Double Blended Self Compacting Concrete

P. NAGA SUNDAR KUMAR[1]

[1]Graduated Civil Engineer, MallaReddy Engineering College, Hyderabad, Telangana.

ABSTRACT: *Concrete is the most widely used Civil Engineering material employed for the construction of various types of structures in the world. Continuous research has been carried out in the area of concrete technology to improve the quality of concrete and to make it suitable for different purposes. As a result, many forms of concrete like High strength concrete, High performance concrete, Fiber reinforced concrete, self-compacting concrete (SCC) have been developed. Self-compacting concrete (SCC) represents one of the most outstanding advances in concrete technology during the last decade. Self compacting concrete is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes its suitable for placing in difficult situation and in sections with congested reinforcement. The aim of the study is to make use of Ground Granulated Blast Furnace Slag and Metakaolin as replacements of cement and understand its effect on the fresh properties and hardened properties of concrete. The investigation includes the concept of double blending of Ground Granulated Blast furnace Slag and Metakaoloin, this double blend exploits the beneficial characteristics of Pozzolanic materials in producing a better concrete.*

Key words:- *SCC – Self Compacting Concrete, GGBS – Ground Granulated Blast Furnace Slag, Metakaolin.*

1. INTRODUCTION

1.1 Self compacting concrete

Self-Compacting Concrete or Self Consolidating Concrete, SCC, is defined as a Concrete that is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeneity. It was originally developed in Japan, to overcome the problems caused by lack of complete and uniform compaction through vibrators. It has since proved to be economically beneficial because of a number of factors:

- *improved durability and compressive strength*
- *easier placing and hence reduction in manpower at the time of placing*
- *better surface finishes*
- *greater freedom in design which can lead to thinner concrete sections*
- *reduced noise levels because of absence of vibration*

SCC can be used even in the presence of dense reinforcements due to its flowing, passing and filling abilities.

1.2 Need of self compacting concrete

Self-consolidating concrete is a highly flow able type of concrete that spreads into the form without the need for mechanical vibration. Self-compacting concrete is a non-segregating concrete that is placed by means of its own weight. The importance of self-compacting concrete is that maintains all concrete's durability and characteristics, meeting expected performance requirements. In certain instances the addition of super plasticizers and viscosity modifier are added to the mix, reducing bleeding and segregation. Concrete that segregates loses strength and results in honeycombed areas next to the formwork. A well designed SCC mix does not segregate, has high deformability and excellent stability characteristics.

1.3 Properties of Self Compacting Concrete

Self-compacting concrete produces resistance to segregation by using mineral fillers or fines and using special admixtures. Self-consolidating concrete is required to flow and fill special forms under its own weight, it shall be flow able enough to pass through highly reinforced areas, and must be able to avoid aggregate segregation. This type of concrete must meet special project requirements in terms of placement and flow.

Self-compacting concrete with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste. The concrete mix of SCC must be placed at a relatively higher velocity than that of regular concrete. Self-compacting concrete has been placed at heights taller than 5 meters without aggregate segregation. It can also be used in areas with normal and congested reinforcement, with aggregates as large as 2 inches.

Fig1.1 Placing of Self Compacting Concrete

1.4 Double Blended Self Compacting Concrete

Double blended cement is characterised by part replacement of cement with mineral admixtures/additives such as metakaolin, ground granulated blast furnace slag etc. The corresponding concrete is termed as double blended concrete. These admixtures are found to enhance the physical, chemical and mechanical properties of the concrete i.e. in terms of its strength parameters (compressive and flexural) as well as durability parameters.

1.5 Characteristic of Self Compacting Concrete

The main characteristics of SCC are the properties in the fresh state. In order to flow, fill through the dense reinforcement the SCC must pose certain properties like
1) Passing ability
2) Filling ability
3) Resistance to Segregation
The passing ability of SCC is to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking. The filling ability of SCC to flow into and fill completely all spaces within the formwork, under its own weight. The resistance to segregation is to maintain its stability under high flow conditions i.e. it should not segregate and should remain homogenous in composition during transport and homogeneity.

1.6 Advantages of Self Compacting Concrete

Faster construction times. Easier placing and better surface finish. Greater freedom in design. Improved durability and reliability of concrete structures. Ease of placement results in cost savings through reduced equipment and labour requirement. Improved quality of concrete and reduction of onsite repairs and overall cost. Possibilities for utilization of dusts which are currently waste products and which are costly to dispose of.

