INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 02, February 2025, pp : 395-410
www.ijprems.com
editor@ijprems.com
e-ISSN : 2583-1062
Impact Factor : 7.001

EXPERIMENTAL STUDY OF CONCRETE GRADE BY REPLACEMENT OF FLY ASH AND SILICA FUME WITH CEMENT & RECYCLED AGGREGATE WITH NATURAL COARSE AGGREGATE

Shivangi Bundela[1], Chetali Gangwal[2], Chaitanya Mishra[3]

[1]Student, Department Of Civil Engineering Oriental University, Indore M.P., India.

[2,3]Assistant Professor, Department Of Civil Engineering Oriental University, Indore M.P., India.

ABSTRACT

Preservation of environment and conservation of natural resources is the essence of any development. Also the present R and D continuously deal with technological and industrial development on waste management. In order to address environmental effects associated with cement manufacturing, it is crucial to advance alternative binders to compose concrete. Consequently extensive delving is continuing, on substitution of cement by differing waste materials and industrial offshoot. As partial replacement of cement and/or aggregate attempts on fly ash, demolished concrete, waste Silica Fume , rice husk etc. have already been accomplished in concrete industries. If little waste material found convenient and economical for concrete manufacturing, a major gain will be achieved in disposal of waste management and depression in construction cost. The work audits the feasibility of fly ash, Silica Fume and demolished concrete as partial substitute of cement and natural coarse aggregate respectively.

For this intent, procedure is partitioned into two stages. The initial stage proceeds with replacing 25% cement content by variant proportions of fly ash (FA) and Silica Fume (SF). Further tested for compressive and flexural strength, at 7 days, 14 days &28 days and correlated with conventional concrete. The adequate results were attained with the combination of cement 75% and fly ash 25% in ratio, w.r.t properties tested. In second stage, same optimum ratio of cement and fly ash is added with partly replaced natural coarse aggregate (NCA) with recycled concrete aggregate (RCA) in concrete. For test intent, recycled aggregates were accessed from crushed concrete cubes of grade M25 in laboratory. Variant composition of natural coarse aggregate and recycled aggregate adopted and test samples from this matrix were prepared for the same test as mentioned above. Observations reveal, combination of 90% NCA and 10% RCA in ratio, leads to adequate results.

1. INTRODUCTION

In recent years, there has been a growing awareness of environmental concerns, leading to an increased interest within the construction industry to utilize waste or recycled materials in concrete production. Many materials traditionally considered waste are now being recognized as valuable resources. For example, silica fume, often discarded from various shops, is an inert substance that can be recycled without undergoing any chemical changes. Similarly, fly ash, a byproduct of thermal power plants, poses environmental hazards when not properly managed. However, its incorporation into concrete as a partial replacement for cement has garnered attention due to its beneficial properties.

Recycled concrete aggregates (RCA), created by crushing old concrete, are another resource gaining traction. RCA is primarily used in road base construction, with extensive research focusing on its potential in recycling asphalt pavement into new mixtures. The aggregate obtained from processing previously used construction materials, such as crushed, washed, and graded concrete, serves as an efficient replacement for traditional aggregates in new concrete production.

One of the innovative uses of waste silica fume is incorporating it as an aggregate substitute in water filtration, sand coverings for athletic fields, plastering, and concrete applications. The increasing demand for concrete has led to the excessive use of natural river sand, causing environmental challenges such as depletion of water tables and damage to infrastructure like bridge piers. Consequently, the construction industry has been exploring the potential of crushed silica fume as a substitute for river sand.

However, silica fume can trigger undesirable alkali-silica reactions in concrete due to its secondary silica content. Although solutions have been proposed to mitigate these reactions, they come with limitations, making it crucial to further study the use of silica fume in concrete applications. Ongoing research focuses on controlling alkali-silica reactions and ensuring the long-term performance of silica fume-based concrete.

In terms of fly ash, its pozzolanic properties make it a valuable substitute for traditional Portland cement in concrete production. Fly ash not only reduces the risk of sulfate attacks, alkali-silica reactions, carbonation, and chloride-induced corrosion but also lowers the heat of hydration in early-stage concrete. The chemical reactivity of fly ash with calcium hydroxide (CH), a byproduct of cement hydration, helps form a stable and durable calcium silicate hydrate (C-S-H) gel, which improves the longevity of the concrete.

Concrete durability is often compromised by the presence of CH, which reacts with various compounds, leading to sulfate attacks, expansion due to alkali-silica reactions, and the formation of weak calcium carbonate ($CaCO3$) when exposed to atmospheric CO2. Fly ash, by reacting with CH, prevents these issues, enhancing the overall stability of the concrete.

Given the environmental and economic pressures of sourcing natural aggregates for road construction, the use of recycled materials has gained importance. Recycled materials can be used in unbound or lightly cemented forms for various layers of road structures. This project aims to explore the use of recycled materials and determine the appropriate mix proportions for optimal performance in road construction.

In the first phase of the project, different binder proportions, including partial replacements of cement with fly ash and silica fume, will be prepared and tested through cube and beam samples. After analyzing the results, the most effective proportion will be selected for further study. In the second phase, natural aggregates will be partially replaced with recycled concrete aggregates, and additional tests will be conducted to evaluate the outcomes.

2. OBJECTIVE OF RESEARCH

In this experimental procedure of investigation the following are the main objectives of study:-

1. To understand the effectiveness of fly ash, Silica Fume and recycled aggregate in strength enhancement.

2. To evaluate the utility of fly ash, Silica Fume and recycled concrete aggregates as a partial replacement of materials in conventional concrete.

Formulation of Research

In this stage of work cement is partially replaced by FA & SF in different percentages as shown in the table below. 7 batches are prepared in different proportions including conventional concrete mix (Cement as binder,Sand as fine aggregates & Natural Coarse Aggregates). Beams as well as Cubes are casted for defining compressive and flexural powers separately at 7, 14 and 28 days.

