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INFLUENCE OF NANOSILICA AND MICROSILICA ON THE STRENGTH PARAMETERS OF CONCRETE CONTAINING RECYCLED AGGREGATES

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I. ABSTRACT

***D**evelopment of cities is increasing at an alarming rate now a day. This development demands for a huge amount of building material. The stone aggregates being a major component of concrete are not locally available in the cities and hence acute shortage is faced by the construction industry. Further, due to demolition of old structures in cities the waste concrete is laying as it is without any use and with no specific dumping place. Thus it is required to recycling and reusing the waste material with any possible manner. In the present study recycled aggregates are used in the concrete and the effect of nanosilica and microsilica on recycled aggregate concrete has been investigated. In the first series of tests natural aggregates are replaced by recycled aggregates in varying percentages i.e. 20%, 30%, 40% and 50%. In the second series of tests, cement was partially replaced by microsilica and nanosilica by 5%, 8% and 10% and 1%, 2% and 3% respectively both in natural aggregate concrete and recycled aggregate concrete. Further, cement was replaced by both nanosilica and microsilica i.e. (1%, 2%) and (5%, 8%) respectively in concrete containing fresh aggregates as well as partial recycled aggregates.*

The results obtained from the study showed that a maximum decrease of 18% was observed when 50% recycled aggregates are used. The addition of both nanosilica and microsilica improved the compressive strength at early ages in natural as well as recycled aggregate concrete. The maximum compressive strength was observed in concrete containing 2% nanosilica & 5% microsilica. Maximum compressive strength for nanosilica and microsilica was observed at 2% and 8% respectively. Increase in about 30% of strength was observed when combinations of 1% nanosilica with 8% microsilica & 2% nanosilica with 5% microsilica were used.

I. INTRODUCTION

Indian construction industry today is amongst the five largest in the world and at the current rate of growth, it is slated to be amongst the top two in the next century. Aggregates supply has also emerged as a problem in some of the metropolis in India. With the shortage as likely seen today the future seems to be in dark for the construction sector. The requirements of natural aggregates are notonly required to fulfill the demand for the upcoming projects, but also are the needs of the extensive repairs or replacements required for the existing infrastructure and dilapidated buildings built few decades back. Construction and demolition disposal has also emerged as a problem in India. India is presently generating construction and demolition waste to the tune of 10-12 million tons, which is comparable to some of the developed nations and these figures are likely to double fold in the next 7 years. The management of construction and demolition waste is a major concern due to increased quantity of demolition rubble, continuing shortage of dumping sites, increase in cost of disposal and transportation and above all the concern about environment degradation. Although a substantial portion of construction materials could be substituted by re-processed construction waste material, these options are not exercised in developing countries due to lack of knowledge and insufficient regulatory frameworks resulting in waste getting piled up causing disposal problems. The increasing problems associated with construction and demolition waste have led to a rethinking in developed countries and many of these countries have started viewing this waste as resource and presently have fulfilled a part of their demand for raw material. Since concrete composes 35% of the waste as per the survey conducted by Municipal Corporation of Delhi, India may also have to seriously think of reusing demolished rubble and concrete for production of recycled construction material. Work on recycled concrete has been carried out at few places in India but waste and quality of raw material produced being site specific, tremendous inputs are necessary if recycled material has to be used in construction for producing high-grade concrete.

II. UTILIZATION OF RAC BY DIFFERENT COUNTRIES

Recycled aggregates have been successfully used in concrete production for more than half century. In Europe, recycling waste industries are well established. After the Second World War, European countries have been utilizing the C&D waste for concrete production. The European Demolition Association calculated that, approximately 200 million tons of wastes are generated every year in Europe (Tabsh and Abdelfatah 2009). But currently, only 30% of the waste is being recycled. In Europe, recycling and reusing of C&D waste is a popular and well supported program by the European Commission on Management of Construction and Demolition Waste. The target levels of recycling C&D waste of different European Union members are varied from 50% to 90% (Tabsh and Abdelfatah 2009). On the other hand, some of the European Union countries are still struggling to achieve this high recycling rate such as the recycling rate of Spain and Greece is about less than 20% where Ireland, Germany, Netherland, and Denmark, effectively achieve recycling rate which is higher than 70% (Jeffrey 2011).

