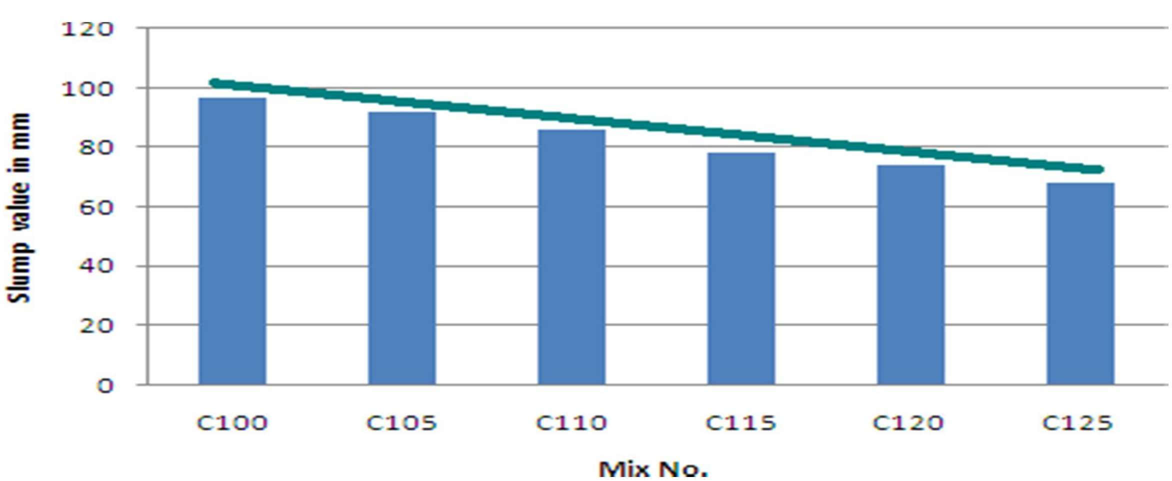

Fig. 12– Slump value in mm for C1 (ordinary portland cement)category mix

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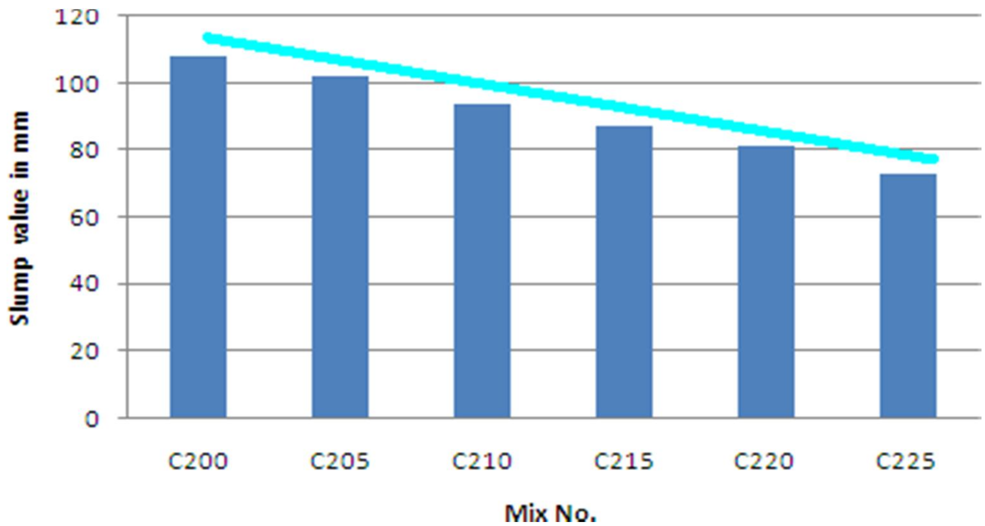

Fig. 13– Slump value in mm for C2(blended cement)category mix

IV. CONCLUSIONS AND FUTURE SCOPE

A. Conclusions

In the present work marble powder and steel slag have been investigated as alternate cementitious materials. Concrete mixes have been prepared by replacing cement with these materials in different percentage, thereafter, their compressive strength and slump values are determined and compared with ordinary Portland cement concrete values. Two categories of concrete mixes C1(ordinary blended cement) and C2(blended cement) have been prepared in C1(ordinary blended cement) category ordinary cement has been used and in C2 (blended cement) category blended cement with 1:1 ratio of cement and marble powder has been used. Following are the conclusions of the present work