3. OBJECTIVES OF THE STUDY

SCOPE OF PRESENT STUDY

MATERIALS USED

1. Cement (OPC)
2 Sand
3. Aggregate
4 Fly ash
5 Silica Fume
6 Recycle Aggregate

1 Cement

Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO_2), 3-8% Alumina (Al_2O_3), 0.5-6% Iron Oxide (Fe_2O_3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO_3), 0.5-3% Soda And Potash (Na_2O+K_2O).

2 Sand

Sand is a naturally happening granular material made of finely isolated rocks and mineral particles. It is characterized by size, being finer than gravel and coarser than silt. Sand could additionally be referred as textural class of soil or soil type; i.e. a soil holding more than 85% sand-sized particles (by mass).

The contents of sand varies, relying upon local rock sources and conditions, yet the most regular constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, alternately SiO2), in quartz form.

3. Natural Coarse Aggregate

Construction aggregate, or essentially “Aggregate”, is an expansive classification of coarse particulate material utilized within construction, including gravel, sand, crushed stone, recycled concrete, slag and geo engineered aggregates. The majorly mined materials in the universe are aggregates.

Aggregates are comprised of composite materials for example, concrete and asphalt concrete; the aggregate serves as reinforcement for overall composite material. Because of the relatively high hydraulic conductivity value as contrasted with most soils, aggregates are generally utilized within waste requisitions for example, foundations and French drainage system, septic channel fields, retaining wall drainage system, and road side edge drains. Aggregates are likewise utilized as base material under foundations, roads, and railroads.

4. Fly Ash

Fly ash, otherwise called flue-ash, may be a standout amongst the residues created under combustion, and comprises those fine particles that rise with flue gases. Ash that doesn't rise is called bottom ash. In mechanical context, fly ash typically alludes with burning of coal. Fly ash is by and large caught by electrostatic precipitators or other molecule filtration gear before those pipe gasses arrive at the chimneys of coal-fired power plants. Liable upon the source and creation of the coal continuously burned, the contents for fly ash change considerably, in any case all fly ash incorporates significant sums of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic parts in many coal-bearing rock strata.

5 Silica Fume

Silica fume, also known as microsilica, is a byproduct of producing silicon and ferrosilicon alloys in electric arc furnaces. It is an ultra-fine powder, typically 100 times smaller than a grain of cement, primarily composed of amorphous silicon dioxide (SiO_2). Due to its small particle size and high surface area, silica fume is used as a pozzolanic material in concrete, enhancing its strength, durability, and resistance to chemical attack. When added to concrete, it fills in the microscopic voids between cement particles, leading to denser, stronger, and less permeable concrete, which is especially useful in high-performance and marine structures.

6 Recycled concrete aggregate (RCA):

RCA is granular material fabricated by evacuating, smashing, and preparing hydraulic cement concrete, asphalt for reuse with a pressure driven solidifying medium to deliver fresh flooring concrete. The aggregate reserved on the 4.75 mm sieve is called coarse aggregate; material passing the 4.75 mm strainer is called fine aggregate.

4. METHODOLOGY

As Cement is halfway supplanted by Fly Ash and Silica Fume , so in first phase of work 7 batches of various proportions of binders are arranged and cubes and beams are casted. Results acquired were examined and extent that gave ideal qualities are taken for the following stage. In second phase of work NA are somewhat supplemented by Recycled Concrete Aggregates and 5 groups are arranged and results are examined.

Mixing

Mix the concrete either by laboratory batch mixer or by hand.

(i) Mix the cement and fine aggregate thoroughly in a water tight none-absorbent platform until the mixture is totally blended and is in the form of uniform color

(ii) Add the coarse aggregate in that mixture and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch of the material.

(iii) Add water in that mixture and mix it well until the concrete appears to be homogeneous in appearance and of the desired consistency throughout of it.

Sampling

(i) Clean the mould and apply oil in it.

(ii) Fill the concrete in the mould in different layers of thickness 5 cm.

(iii) Compact each layer with tamping rod not less than 35strokes per layer.

(iv) Level the top surface and smoothen it with a trowel so that no concrete is visible out of the mould.

Curing of Specimen

The test cubes are stored in moist condition for 24 hours and after that the specimens are marked on its top and removed from the molds and keep it in submerged fresh water until taken out for the test.

Casted Cube

Procedure

(I) Remove the sample from water after particular curing time and clean out excess water from the surface.

(II) Clean the bearing surface of the testing machine.

(III) Place the sample in the machine in such a way that the load will be applied to the opposite side of the cube cast.

(IV) Support the specimen centrally on the base plate of the machine.

(V) Rotate the movable portion gently by hand so that it touches the top face of the specimen.

(VI)Apply the load slowly without distress and continuously at the rate of 140kg/cm2/minute till the sample fails.

(VII) Record the maximum load and note any remarkable features in the type of failure.

Load applied on Cube

Calculations

Size of the cube =15cm x 15cm x 15cm

Area of the specimen = 225cm^2

Characteristic compressive strength (fck) = M20.

Expected maximum load =fck x f.s x area of specimen.

Same calculation should be done for 28 day compressive strength test.

Maximum load applied is in tones (To be converted in Newton)

Compressive strength =Load applied (in Newton) / Area of cube (in mm^2) is computed (in N/mm^2).

Precautions

The water used for curing should be clean and tested every 7days accordingly and the temperature of the water must be at 27^{o}C(+-2^{o}C).

PARTIAL REPLACEMNET OF FA & SF

In this stage cement is partially replaced by different proportion of FA and SF in seven batch mixes.