Fig1.2 Application of Self Compacting Concrete

1.7 Mineral Admixtures

These days concrete is being used for wide varieties of purposes to make it suitable in different conditions. In such cases, admixture is used to modify the properties of ordinary concrete so as to make it suitable for any situation. In developing countries like India, Pozzolonic materials are mainly available as industrial waste by-products, fly ash, silica fume; stone dust, blast furnace slag, rice husk ash, metakaolin etc., are some of the industrial wastes. Extensive research work has been carried on the use of pozzolonas in construction materials.

1.8 Ground Granulated Blast Furnace Slag (GGBS)

GGBS is obtained by quenching molten iron slag from a blast furnace in water or steam to produce glassy, granular product that is then dried and ground into fine powder. The replacement of cement with GGBS reduces the unit water content needed for the concrete and thereby increasing the durability of the structure. It also reduces the temperature rise and helps to avoid early age cracking, improved workability, increased resistance to chemical attack and corrosion resistant.

1.9 Metakaolin

Metakaolin is a pozzolan, probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC. Its quality is controlled during manufacture, resulting in a much less variable material than industrial pozzolans that are by-products. First used in the 1960s for the construction of a number of large dams in Brazil, metakaolin was successfully incorporated into the concrete with the original intention of suppressing any damage due to alkali-silica reaction.

2.Literature Review

Title :- *Mix proportioning system for Self Compacting Concrete*
Authors :- *Okamura and Ozawa*
Year of Publication :- *2003*
Abstract :- *They have proposed a mix proportioning system for SCC. In this system, the coarse aggregate and fine aggregate contents are fixed and self-compactibility is to be achieved by adjusting the super plasticizer dosage. The Super Plasticizer dosage is assumed to be 0.9-1.0 by volume depending on the properties of the powder and the super plasticizer dosage.*
Title :- *Impact of fly ash and silica fume on Compressive strength of Self Compacting Concrete*

Authors :- *Heba A Mohamed*
Year of Publication :- *2011*
Abstract :- *The investigation about the effect of fly ash and silica fume on the compressive strength of self compacting concrete under different curing condition. The work involved different types of mixes the first consisted of different percentages of fly ash (FA), the second uses different percentages of silica fume(SF) and the third uses a mixture of FA and SF. The results were obtained as higher the percentage of FA the higher the values of concrete compressive strength until 30% of FA.*

Title :- *Double blended Self Compacting Concrete*
Authors :- *T. Jeevetha and Dr S. Krishnamurthy*
Year of Publication :- *2014*
Abstract :- *They studied about the strength properties of self compacting concrete with silica fume and Ground granulated blast furnace slag was replaced with cement in 5% an 10%. It was concluded that at 5% replacement of silica fume the mix shows good workability and compressive strength.*

Title :- *Self Compacting Concrete and Properties*
Authors :- *Ankit J Patel*
Year of Publication :- *2014*
Abstract :- *They investigated about the properties of self compacting concrete with the use of waste material. The study made use of ground granulated blast furnace slag and metakaolin as a replacement of cement in 9%, 14%,18% and understand its effect on fresh properties ,compressive strength of SCC.*

Title :- *Mix design for the Self Compacting Concrete by Japanese method*
Authors :- *Pratibha agarwal*
Year of Publication :- *2015*
Abstract :- *The Study have come up with a mix design for the self compacting concrete using Japanese method of mix design, initial mix design was carried out at coarse aggregate content of 50 percent by volume of concrete and fine aggregate content of 40 percent by volume of mortar in concrete, the water/powder ratio was kept at 0.90.*

Title :- *Factors affecting Self Compacting Concrete*
Authors :- *Joan Raudridge*
Year of Publication :- *2016*
Abstract :- *He stated factors Affecting Self Compacting Concrete using self-compacting concrete must not be used indiscriminately. Some factors can affect the behavior and performance of self-compacting concrete as hot weather.*

Title :- *Characteristics of self-compacting concrete*
Authors :- *U .N Shah and Dr. C.D Modhera*
Year of Publication :- *2014*
Abstract :- *They concluded from the study on process fly ash effect on hardened properties of self compacting concrete that the reduction in compressive strength as the fly ash percentage got increased. Study show that the strength reductions from 50 Mpa to 25 Mpa for fly ash replacement of 30 to 70 percentages at the age of 28 days.*

Title :- *Design Mix for Self Compacting Concrete*
Authors :- *Shwetang Kundu*
Year of Publication :- *2016*
Abstract :- *He stated that Self Compacting Concrete can be obtained by modifying the fine aggregate and coarse aggregate quantities such that fine aggregate is nearly 50% – 60% of total aggregate.*