Currently in USA, around 2.2 billion tons of virgin aggregates are being produced every year (USGS 2009) and about 10-15% of this quantity is used for pavements. In addition, other maintenance and construction works for roads are required further 20-30% of aggregate. The rest amount of aggregate is consumed for structural applications, which is about 60-70%. In USA, 50% of recycled aggregate is produced by natural aggregate producer, 14% by debris recycling center, and 36% by contractors. Many initiatives were taken to facilitate the application of recycled aggregate but initially the application was limited for road construction as base or filler material (Gilpin et al. 2004). A geological survey carried out in 2000 revealed that every year almost 100 million tons of recycled concrete aggregate is produced in US. This huge amount of recycled concrete aggregate is utilized by various sectors such as asphalt pavement (9%), new concrete production (6%), riprap (14%), base materials (68%), and other (7%) (Li 2005). California, Michigan, Texas, Minnesota, and Virginia are taking the initiative regarding the utilization of recycled aggregate in new concrete (FHWA 2004). Minnesota Department of Transportation succeed to save $600,000 by using recycled aggregate to construct a 16 miles plain concrete pavement in 1980 (Salem et al. 2003). It is possible to save $11 in every 1000 kg by using recycled concrete aggregate instead of natural aggregate (Smith etal. 2008).

The use of RCA is very specific and limited in Canada. It is estimated that the utilization of RCA is only 3% in Ontario (Miller 2005). Previously, Ministry of transportation ofOntario (MTO) did not encourage the use of recycled aggregate in construction. Later they started to use blending aggregates (natural and recycled) for the sub base and base of concrete pavement (Gilbert 2005).

Among the Asian countries, Japan has a very fascinated and enriched research history regarding RAC. Due to the structural safety requirement very little amount of recycled aggregate is being used in the real case scenario/field. Never the less in 1991 recycling law was established by Japan government, to encourage the reuse of demolition waste specially the waste concrete. After this initiative the rate of application of recycled aggregate increased from 48% (1990) to 96% in 2000, though they were mostly as a sub-base materials for concrete pavement (Kawano 2003).

Every year 14 million tons of wastes are generated in Hong Kong. Earlier, non-hazardous wastes were used for land reclamation process. Due to various difficulties this recycling process was hindered. SAR government of Hong Kong started a pilot project incorporating recycling facility of C&D waste where daily recycling capacity was 2400 tons. They successfully reused recycled aggregate in different appropriate government projects (Rao et al. 2007).

Like other countries, Taiwan introduced some comprehensive program to fascinate and promote the application of recycled aggregate in the production of new concrete. In 1999 they utilized RAC during the rehabilitation program of infrastructures after a devastating earthquake.

In India, about 14.5 MT of solid wastes are generated annually from construction industries, which include wasted sand, gravel, bitumen, bricks, and masonry, concrete.

However, some quantity of such waste is being recycled and utilized in building materials and share of recycled materials varies from 25% in old buildings to as high as 75% in new buildings.

Almost 30 million tons of C&D waste was generated during rehabilitation program. This unexpected situation was overcome by successfully recycling 80% of those waste and 30% of those recycled material was used as pavement base (Rao et al. 2007).

III. OBJECTIVES

- To explore the possibility of partial replacement of natural aggregates by recycled aggregates at varying percentages in concrete.
- To study the effect of partial replacement of cement with nanosilica on compressive strength of concrete containing natural aggregates and recycled aggregates in different percentages i.e. (30% & 40%).
- To study the effect of partial replacement of cement with microsilica oncompressive strength of concrete containing natural aggregates and recycledaggregates in different percentages i.e. (30% & 40%).

- To compare the effects of partial replacement of cement with both nanosilica andmicrosilica in varying percentages respectively on compressive strength of concrete containing natural aggregates and recycled aggregates in different percentages i.e.(30%& 40%).