Mixing of Concrete

Batch mix-01

In batch mix 01, nine cubes are casted having Cement + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weight of materials for the batch is listed below:-

- Cement = 16.70 kg
- Sand = 16.70 kg
- NCA = 33.42 kg

Batch mix-02

In batch mix 02, nine cubes are casted having 75% Cement + 25% FA + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weight of materials for the batch is listed below:-

- Cement = 12.50 kg
- FA = 4.18 kg
- Sand = 16.70 kg
- NCA = 33.42 kg

Batch mix-03

In batch mix 03, nine cubes are casted having 75% Cement + 20% FA + 5% SF + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weight of materials for the batch is listed below:-

- Cement = 12.50 kg
- FA = 3.34 kg
- SF = 0.84 kg
- Sand = 16.70 kg
- NCA = 33.42 kg

Batch mix-04

In batch mix 04, nine cubes are casted having 75% Cement + 15% FA + 10% SF + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weights of materials for the batch are listed below:-

- Cement = 12.50 kg
- FA = 2.50 kg
- SF = 1.68 kg
- Sand = 16.70 kg
- NCA = 33.42 kg

Batch mix-05

In batch mix 05, nine cubes are casted having 75% Cement + 10% FA + 15% SF + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weights of materials for the batch are listed below:-

- Cement = 12.50 kg
- FA = 1.68 kg
- SF = 2.50 kg
- Sand = 16.70 kg
- NCA = 33.42 kg

Batch mix-06

In batch mix 06, nine cubes are casted having 75% Cement + 5% FA + 20% SF + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weights of materials for the batch are listed below:-

- Cement = 12.50 kg
- FA = 0.84 kg
- SF = 3.34 kg
- Sand = 16.70 kg
- NCA = 33.42 kg

Batch mix-07

In batch mix 07, nine cubes are casted having 75% Cement + 25% SF + Sand + Natural Course Aggregate. In this batch proportion of ingredient in their mix is 1:1:2 by weight of binder, fine aggregate and course aggregates respectively. Weights of materials for the batch are listed below:-

- Cement = 12.50 kg
- SF = 4.18 kg

- Sand = 16.70 kg
- NCA = 33.42 kg

Casting of cubes

According to IS: 516-1959, test specimen for determining compressive strength of concrete of cubical shape should be 15 cm*15cm*15cm. If maximum size of aggregate is not more than 2 cm then a cubical shape of 10cm*10cm*10cm may be used as an alternative.In this research work i have used a cubical shaped specimen of size 15cm*15cm*15cm. During casting of cubes, mixing of materials and proportioning is done as per IS: 516-1959 as specified in clause in 2. Page no 4.A mix proportion of 1:1:2 of binder, fine aggregate and coarse aggregate respectively is adopted for this work.

TESTING OF SPECIMENS

1. Test of Cement

1.Consistency test

2. Initial and final setting time test

3. Early hardening

4. Unsoundness

2. Testing of Aggregates

1. Aggregate Impact Value

2. Aggregate Abrasion Value

3. Aggregate Crushing Value

3 Concrete (M-25)

1 Slump Test for normal concrete

2 Compressive Strength Test

5. RESULT

Result of testing materials: From the above methodology the result of the testing material as shown in below:

Initial and Final setting time test:

S.no	Setting Time (minutes)		Depth of penetration (mm)
	Initial	Final	
1.	37 minutes	10 hrs.	5 mm

Result:-1. The initial setting time of the cement sample is found to be 37 minutes

2. The final setting time of the cement sample is found to be 10hrs.

Consistency test: **Consistency results of cement**

Wt. of Cement (gm.)	Quantity. of Water added (gm.)	Penetration (mm)	% of Water (P)
300	100	15	0.30
300	140	7	0.385
300	150	6	0.40

Result (Stage 1)

As work is carried out in single stages, result of stage1 is presented in graphical form. Tests are performed on cubes, beams& cylinders and their 7 days, 14 days & 28 days strengths have been determined. A comparison based on strength of different mix proportions is carried out. A comparison of strengths for 7 days, 14 days and 28 days are also formulated.

As explained before, cement is partially replaced by SF in this stage and 7 batches are been prepared. In each batch mix 9 cubes, 6 beams& 6 cylinders are casted on which 7 days; 14 days & 28 days strength tests are performed. Results of these tests are discussed in this chapter.

Compressive Strength Test

Compressive strength test is performed on 3 cubes of each batch mix for 7 days, 14 days & 28 days. There are 7 batch mixes and each one having 9 cubes. Of these 9 cubes, 3 cubes are tested for 7 days, 14 days & 28 days each. An average of 3 values as tabulated in subhead results, are considered for discussions.

Testing of cube

Compressive Strength Result for 7 days(Stage 1)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cube-1	395.30	17.57	18.17
		Cube-2	423.60	18.83	
		Cube-3	407.50	18.11	
Mix-02	C(75%)+S+NCA+ FA(25%)+SF(0%)	Cube-1	503.00	22.36	23.20
		Cube-2	529.70	23.54	
		Cube-3	533.40	23.71	
Mix-03	C(75%)+S+NCA+ FA(20%)+ SF (5%)	Cube-1	437.20	21.03	21.74
		Cube-2	505.90	22.48	
		Cube-3	488.80	21.72	
Mix-04	C(75%)+S+NCA+ FA(15%)+ SF (10%)	Cube-1	441.00	19.61	21.08
		Cube-2	494.50	21.98	
		Cube-3	487.40	21.66	
Mix-05	C(75%)+S+NCA+ FA(10%)+ SF (15%)	Cube-1	447.30	19.88	18.91
		Cube-2	413.90	18.40	
		Cube-3	415.00	18.44	
Mix-06	C(75%)+S+NCA+ FA(5%)+ SF (20%)	Cube-1	372.50	16.56	17.23
		Cube-2	390.80	17.37	
		Cube-3	399.80	17.77	
Mix-07	C(75%)+S+NCA+ FA(0%)+ SF (25%)	Cube-1	340.40	15.13	15.36
		Cube-2	348.70	15.5	
		Cube-3	347.90	15.46	