1) Suitability of waste materials such as marble powder, and steel slag as alternative construction material has been investigated.
2) The concrete mixes formed by using above materials have been tested for Compressive strength after 7, 14 and 28 days and Workability.
3) Concrete mix of grade M 20 has been considered for performing the present study.
4) Water cement ratio has been considered as 0.5 for optimum consistency.
5) Two categories of concrete mixes have been prepared in first category ordinary cement has been used and in second category blended cement with 1:1 ratio of cement and marble powder has been used.
6) In each category steel slag replaced coarse aggregates in 5 different percentage 5%, 10%, 15%, 20% and 25% by weight. For each replacement 3 cubes have been casted and average value of measured quantity has been considered.
7) Strength of concrete increases with the increase in proportion of steel slag in concrete.
8) Slump value reduces with the increase in the proportion of steel slag.
9) In C1 (ordinary blended cement) category compressive strength increases rapidly when content of steel slag is more than 15%. However, for C2(blended cement) category mixes, development of strength is very high even with low proportion of steel slag, when compared to C1(ordinary blended cement) category mixes. In C1(ordinary blended cement) and C2 (blended cement) category compressive strength increase rapidly up-to 15% content of steel slag. Moreover, for C2 (blended cement)category mixes, development of strength is more than C1 (ordinary blended cement) category mixes.
10) Slump value for C1(ordinary blended cement) category mixes is lower than slump of C2(blended cement) category. Workability of both the category mixes decreases with the enhancement in the proportion of steel slag.

B. Future Scope

To investigate the appropriateness and effectiveness of alternative materials in civil engineering works and materials, as a replacement to chief constituents, further more results have been required.

1) This work can be extended for high grade of concrete.
2) Mix design of concrete by using other waste materials.

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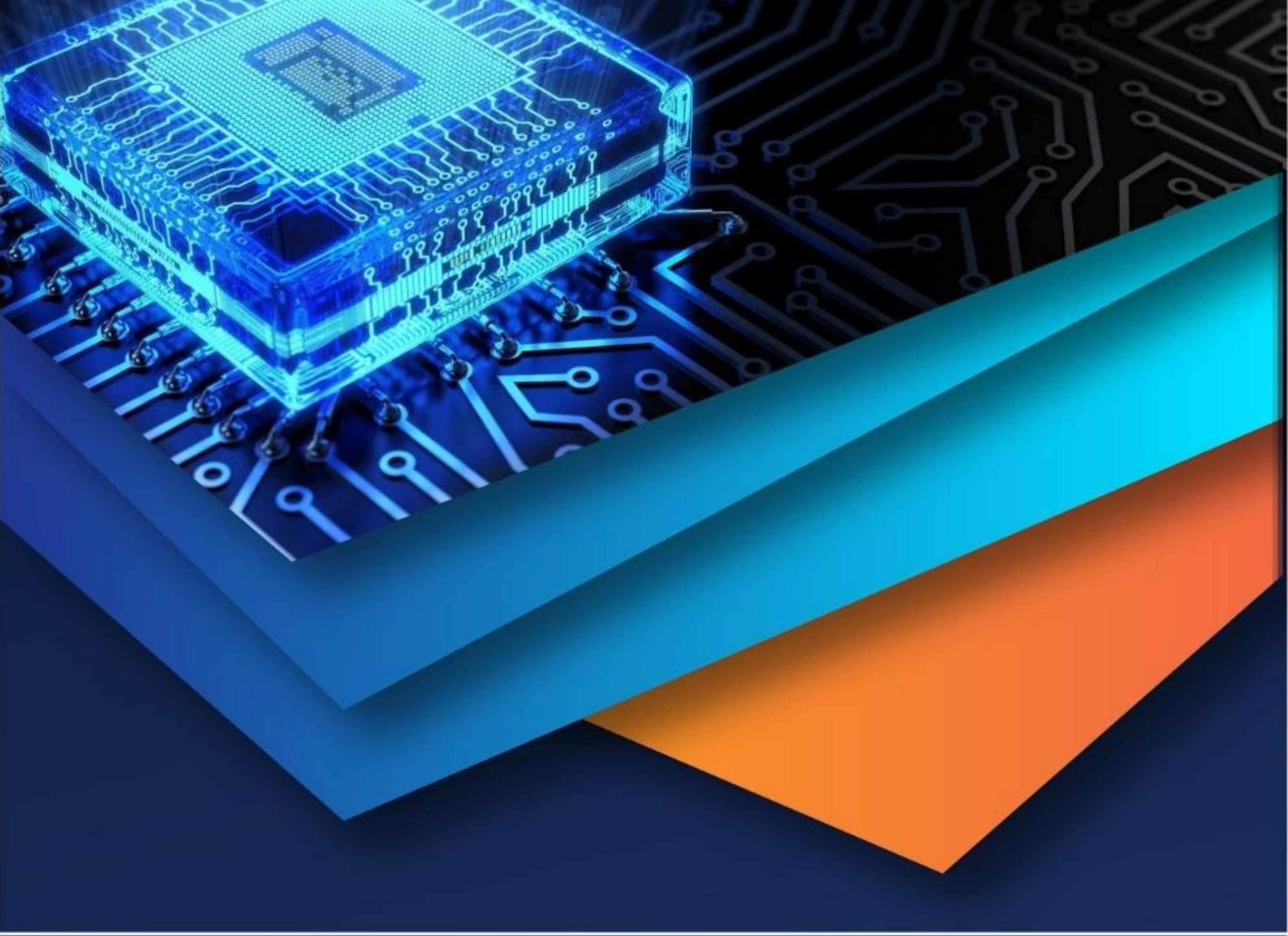

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