IV. SCOPE OF THE STUDY

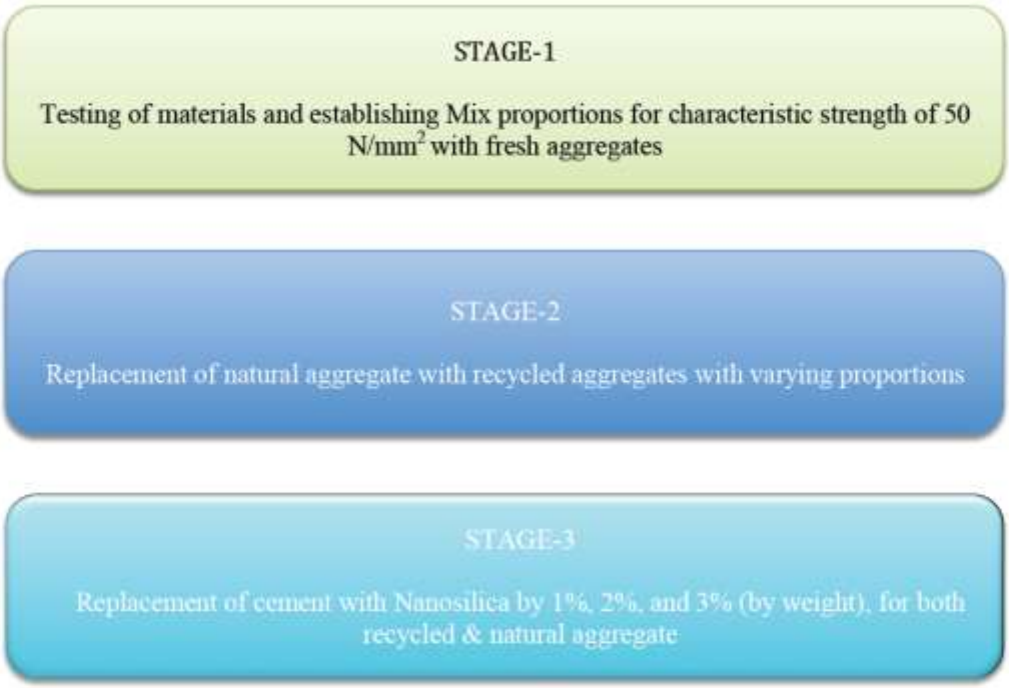
The experimental work carried out in this investigation consisted of testing 240 number of cubical specimen of size 150mm×150mm×150mm for the compressive strength of NAC, RAC and RAC containing nanosilica and microsilica. The detailed scope of work has been given below:

- Testing of constituent material of concrete i.e. cement, sand, coarse aggregates, fine aggregates and recycled aggregates for their physical properties as per relevant code.
- Designing of concrete mix for characteristic strength of 50N/mm2.
- Casting of cubical specimens of normal concrete, recycled aggregate concrete and recycled aggregate concrete blended with microsilica and nanosilica.
- Curing of test specimens for different curing periods i.e. 7days and 28 days.

24number of specimens were cast with normal grade concrete, 36 number of specimens were cast with recycled aggregate concrete, 60 number of specimens of natural aggregate concrete containing microsilica & nanosilica and 120 number of specimens of recycled aggregate concrete were cast containing microsilica and nanosilica.

V. EXPERIMENTAL PROGRAMME

The experimental program consisted of five main stages, the layout of which is shown
Below.