Compressive Strength Result for 14 days(Stage 1)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cube-1	450.60	20.03	20.63
		Cube-2	478.00	21.24	

		Cube-3	463.70	20.61	
Mix-02	C(75%)+S+NCA+ FA(25%)+ SF (0%)	Cube-1	581.50	25.84	26.40
		Cube-2	600.20	26.68	
		Cube-3	600.10	26.67	
Mix-03	C(75%)+S+NCA+ FA(20%)+ SF (5%)	Cube-1	537.60	23.89	24.72
		Cube-2	576.70	25.63	
		Cube-3	562.10	24.98	
Mix-04	C(75%)+S+NCA+ FA(15%)+ SF (10%)	Cube-1	509.80	22.66	24.03
		Cube-2	558.20	24.81	
		Cube-3	553.70	24.61	
Mix-05	C(75%)+S+NCA+ FA(10%)+ SF (15%)	Cube-1	509.00	22.62	21.75
		Cube-2	480.10	21.34	
		Cube-3	479.30	21.30	
Mix-06	C(75%)+S+NCA+ FA(5%)+ SF (20%)	Cube-1	432.10	19.20	19.87
		Cube-2	452.90	20.13	
		Cube-3	456.30	20.28	
Mix-07	C(75%)+S+NCA+ FA(0%)+ SF (25%)	Cube-1	394.40	17.53	17.71
		Cube-2	402.30	17.88	
		Cube-3	398.90	17.73	

Compressive Strength Result for 28 days(Stage 1)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cube-1	518.60	23.05	24.13
		Cube-2	560.80	24.93	
		Cube-3	549.50	24.42	
Mix-02	C(75%)+S+NCA+ FA(25%)+ SF (0%)	Cube-1	663.90	29.51	30.61
		Cube-2	700.90	31.15	
		Cube-3	701.50	31.17	
Mix-03	C(75%)+S+NCA+ FA(20%)+ SF (5%)	Cube-1	629.00	27.96	28.67
		Cube-2	662.00	29.42	
		Cube-3	644.20	28.63	
Mix-04	C(75%)+S+NCA+ FA(15%)+ SF (10%)	Cube-1	573.30	25.48	27.36
		Cube-2	635.40	28.24	
		Cube-3	638.00	28.36	
Mix-05	C(75%)+S+NCA+ FA(10%)+ SF (15%)	Cube-1	592.70	26.34	25.16
		Cube-2	553.40	24.60	
		Cube-3	551.90	24.53	
Mix-06	C(75%)+S+NCA+ FA(5%)+ SF (20%)	Cube-1	491.00	21.82	22.86
		Cube-2	518.70	23.05	
		Cube-3	533.30	23.70	

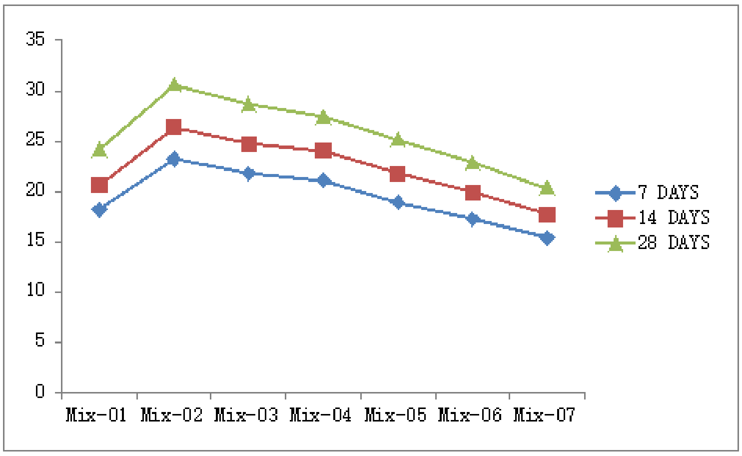
Mix-07	C(75%)+S+NCA+ FA(0%)+ SF (25%)	Cube-1	447.00	19.87	20.32
		Cube-2	468.10	20.80	
		Cube-3	456.60	20.29	

As shown in 1 (7 days strength), when cement is partially replaced 25% by FA i.e. Mix-02, compressive strength is increased by 27.68%. Afterwards when % of FA is reduced and replaced by SF, strength starts decreasing and for Mix-07, a minimum of strength is achieved.

When 2 (14 days strength) is analyzed, Mix-02 gives 27.97% more strength when compared with Mix-01. Here also, when % of FA is reduced and replaced by SF, strength starts decreasing and for Mix-07, a minimum of strength is achieved.

28 days strength in 3 shows an increment of 26.85% of strength of Mix-02 as compared with Mix-01. Again strength is decreased when FA is replaced with SF and a minimum strength is found for Mix-07.

As discussed here, it can be said that an increment in compressive strength of Mix-02 nearly 27% is achieved as compared with conventional concrete mix i.e. Mix-01.



Compressive Strength in N/mm^2 at various age (Days) (Stage-1)

In graph: 4, compressive strength of cubes at various age (in days) of Mix-01 to Mix-07 is shown.