Title :- *Effects of Metakaolin Content on Fresh and Hardened Properties of Self Compacted Concrete*
Authors :- *S. Mahesh*
Year of Publication :- *2014*
Abstract :- *He investigated about the self compacting concrete and its properties by replacing the cement content in levels of 10%, 20%, 30%, 40% and 50% by metakaolin. In the study it has been found that with increase in the super plasticizers dosage the workability. The acid resistance of SCC with metakaolin was higher when compared with concrete mixes without fly ash at the age of 28, 56 days.*

Title :- *DESIGN AND ANALYSIS OF SELF COMPACTING CONCRETE USING NAN–SU METHOD*
Authors :- *Pradnya P.Urade*
Year of Publication :- *2014*
Abstract :- *He made a comparative study of properties of self compacting concrete with ground granulated blast furnace slag and fly ash as admixtures. The effect of use of above mineral admixture fines on fresh properties of SCC was studied. The cement was replaced in 10%, 20% and 30% by GGBS and fly ash. A suitable and appropriate chemical admixture i.e. super plasticizer was used. The addition of 10 %, GGBFS and Fly Ash in SCC mixes increases the self compact ability characteristic like filling ability, passing ability, flowing ability and segregation resistance. And it can also be seen that compressive strength, flexural strength and split tensile strength is maximum for 10% replacement as compared to 20% and 30 %.*

Title :- *Replacement of cement by mineral admixtures in Self Compacting Concrete*
Authors :- *Arunika Chandra and M. Bhasker*
Year of Publication :- *2015*
Abstract :- *The present experimental investigations, double- blending of ordinary Portland cement (OPC) and two mineral admixtures, fly ash and CSF are blended together to develop double blended concrete*

mix. M80 design mix of concrete is taken as reference. The percentages of fly ash and CSF are varied. The results have indicated that double blending has helped concrete in respect of using lesser cement, without sacrificing the strength. The double blended fibrous high strength concrete has optimum properties in all the respects.

Title :- *Experimental Research on Double Blended Self-Compacting Geo Polymer Concrete*
Authors :- *R.Srinivas Prabhu and S.Vivek*
Year of Publication :- *2016*
Abstract :- *Self-compacting concrete (SCC) represents one of the most outstanding advances in concrete technology during the last decade. self compacting concrete is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes its suitable for placing in difficult situation and in sections with congested reinforcement. The investigation includes the concept of double blending of Fly ash, GGBS and Silica Fume, this double blend exploits the beneficial characteristics of Pozzolanic materials in producing a better concrete.*

Title :- *Impact And Permeability of Fibrous Double Blended Self Compacting Concrete*
Authors :- *B. L. P Swami*
Year of Publication :- *2016*
Abstract :- *The present experimental project, self-compacting concrete of M40 is tried using double blended technique with condensed silica fume (CSF),as a partial replacement by weight of cement at percentage of 10% and fly ash at 20%. Steel fibers having aspect ratio of 10, 15, 20 and 25 are also used. The various proportions of steel fibers are added at 0%, 0.1%, 0.2%, 0.3% and 0.4% as percentages of the volume of concrete . Based on the experimental results obtained in the present project work, conclusions are drawn on the improvement of strength properties of SCC by triple blending.*

3. METHODOLOGY

The following steps were considered in the methodology of present work carried out.

COLLECTION OF MATERIALS

⬇

STUDY OF MATERIALS

⬇

MIX DESIGN

⬇

MIXING WITH SPECIFIC PROPORTION

⬇

MOULDING OF SPECIMEN

⬇

DEMOULDING OF SPECIMEN

⬇

CURING FOR 7,28 DAYS

⬇

TESTING OF SPECIMEN

⬇

RESULT ANALYSIS AND CONCLUSION

The materials used investigation are:
1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Metakaolin
5. Ground Granulated Blast Furnace Slag (GGBS)
6. Chemical admixture: Super Plasticizer (Conplast SP430)
7. Water

3.1 Cement

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

The cement used is OPC 53 Grade cement which is required to conform to BIS specification IS: 12269-1987 with a designed strength for 28 days being a minimum of 53 MPa or 530 kg/sqcm. 53 Grade OPC provides high strength and durability to structures because of its optimum particle size distribution and superior crystallized structure. The cement used is Ultratech 53 grade cement.