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STAGE-4

Replacement of cement with micro silica by 5%, 8%, and 10% (by weight), for both recycled & natural aggregate

STAGE – 5

Replacement of cement with both micro silica and nano silica

VI. RESULTS AND DISCUSSION

Table 6.1: Details of mix for concrete containing fresh aggregate

S.No.	Mix name	%age replacement by Recycled aggregate	Nano silica	Micro silica	7 day compressive strength (MPa)	28 day compressive strength (MPa)
1	F	0	0	0	48.73	58.92
2	F1	0	1	0	54.28	61.82
3	F2	0	2	0	58.21	71.21
4	F3	0	3	0	57.55	69.65
5	F5	0	0	5	52.50	64.37
6	F8	0	0	8	56.90	70.05
7	F10	0	0	10	55.19	65.73
8	F 1+5	0	1	5	56.15	70.05
9	F 1+8	0	1	8	58.30	74.70
10	F 2+5	0	2	5	60.73	73.24
11	F 2+8	0	2	8	55.97	69.97

From table 6.1, it can be concluded as follows

1.There is an increase of about 20.80% in compressive strength when 2% NS was used.

2.There is an increase of about 18.89% in compressive strength when 8% MS was used.

3.There is an increase of about 26.89% & 24.30% when 1%NS+8%MS & 2%NS+5%MS respectively was used.

Table 6.2: Details of mix for concrete containing 30% recycled aggregate

S.No.	Mix name	%age replacement by Recycled	Nano silica	Micro silica	7 day compressive strength(MPa)	28 day compressive strength(MPa)
1	R	30	0	0	46.73	57.91
2	R1	30	1	0	53.30	62.99
3	R2	30	2	0	57.20	68.99
4	R3	30	3	0	59.91	69.33
5	R5	30	0	5	51.24	62.30
6	R8	30	0	8	55.12	67.84
7	R10	30	0	10	53.79	64.16
8	R 1+5	30	1	5	59.13	69.44
9	R 1+8	30	1	8	62.01	72.67
10	R 2+5	30	2	5	60.74	71.24
11	R 2+8	30	2	8	58.90	68.14

From Table 4.8, it can be concluded as follows

1.In recycled aggregate concrete containing 30% RA has an increase of about 19.13% in compressive strength when 2% NS was used

2.There is an increase of about 17.5% in compressive strength when 8% MS was used

3.There is an increase of about 25.28% & 23.02% when 1%NS+8%MS & 2%NS+5%MS respectively was used

Table 6.3: Details of mix for concrete containing 40% recycled aggregate

S.No.	Mix name	%age replacement by Recycled	Nano silica	Micro silica	7 day compressive strength(MPa)	28 day compressive strength(MPa)
1	T	40	0	0	42.16	55.27
2	T1	40	1	0	51.99	62.61
3	T2	40	2	0	53.04	64.11
4	T3	40	3	0	54.22	61.63
5	T5	40	0	5	48.76	61.33
6	T8	40	0	8	52.48	64.48
7	T10	40	0	10	52.12	65.60
8	T 1+5	40	1	5	51.51	63.10

9	T 1+8	40	1	8	53.54	69.50
10	T 2+5	40	2	5	54.77	68.52
11	T 2+8	40	2	8	52.01	69.88

From table 6.3, it can be concluded as follows

1.There is an increase of about 16%% in compressive strength when 2% NS was used.

2.There is an increase of about 16.6% & 18.9% in compressive strength when 8% MS & 10% MS resp. wasused.

3.There is an increase of about 25.74% & 23.97% when 1%NS+8%MS & 2%NS+5%MS respectively was used.

VII. CONCLUSIONS

On the basis of the results obtained in this study, the following conclusions can be drawn:

1. The percentage increase in replacement of natural aggregates by recycled aggregates decreased the compressive strength of concrete. The 6.2% decrease in strength was found to be up to 40% replacement of aggregates. However, 50% replacement of natural aggregates by recycled aggregates resulted in 17.97% decrease in strength compared to natural aggregates concrete. The decrease in compressive strength due to addition of recycled aggregates may be due to the increased porosity and decreased crushing strength and impact value of recycled aggregate.
2. Maximum strength was achieved with nanosilica in both natural and recycled aggregate concrete when its percentage value is 2%.
3. Maximum strength was achieved with microsilica in both natural and recycled aggregate concrete when its percentage value is 8%.
4. Maximum strength was achieved with combined microsilica and nanosilica when its percentage is (1%NS + 8%MS) & (2%NS+8%MS) was used in both natural and recycled aggregate concrete.