Flexural strength Test

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 108KN/min. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code flexural strength is calculated and tabulated below:-

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 02, February 2025, pp : 395-410
www.ijprems.com
editor@ijprems.com
e-ISSN : 2583-1062
Impact Factor : 7.001

Testing of beam

Flexural Strength Result for 7 days(Stage 1)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURALSTRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	9.40	3.76	3.88
		Beam -2	10.00	4.00	
Mix-02	C(75%)+S+NCA+FA(25%)+ SF (0%)	Beam -1	11.80	4.72	4.85
		Beam -2	12.45	4.98	
Mix-03	C(75%)+S+NCA+FA(20%)+ SF (5%)	Beam -1	11.30	4.52	4.53
		Beam -2	11.35	4.54	
Mix-04	C(75%)+S+NCA+FA(15%)+ SF (10%)	Beam -1	11.30	4.52	4.46
		Beam -2	11.00	4.40	
Mix-05	C(75%)+S+NCA+FA(10%)+ SF (15%)	Beam -1	10.50	4.20	4.21
		Beam -2	10.55	4.22	
Mix-06	C(75%)+S+NCA+FA(5%)+ SF (20%)	Beam -1	9.80	3.92	3.88
		Beam -2	9.60	3.84	
Mix-07	C(75%)+S+NCA+FA(0%)+ SF (25%)	Beam -1	8.95	3.58	3.62
		Beam -2	9.15	3.66	

Flexural Strength Result for 14 days(Stage 1)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURALSTRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	10.80	4.32	4.45
		Beam -2	11.45	4.58	
Mix-02	C(75%)+S+NCA+ FA(25%)+ SF (0%)	Beam -1	13.70	5.48	5.58
		Beam -2	14.20	5.68	
Mix-03	C(75%)+S+NCA+ FA(20%)+ SF (5%)	Beam -1	13.20	5.28	5.34
		Beam -2	13.50	5.40	
Mix-04	C(75%)+S+NCA+ FA(15%)+ SF (10%)	Beam -1	13.10	5.24	5.19
		Beam -2	12.85	5.14	
Mix-05	C(75%)+S+NCA+ FA(10%)+ SF (15%)	Beam -1	12.15	4.86	4.89
		Beam -2	12.30	4.92	
Mix-06	C(75%)+S+NCA+ FA(5%)+ SF (20%)	Beam -1	11.30	4.52	4.41
		Beam -2	10.75	4.30	
Mix-07	C(75%)+S+NCA+ FA(0%)+ SF (25%)	Beam -1	10.40	4.16	4.23
		Beam -2	10.75	4.30	

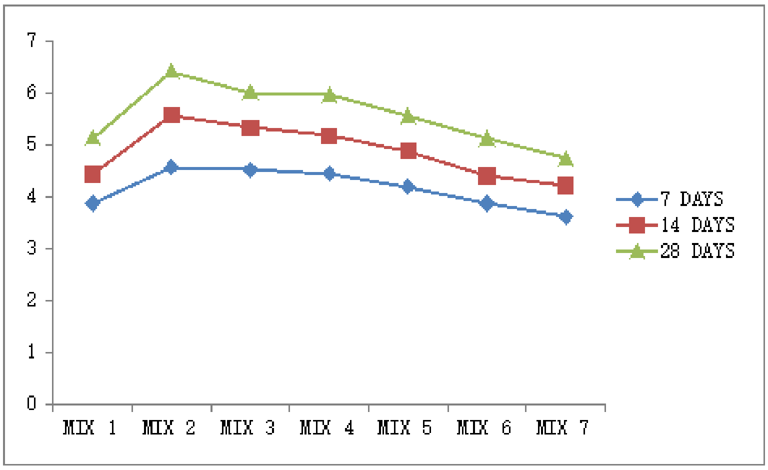
Flexural Strength Result for 28 days(Stage 1)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURALSTRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	12.40	4.96	5.14

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 02, February 2025, pp : 395-410
www.ijprems.com
editor@ijprems.com
e-ISSN : 2583-1062
Impact Factor : 7.001

		Beam -2	13.30	5.33	
Mix-02	C(75%)+S+NCA+FA(25%) + SF (0%)	Beam -1	15.50	6.20	6.43
		Beam -2	16.65	6.66	
Mix-03	C(75%)+S+NCA+FA(20%) + SF (5%)	Beam -1	14.85	5.94	6.02
		Beam -2	15.25	6.10	
Mix-04	C(75%)+S+NCA+FA(15%) + SF (10%)	Beam -1	15.10	6.01	5.98
		Beam -2	14.80	5.92	
Mix-05	C(75%)+S+NCA+FA(10%) + SF (15%)	Beam -1	14.00	5.60	5.57
		Beam -2	13.85	5.54	
Mix-06	C(75%)+S+NCA+FA(5%)+ SF (20%)	Beam -1	13.20	5.28	5.13
		Beam -2	12.45	4.98	
Mix-07	C(75%)+S+NCA+FA(0%)+ SF (25%)	Beam -1	11.85	4.75	4.75
		Beam -2	11.90	4.76	

As discussed here, it can be said that an increment in compressive strength of Mix-02 nearly 25% is achieved as compared with conventional concrete mix i.e. Mix-01.



Flexural Strength in N/mm^2 at various age (Days) (Stage-1)

In graph: , flexural strength of cubes at various ages (in days) of Mix-01 to Mix-07 is shown.

Result (Stage 2)

In this stage a total of 6 batches are prepared as stated in the section experimental work and results. Mix-02 is the mix which gives optimum strength from stage-1, which is mix-02 of stage-1 having 75% cement and 25% FA along with sand and NCA. Batch Mix-03 to Mix-06 NCA is partially replaced by RCA. In each batch mix 9 cubes and 6 beams are casted on which 7 days; 14 days & 28 days strength tests are performed. Results of these tests are discussed in this chapter.

Tests are performed on casted cubes and beams. Results are tested on follows:-

Compressive Strength

Compressive strength test is performed on 3 cubes of each batch mix for 7 days, 14 days & 28 days. There are 6 batch mixes and each one having 9 cubes. Of these 9 cubes, 3 cubes are tested for 7 days, 14 days & 28 days each. An average of 3 values as tabulated in subhead results, are considered for discussions.