Fig 3 Ultratech Cement

The physical and chemical properties of cement are

Oxides	Percent(%) content
CaO	60 – 67
SiO_2	17 – 25
Al_2O_3	3.0 – 8.0
Fe_2O_3	0.5 – 6.0
MgO	0.1 – 4.0
Alkalies(K_2O, Na_2O)	0.4 – 1.3
SO_3	1.3 – 3.0

Table – 3.1 Chemical Properties of Cement

The major compounds in the cement are following

Name of Compound	Formula	Abbreviated Formula
Tricalcium silicate	$3\ CaO.SiO_2$	C_3S
Dicalcium silicate	$2\ CaO.SiO_2$	C_2S
Tricalcium aluminate	$3\ CaO.Al_2O_3$	C_3A
Tetracalcium alumino ferrite	$4\ CaO.Al_2O_3.Fe_2O_3$	C_4AF

Table – 3.1.1 Major compounds of cement

Fig 3.1 Cement

The following tests were performed to find the physical properties of cement

- *Fineness*
- *Specific Gravity*
- *Consistency*
- *Soundness*
- *Setting Time*
  - *Initial setting time*
  - *Final setting time*

3.1.1 Fineness of cement

Objective :-
To determine the fineness of the cement by dry sieving.

Apparatus :-
a) *Standard balance with 100gm weighing capacity*
b) *IS : 90 micron sieve confirming to IS : 460 – 1962*

Procedure :-
- *Break down any air – set lumps in the cement sample with fingers.*
- *Weigh accurately 100gms of the cement and place it on a standard 90 micron IS sieve.*
- *Continuously sieve the sample for 15 minutes.*
- *Weigh the residue left after 15 minutes of sieving. This completes the test.*

Calculation :-
The percentage weight of residue over the total sample is reported.

$$\%\ Weight\ of\ Residue = \frac{Wt.of\ Sample\ Retained\ on\ the\ Sieve}{Total\ Weight\ of\ Sample}$$

$$= \frac{8}{100} \qquad 8 \ = 8\%$$

Limits :-
The percentage residue should not exceed 10%

Precautions :-
Sieving shall be done holding the sieve in both hands and gentle wrist motion, this will involve no danger of spilling cement, which shall be kept well spread out on the screen. More or less continuous rotation of the sieve shall be carried out through out sieving.

Fig 3.1.1 IS 90 micron sieve

3.1.2 Specific Gravity

Objective :-
To determine the specific gravity of the cement using specific gravity bottle.

Apparatus :-
a) *Specific Gravity bottle – 100 ml capacity*
b) *Balance capable of weighing accurately up to 0.01 gm*

Procedure :-
- *Weigh a clean and dry specific gravity bottle with its stopper (W1).*
- *Place a sample of cement up to half of the flask (about 50 gm) and weight with its stopper(W2).*
- *Add kerosene to cement in flask till it is about half full. Mix thoroughly to remove entrapped air.*
- *Continue and add more kerosene till it is flush with graduated mark. Dry the outside and weigh (W3).*

- *Empty the flask, clean it and refill with clean kerosene flush with graduated mark wipe dry the outside and weigh (W4).*

Calculations :-

Specific gravity = $\dfrac{(W2 - W1)}{(W2 - W1) - (W3 - W4) \times 0.79}$

where W1 = weight of empty flask
W2 = weight of flask + cement
W3 = weight of flask + cement + kerosene
W4 = weight flask + kerosene
0.79 = specific gravity of kerosene

Fig 3.1.2 Specific gravity bottle

Limits :-

Specific gravity of cement = 3.15 g/cc

3.1.3 Consistency of cement :-

Aim:-

To determine the water content required to produce Cement of Standard Consistency.

Apparatus :-

Vicat Apparatus, Balance, Stop Watch, Measuring Cylinder, trowel, Plunger G

Fig 3.1.3 Vicat Apparatus

Procedure :-

- *Firstly take the vicats apparatus and assemble the same with Plunger G, and later check the equipment for any correction if required by allowing the plunger to rest on the base plate and note the reading on the scale, if it is zero no correction is required any value higher than zero should be noted as correction.*
- *Take 300 g of cement passing through 90 micron ÌS sieve and place it in tray.*
- *Mix about 25% water by weight of dry cement thoroughly to get a cement paste.*
- *Fill the vicat mould, resting upon a glass plate, with this cement paste.*
- *After filling the mould completely, smoothen the surface of the paste, making it level with top of the mould and shake it slightly to expel air.*
- *Place the whole assembly (i.e. mould + cement paste + glass plate) under the rod bearing plunger.*
- *Lower the plunger gently so as to touch the surface of the test block and quickly release the plunger allowing it to sink into the paste.*
- *Measure the depth of penetration and record it.*
- *Prepare trial pastes with varying percentages of water content and follow the steps (2 to 7) as described above, until the depth of penetration becomes 5 to 7 mm from the bottom.*