Compressive Strength Result for 7 days (Stage 2)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cube-1	395.30	17.57	18.17
		Cube-2	423.60	18.83	

		Cube-3	407.50	18.11	
Mix-02	C(75%)+S+FA(25%) + SF (0%)+NCA(100%)	Cube-1	503.00	22.36	23.20
		Cube-2	529.70	23.54	
		Cube-3	533.40	23.71	
Mix-03	C(75%)+S+FA(25%) + SF (0%)+NCA(90%)+RCA(10%)	Cube-1	514.30	22.86	23.49
		Cube-2	550.20	24.45	
		Cube-3	521.00	23.16	
Mix-04	C(75%)+S+FA(25%) + SF (0%)+NCA(80%)+RCA(20%)	Cube-1	472.80	21.01	20.58
		Cube-2	452.30	20.10	
		Cube-3	463.90	20.62	
Mix-05	C(75%)+S+FA(25%) + SF (0%)+NCA(70%)+RCA(30%)	Cube-1	428.00	19.02	19.91
		Cube-2	482.70	21.45	
		Cube-3	433.30	19.26	
Mix-06	C(75%)+S+FA(25%) + SF (0%)+NCA(60%)+RCA(40%)	Cube-1	450.17	20.03	19.68
		Cube-2	446.30	19.84	
		Cube-3	431.00	19.16	

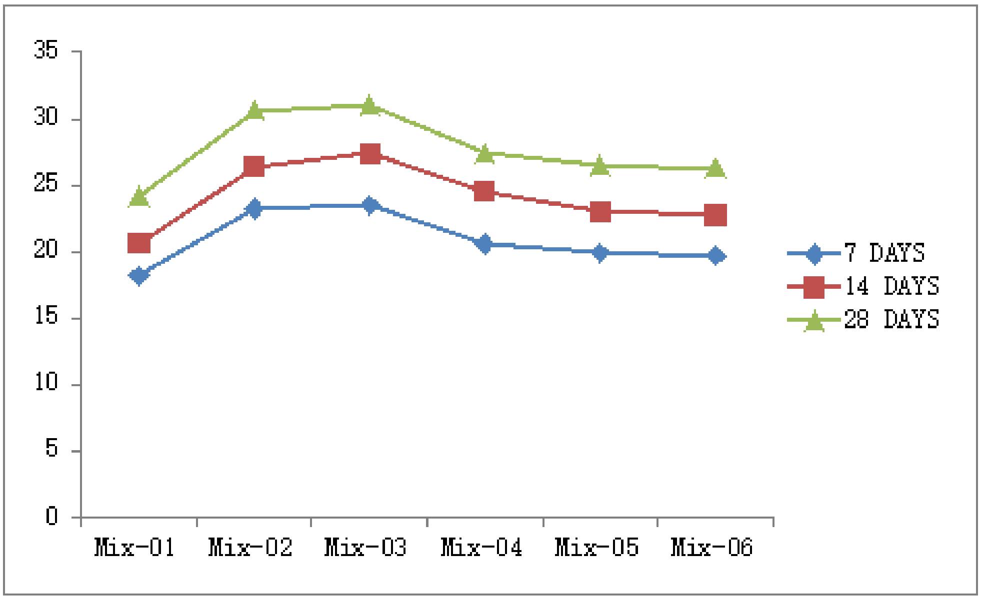
Compressive Strength Result for 14 days (Stage 2)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cube-1	450.60	20.03	20.63
		Cube-2	478.00	21.24	
		Cube-3	463.70	20.61	
Mix-02	C(75%)+S+FA(25%)+ SF (0%)+NCA(100%)	Cube-1	581.50	25.84	26.40
		Cube-2	600.20	26.68	
		Cube-3	600.10	26.67	
Mix-03	C(75%)+S+FA(25%)+ SF (0%)+NCA(90%)+RCA (10%)	Cube-1	596.60	26.52	27.36
		Cube-2	635.50	28.24	
		Cube-3	614.80	27.32	
Mix-04	C(75%)+S+FA(25%)+ SF (0%)+NCA(80%)+RCA (20%)	Cube-1	541.40	24.06	24.51
		Cube-2	533.40	23.70	
		Cube-3	580.00	25.78	
Mix-05	C(75%)+S+FA(25%)+ SF (0%)+NCA(70%)+RCA (30%)	Cube-1	496.50	22.07	23.02
		Cube-2	561.50	24.96	
		Cube-3	495.80	22.03	
Mix-06	C(75%)+S+FA(25%)+ SF (0%)+NCA(60%)+RCA (40%)	Cube-1	522.50	23.22	22.74
		Cube-2	508.40	22.60	
		Cube-3	504.20	22.41	

Compressive Strength Result for 28 days (Stage 2)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cube-1	518.60	23.05	24.13
		Cube-2	560.80	24.93	
		Cube-3	549.50	24.42	
Mix-02	C(75%)+S+FA(25%)+ SF(0%)+NCA(100%)	Cube-1	663.90	29.51	30.61
		Cube-2	700.90	31.15	
		Cube-3	701.50	31.17	
Mix-03	C(75%)+S+FA(25%)+ SF (0%)+NCA(90%)+RC A(10%)	Cube-1	678.90	30.17	31.02
		Cube-2	726.70	32.30	
		Cube-3	688.30	30.59	
Mix-04	C(75%)+S+FA(25%)+ SF (0%)+NCA(80%)+RC A(20%)	Cube-1	621.70	27.63	27.36
		Cube-2	603.40	26.82	
		Cube-3	621.60	27.63	
Mix-05	C(75%)+S+FA(25%)+ SF (0%)+NCA(70%)+RC A(30%)	Cube-1	567.10	25.20	26.52
		Cube-2	641.00	28.49	
		Cube-3	582.30	25.88	
Mix-06	C(75%)+S+FA(25%)+ SF (0%)+NCA(60%)+RC A(40%)	Cube-1	605.50	26.91	26.24
		Cube-2	590.90	26.26	
		Cube-3	574.70	25.54	

With reference to above discussion, it can be said that an increment in compressive strength of Mix-02 nearly 27% is achieved & increment in compressive strength of Mix-03 nearly 29% is achieved as compared with conventional concrete mix i.e. Mix-01. Also it is seen that when NCA is partially (10%) replaced by RCA, better results can be expected.



Graph 4.12: Compressive Strength in N/mm^2 at various age (Days) (Stage-2)

In graph: 12, compressive strength of cubes at various ages (in days) of Mix-01 to Mix-06 is shown.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 02, February 2025, pp : 395-410
e-ISSN : 2583-1062
Impact Factor : 7.001

Flexural Strength

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 28 days of the sample. Placement of sample in instrument is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 1.8KN/min. Load is applied until specimen fails and load at which sample fails is recorded. As specified in the IS code flexural strength is calculated and tabulated below:-

Flexural Strength Result for 7 days (Stage 2)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURAL STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	9.40	3.76	3.88
		Beam -2	10.00	4.00	
Mix-02	C(75%)+S+FA(25%)+ SF (0%)+NCA(100%)	Beam -1	11.80	4.72	4.85
		Beam -2	12.45	4.98	
Mix-03	C(75%)+S+FA(25%)+ SF (0%)+NCA(90%)+RCA(10%)	Beam -1	13.15	5.26	5.17
		Beam -2	12.70	5.08	
Mix-04	C(75%)+S+FA(25%)+ SF (0%)+NCA(80%)+RCA(20%)	Beam -1	10.30	4.12	4.22
		Beam -2	10.80	4.32	
Mix-05	C(75%)+S+FA(25%)+ SF (0%)+NCA(70%)+RCA(30%)	Beam -1	11.00	4.40	4.18
		Beam -2	9.95	3.96	
Mix-06	C(75%)+S+FA(25%)+ SF (0%)+NCA(60%)+RCA(40%)	Beam -1	10.00	4.00	4.12
		Beam -2	10.60	4.24	

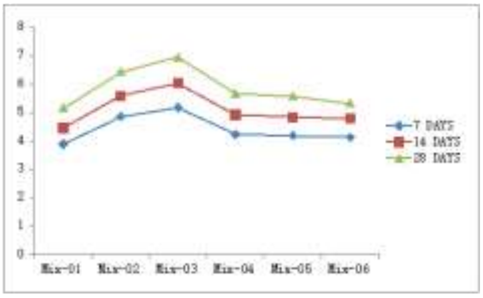
Flexural Strength Result for 14 days (Stage 2)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURAL STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	10.80	4.32	4.45
		Beam -2	11.45	4.58	
Mix-02	C(75%)+S+FA(25%)+ SF (0%)+NCA(100%)	Beam -1	13.70	5.48	5.58
		Beam -2	14.20	5.68	
Mix-03	C(75%)+S+FA(25%)+ SF (0%)+NCA(90%)+RCA(10%)	Beam -1	15.30	6.12	6.03
		Beam -2	14.85	5.94	
Mix-04	C(75%)+S+FA(25%)+ SF (0%)+NCA(80%)+RCA(20%)	Beam -1	12.15	4.86	4.92
		Beam -2	12.45	4.98	
Mix-05	C(75%)+S+FA(25%)+ SF (0%)+NCA(70%)+RCA(30%)	Beam -1	12.50	5.00	4.83
		Beam -2	11.65	4.66	
Mix-06	C(75%)+S+FA(25%)+ SF (0%)+NCA(60%)+RCA(40%)	Beam -1	11.60	4.64	4.74
		Beam -2	12.10	4.84	

Flexural Strength Result for 28 days (Stage 2)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURAL STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	12.40	4.96	5.14
		Beam -2	13.30	5.33	
Mix-02	C(75%)+S+FA(25%)+ SF (0%)+NCA(100%)	Beam -1	15.50	6.20	6.43
		Beam -2	16.65	6.66	
Mix-03	C(75%)+S+FA(25%)+ SF (0%)+NCA(90%)+RCA(10%)	Beam -1	17.40	6.96	6.93
		Beam -2	17.25	6.90	
Mix-04	C(75%)+S+FA(25%)+ SF (0%)+NCA(80%)+RCA(20%)	Beam -1	13.85	5.54	5.65
		Beam -2	14.40	5.76	
Mix-05	C(75%)+S+FA(25%)+ SF (0%)+NCA(70%)+RCA(30%)	Beam -1	14.60	5.84	5.57
		Beam -2	13.25	5.30	
Mix-06	C(75%)+S+FA(25%)+ SF (0%)+NCA(60%)+RCA(40%)	Beam -1	13.45	5.38	5.32
		Beam -2	13.15	5.26	

With reference to above discussion, it can be said that an increment in compressive strength of Mix-02 nearly 25% is achieved & increment in compressive strength of Mix-03 nearly 34% is achieved as compared with conventional concrete mix i.e. Mix-01. Also it is seen that when NCA is partially (10%) replaced by RCA, better results can be expected.



Graph 4.16: Flexural Strength in N/mm^2 at various age (Days) (Stage-2)

flexural strength of cubes at various ages (in days) of Mix-01 to Mix-06 is shown.From all the above results and discussions I found that first, if we replace cement partially (25%) by FA, nearly 27% compressive strength and 25% flexural strength higher than conventional concrete can be achieved. Further, if in this combination, NCA are partially (10%) replaced by RCA, nearly 29% compressive strength and 34% flexural strength higher can be achieved.