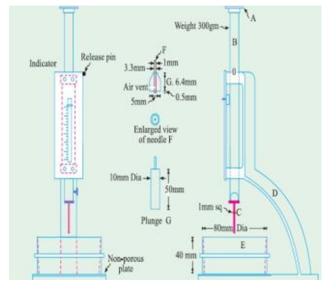


Fig 3.1.4 Vicat Apparatus view

Observation :-

S.No	*Quantity of Cement*	*Volume of water*	*Penetration of plunger from bottom*	*% of water*
1	*300 gm*	*75 ml*	*30 mm*	*25*
2	*300 gm*	*90 ml*	*15 mm*	*30*
3	*300 gm*	*96 ml*	*6 mm*	*32*

Table – 3.1.2 Observation of Consistency

Calculations:-

Calculate percentage of water (P) by weight of dry cement required to prepare cement paste of standard consistency by following formula, and express it to the first place of decimal.

$$P = \frac{W}{C} \times 100$$

Where,
W=is the Volume of water in ml
C=weight of cement used in gms

P = (96/300) X 100
= 32 %

Precautions

- *Gauging time should be strictly observed*
- *Room temperature should be well maintained as per test requirement.*
- *All apparatus used should be clean.*

- *The experiment should be performed away from vibrations and other disturbances.*

3.1.4 Setting Time of cement :-

Objective :-

To determine the initial and final setting time of a given sample of cement.

Apparatus :-

Vicat apparatus, Balance, Gauging Trowel, Stop Watch, etc.

Procedure :-

- *Prepare a neat 300 gms cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.*
- *Start a stop-watch at the instant when water is added to the cement and fill the Vicat mould with a cement paste gauged as above, the mould resting on a nonporous plate. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould.*
- *Immediately after moulding, place the test block in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.*
- *Determination of Initial Setting Time - Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle , lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block*
- *Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould shall be the initial setting time.*
- *Determination of Final Setting Time - Replace the needle of the Vicat apparatus by the needle with an annular attachment.*
- *The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so.*
- *The period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.*

Fig 3.1.5 Needle used for Initial setting tim

Fig 3.1.6 Needle used for Final setting time

Observation :-

- *The normal consistency of a given sample of cement is _ 32__ %*
- *Volume of water addend (0.85 times the water required to give a paste of standard consistency) for preparation of test block _ 82 _ ml*

3.1.5 Soundness of Cement :-

Objective :-

To determine the soundness of a given sample of cement by Le-Chatelier method.

Apparatus :-

Le- Chatelier test apparatus conform to IS : 5514-1969, Balance, Gauging Trowel, Water Bath etc.

Fig 3.1.7 Le- Chatlier test apparatus

Procedure :-

- *Place the lightly oiled mould on a lightly oiled glass sheet and fill it with cement paste formed by 10 gauging cement with 0.78 times the water required to give a paste of standard consistency.*
- *The paste shall be gauged in the manner and under the conditions prescribed, taking care to*

keep the edges of the mould gently together while this operation is being performed.

- *Cover the mould with another piece of lightly oiled glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27 ± 2°C and keep there for 24 hours.*
- *Measure the distance separating the indicator points to the nearest 0.5 mm. Submerge the mould again in water at the temperature prescribed above.*
- *Bring the water to boiling, with the mould kept submerged, in 25 to 30 minutes, and keep it boiling for three hours. Remove the mould from the water, allow it to cool and measure the distance between the indicator points.*
- *The difference between these two measurements indicates the expansion of the cement. This must not exceed 10 mm for ordinary, rapid hardening and low heat Portland cements. If in case the expansion is more than 10 mm as tested above, the cement is said to be unsound.*

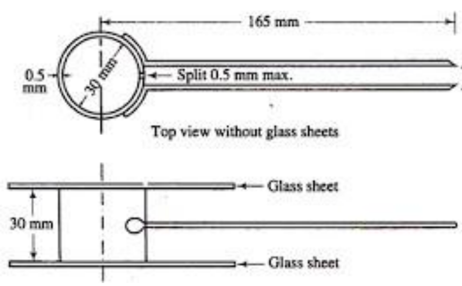


Fig 3.1.8 Le- Chatlier apparatus dimensions

Result :-
The difference between the initial and final measurements
Conclusion :-
The given cement is said to be sound / unsound.

3.2 Fine Aggregate :-

Fine aggregate includes the particles that all passes through 4.75 mm sieve and retain on 0.075 mm sieve. The fine aggregate considered is river sand, Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass.