6. CONCLUSIONS

- From the above graphs and previous discussion, following conclusion is drawn:-
- The exchanging of cement at an optimal percentage by FA (25%), improved compressive and flexural strengths as compared to conventional concrete in stage-1.
- In stage-1, on decreasing percentage exchanging of FA (25% to 0%) by increasing percentage exchanging of SF (0% to 25%), a decreased strength is determined, i.e. When SF is used as a exchanging material, and strength of concrete gets reduced.
- When mix proportion providing optimal strength in stage-1 is considered for stage-2, 10% NCA exchanging by RCA gives a higher strength values for both compressive and flexural.
- On increasing percentage exchanging of RCA by replacing NCA, a continue decrease in strength is investigated. It shown, only 10% exchanging of NCA by RCA gives increased strength properties.
- A maximum compressive and flexural power is noted when 25% cement is replaced by FA & 10% NCA are replaced by RCA for all 7 days, 14 days and 28 days curing period.
- The increase in flexural power is additional when compared with compressive power with exchanging of conventional materials.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 02, February 2025, pp : 395-410
www.ijprems.com
editor@ijprems.com
e-ISSN : 2583-1062
Impact Factor : 7.001

It can be concluded from this dissertation work that FA can be used as a partial exchanging of cement and RCA can be used as a partial exchanging of NCA up to an optimal values. SF is not that useful as far as exchanging of cement is worried about. A more detailed revision can be voted out to discuss use of concrete having such materials in future.

7. REFERENCES

[1] M. R.Karim, M.F.Zain, M.Jamil, F.C.Lai, M.N.Islam, Power of Mortar and Concrete as influenced by Rise Husk Ash,World Applied Sciences Journal 19 (10): 1501-1513,2012 ISSN 1818-4952.

[2] D. N. Parekh and Dr. C. D. Modhera, Study on the partial exchanging of fine aggregate using induction furnace slag,American journal of engineering research(AJER),e-ISSN : 2320-0847,p-ISSN :2320-0936,Volume-4 pp-01-05.

[3] R. NAGALAKSHMI, Comprehensive literature review on use of waste product in concrete, International journal of Application or innovation in engineering of management,volume 2,issue 4,April 2013,ISSN 2319-4847.

[4] Dr. G. Vijayakumar, Ms H. Vishaliny, Dr. D. Govindarajulu, Experimental Study On Recycled Aggregate Concrete,International Journal of Engineering Research and Applications (IJERA), ISSN:2248-9622, Vol. 2, Issue 2, Mar-Apr 2012, pp.407 -410.

[5] C. Marthong, T.P Agrawal,Power Study on Exchanging of Coarse Aggregate by Reused Aggregate on Concrete, IJISET International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 4, April 2015, ISSN 2348 – 7968 .

[6] Chandana Sukesh, KatakamBala Krishna, P.Sri Lakshmi Sai Teja, S.Kanakambara Rao,Fly Ash and Recycled Coarse Aggregate in Concrete: New Era for Construction Industries - A Literature Review, International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue5- May 2013

[7] T. Phani Madhavi, V. Sampathkumar, P. Guneasekaran,Performance and Implementation of Low-Quality Recycled Concrete Aggregate, TheJournal of Sustainable Development, Vol. 10, Issue 1 (2013), Pp. 72 – 84.

[8] B.Damodhara Reddy, S.ArunaJyothy , Fawaz Shaik,Performance Evaluation of Recycled Aggregates Used in Concrete, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622 vol.2, Issue4, July-August 2012, pp 1387-1391

[9] Umapathy U 1, Mala C2, Siva K, Experimental Study On Some Hardened Properties Of Air Entrained Recycled Aggregate Concrete, International Journal of Scientific & Technology Research Volume 2, Issue 8, August 2013, ISSN 2277-8616.

[10] P.Padma Rao, A.Pradhan Kumar, B.Bhaskar Singh, Use of recycled concrete aggregate in making concrete- An overview, 34thConference on Our World in Concrete & Structures: 16 - 18 August 2009, Singapore.

[11] M.N.N.Khana, M. Jamil, M.R. Karim and M.F.M. Zain,Use of Recycled Silica Fume Bottles as Fine Aggregates in Concrete Mixture,International Journal of Advanced Science and Technology, Vol.61, (2013), pp.17-28

[12] Mangesh B. Mhatre, Dr. H. S. Chore, Prof. P. A. Dode, Ways to facilitate the use of recycled aggregate concrete, Proceedings of the Institution of Civil EngineersWaste and Resource Management, 16August 2007 Issue WR3 Pages 125–129 to facilitate the e of recycled aggregate concrete.

[13] Vivian W.Y. Tam, Kang Wang and C.M. Tam,Studies on Utilization of Fly Ash and Silica Fume in Concrete International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, Volume-2, Issue-11, November 2014

[14] Tomas U. GanironJr, Power and Durability of Mortar and ConcreteContaining Silica FumeWorld Applied Sciences Journal 32 (5): 752-765, 2014

[15] S R Yadav and S R Pathak,A study on use of Silica Fume in concrete, IJEAR Vol. 4, Issue Spl-2, Jan - June 2014

[16] Akinkurolere Olufunke Olanike, Assessment of Concrete Power Using Partial Exchanging of Coarse Aggregate for waste Tiles and Cement for Silica Fume in Concrete, Umapathy U et al Int. Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 4, Issue 5(Version 1), May 2014, pp.72-76

[17] A.N.Dabhade, Dr.S.R.Choudhari and Dr.A.R.Gajbhiye,Experimental analysis of the use of coconut shell as coarse aggregate, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 10, Issue 6 (Jan. 2014), PP 06-13

[18] Hubert Chang, Ryan Morgan, Umed Aziz, Simon Herfellner& Kenneth Ho, Partial Exchanging of Sand with Quarry Dust in Concrete, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-6, May 2013

[19] Prof. Chetna M.Vyas& Prof. Jayeshkumar Pitroda, Effect of Fly Ash Additive on Concrete Properties, International Journal of Engineering Research and ApplicationsVol. 2, Issue4, July-August 2012, pp.1986-1991.