Fig 3.2 River Sand

The tests that are being performed for the fine aggregates are

- *Particle size distribution*
- *Bulking*

3.2.1 Particle size distribution of fine aggregate :-

Objective :-
To determine fineness modulus of fine aggregate and classifications
Apparatus :-
Test Sieves conforming to IS : 460-1962 Specification of 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron, Balance, Gauging Trowel, Stop Watch, etc.

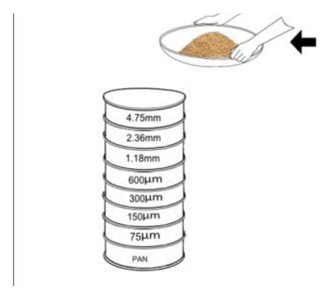


Fig 3.2.1 Order of Sieves

Procedure :-

- *The sample shall be brought to an air-dry condition before weighing and sieving. The air-dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.*
- *The shaking shall be done with a varied motion, backward sand forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions.*
- *Material shall not be forced through the sieve by hand pressure. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve.*
- *Light brushing with a fine camel hair brush may be used on the 150-micron and 75-micron*

IS Sieves to prevent aggregation of powder and blinding of apertures.

- *On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.*

Observation :-

I.S Sieve	Weight Retained on Sieve (gms)	Percentage of Weight Retained (%)	Cumulative % retained	Final Value
4.75 mm	43	4.3	4.3	95.7
2.36 mm	115	11.5	15.8	84.2
1.18 mm	304	30.4	46.2	53.8
600 micron	216	21.6	67.8	32.2
425 micron	69	6.9	74.8	25.3
300 micron	73	7.3	82	18
150 micron	103	10.3	92.3	7.7
75 micron	61	6.1	98.4	1.6
Pan	16	1.6	100	0

Table – 3.2 Observation of Sieve analysis

3.2.2 Bulking :-

Objective :-
To determine bulking of a given sample of fine aggregate
Apparatus :-
Measuring jar, Taping rod
Procedure :-

- *Take a container and fill the sand in loose state till it fill 2/3 rd and its height was noted (h1)*
- *Fill the container with water till bulking stops.*
- *Measure of sand depth when it completely saturate (h2)*

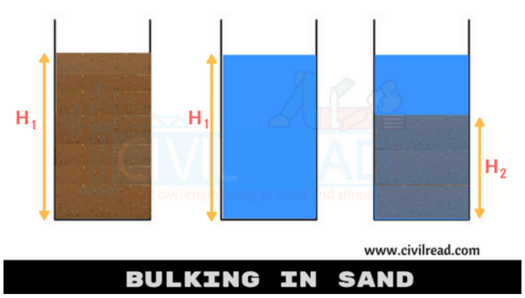


Fig 3.2.2 Bulking of Sand

3.3 Coarse aggregate :-

Coarse aggregates are those particles that are predominantly retained on the 4.75 mm sieve and will pass through 3-inch screen, are called coarse aggregate. The coarser the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area.

Fig 3.3 Coarse aggregate

The tests that are being performed on the coarse aggregate is

- *Specific gravity*
- *Impact test*

3.3.1 Specific gravity :-
Objective :-
To determine specific gravity of a given sample of course aggregate.
Apparatus :-
A wire basket of not more than 6-3 mm mesh, well-ventilated oven.

Fig 3.3.1 Wire mesh bucket

Procedure :-

- *A sample of not less than 2000 g of the aggregate shall be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22°C*

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

to 32°C with a cover of at least 5 cm of water above the top of the basket.

- *Immediately. after immersion the entrapped air shall be removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and aggregate shall remain completely immersed during the operation and for a period of 24 ± l/2 hours afterwards.*
- *The basket and the sample shall then be jolted and weighed in water at a temperature of 22°C to 32°C (weight A1).*
- *The basket and the aggregate shall then be removed from the water and allowed to drain for a few minutes, after which the, aggregate shall be gently emptied from the basket on to one of the dry clothes, and the empty basket shall be returned to the water and weighed in water (weight A2).*
- *The aggregate placed on the dry cloth shall be gently surface dried with the cloth, transferring it to the second dry cloth when the first will remove no further moisture. The aggregate shall then be weighed (weight B).*
- *The aggregate shall then be placed in the oven in the shallow tray, at a temperature of 100 to 110°C and maintained at this temperature for 24 ± l/2 hours. It shall then be removed from the oven, cooled in the airtight container and weighed (weight C).*

Fig 3.3.2 Oven

Calculations :-

Specific gravity, apparent specific gravity and water &sorption shall be calculated as follows:
Specific gravity = C / (A - B)
Apparent Specific gravity = C / (C - B)
Water absorption = 100(B - C) / C
A = Weight of saturated aggregate in water = $(A_1 - A_2)$
B = Weight of the saturated surface - dry aggregate in air.
C = Weight of oven dried aggregate in air.
A_1 = Weight of aggregate and basket in water
A_2 = Weight of empty basket in water

3.3.2 Impact Test :-

AIM :-
To determine the impact value of the road aggregates
APPARATUS :-
The apparatus consists of an impact testing machine, a cylindrical measure tamping rod, IS sieve balance and oven.

Fig 3.3.3 Impact test machine

PROCEDURE :-

- *Sieve the material through IS sieve the aggregates passing through comprises the test material.*
- *Pour the aggregates to fill about 1/3rdd depth of measuring cylinder.*
- *Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.*
- *Add two more layers in similar manner, so that cylinder is full.*
- *Strike off the surplus aggregates. 6. Determine the net weight of the aggregates to the nearest gram (W1).*
- *Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.*
- *Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.*
- *Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls.*
- *Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm (W2). Also weigh the fraction retained in the sieve.*
- *Note down the observations in the Performa and compute the aggregate impact value. The mean of*

two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

PRECAUTIONS :-

- *Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.*
- *In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.*
- *The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mould.*

3.4 Metakaolin :-

Metakaolin is a pozzolan, probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC. Its quality is controlled during manufacture, resulting in a much less variable material than industrial pozzolans that are by-products. First used in the 1960s for the construction of a number of large dams in Brazil. The particle size of metakaolin is smaller than cement particles.

Formation :-

The T-O clay mineral kaolinite does not contain interlayer cations or interlayer water. The temperature of dehydroxylation depends on the structural layer stacking order. Disordered kaolinite dehydroxylates between 530 and 570 °C, ordered kaolinite between 570 and 630 °C. Dehydroxylated disordered kaolinite shows higher pozzolanic activity than ordered. The dehydroxylation of kaolin to metakaolin is an endothermic process due to the large amount of energy required to remove the chemically bonded hydroxyl ions. Above the temperature range of dehydroxylation, kaolinite transforms into metakaolin, a complex amorphous structure which retains some long-range order due to layer stacking.

Fig 3.4 Metakaolin

Chemical composition of metakaolin

Composition	Percentage content
SiO_2	52.4
Fe_2O	4.3
Al_2O_3	36.1
CaO	0.1
MgO	0.84
K_2O	1.38
LiO	3.37

Table – 3.3 Chemical Properties of Metakaolin

Physical properties of metakaolin

Properties	Range
Appearance	OFF White powder
Bulk density	356 gm/lit
Specific gravity	2.63

Table – 3.3.1 Physical Properties of Metakaolin

The metakaolin used is obtained from the Astraa Chemical, Chennai.

3.5 Ground Granulated Blast Furnace Slag :-

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. Silicate and aluminates impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag.

In the case of pig iron production the flux consists mostly of a mixture of limestone and forsterite or in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation. To cool and fragment the slag a granulation process can be applied in which molten slag is subjected to jet streams of water or air under pressure. Alternatively, in the pelletization process the liquid slag is partially cooled with water and subsequently projected into the air by a rotating drum.

Fig 3.5 GGBS

In order to obtain a suitable reactivity, the obtained fragments are ground to reach the same fineness as Portland cement. The glass content of slag suitable for blending with Portland cement typically varies between 90-100% and depends on the cooling method and the temperature at which cooling is initiated.
Chemical properties of Ground-granulated blast-furnace slag

Composition	Percentage content
SiO_2	28 – 38
Al_2O_3	8 – 24
CaO	30 – 50
MgO	1 – 18

Table – 3.4 Chemical Properties of Ground-granulated blast-furnace slag

Physical properties of Ground-granulated blast-furnace slag

Properties	Range
Specific gravity	2.67
Bulk density	Dry – 1531 kg / cu.m Loose – 1337 kg / cu.m
Water absorption	6.5 %

Table – 3.4.1 Physical properties of Ground-granulated blast-furnace slag

The Ground-granulated blast-furnace slag used is obtained from Guru corporation, Vadodara.

3.6 Super Plasticizer:-

Many important characteristics of concrete are influenced by the ratio (by weight) of water to cementations materials (w/cm) used in the mixture. By reducing the amount of water, the cement paste will have higher density, which results in higher paste quality. An increase in paste quality will yield higher compressive and flexural strength, lower permeability, increase resistance to weathering, improve the bond of concrete and reinforcement, reduce the volume change from drying and wetting, and reduce shrinkage cracking tendencies.

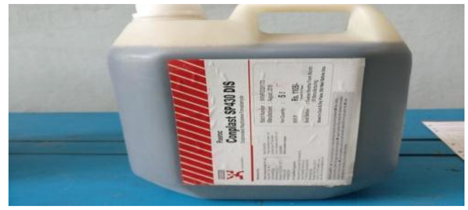


Fig 3.6 Super plasticizer

Super plasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio without negatively affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. This effect drastically improves the performance of the hardening fresh paste. The strength of concrete increases when the water to cement ratio decreases. However, their working mechanisms lack a full understanding, revealing in certain cases cement-super plasticizer incompatibilities.

Properties of Super plasticizer

Properties	Range
Specific gravity	1.18
Appearance	Brown liquid
Chloride content	Nil
Air entrainment	Less than 2% additional air is entrained at normal dosages

Table – 3.5 Properties of Super plasticizer

3.7 Water :-

Water plays a very huge role in the concrete mix. It's purpose is however broken down into two main things
Bonding: water in the ingredient in the concrete that mixes with cement to form what is called a binder. It establishes/increases the bond between the cement, the aggregate and the admixture. Water is also responsible for the process of hydration that leads to the hardening of concrete to form different structures.

Workability: this is the ease of ferrying and mixing concrete. It can also be regarded as the fluidity of the concrete. Thanks to Water, concrete can be easily mixed to form the desired mixture. The role of water is to reduce external friction between the concrete and whichever equipment being used to mix it. It will also reduce internal friction between the aggregate and the *cement. It is because of the workability facilitated by water that concrete can be moulded into different shapes before it can harden.*

Fig 3.7 Water in Concrete mix

3.8 MIX DESIGN :-

The mix design adopted for the Self compacting concrete is from NANSU method.

This method is divided into steps, as shown in Fig. . To determine the amount of aggregates, the volume ratio between the fine aggregate and the aggregate total (S/t) should be verified. According to this method, this ratio should range between 50% and 57%. Given these figures, a 53% S/t ratio was established, and the efficacy of the mixture for self-compactibility on the fresh state tests was analyzed.

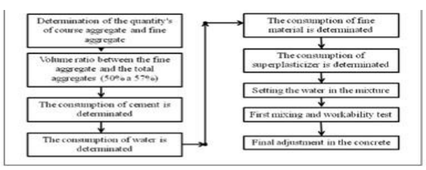


Fig 3.8 Steps followed in Nansu method

Step 1 :- Determination of quantity of Cement
Step 2 :- Determination of quantity of Coarse and Fine aggregate
Step 3 :- Consumption of water
Step 4 :- Consumption of Super plasticizer
The quantity of coarse aggregate is determined by

$$W_g = PF*W_{gL}*(1- S/t)$$

Where:
W_g *- amount of coarse aggregate in kg/m*^{3}*;*
W_{gL} *- density of coarse aggregate, in loose state in kg/m*^{3}
PF - loose state aggregate and compacted state aggregate ratio in mass
S/t - volume ratio between fine aggregate and aggregate total
The quantity of Fine aggregate is determined by

$$W_s = PF*W_{sL}*S/t$$

Where:
Ws - amount of fine aggregate in kg/m^3*;*
WsL - density of fine aggregate, loose state, in kg/m^3
PF - loose state aggregate and compacted state aggregate ratio, in mass
S/t - volume ratio between fine aggregate and aggregate total
The quantity of Cement is determined by

$$C = 1.26 * f_c / 0.14$$

Where:
C - cement consumption in kg/m^3*;*
f_c *- required compressive strength in MPa.*
The water – cement ratio for self compacting concrete according to nansu method varies from 0.2 – 0.3 . By performing various workability tests on the concrete the w/c ratio is finalized.
The fine aggregate is sieved through 1.18 mm sieve and the coarse aggregate used is sieved through 10 mm sieve and retained on the 6.3 mm sieve. The dosage of super plasticizer ranges between 5 – 9 % by the weight of cement and to be find by trying different trial mixes.
Determination of cement content
Target strength at 28 days is 80 Mpa

$$C = 1.16*80 / 0.14$$
$$= 662.8 \text{ kg / cu.m}$$

Determination of coarse aggregate conten $W_g = PF*W_{gL}*(1 - S/t) = 0.981*1602*(1 - 0.52) = 807.6$ *kg/ cu.m*
Determination of fine aggregate content
$W_s = PF*W_{sL}*(S/t) = 1520*0.908*0.52$
$= 716.6$ *kg/ cu.m*
Mix design proportions for M80 self compacting concrete obtained are as follow

Materials	*Quantity*
Cement	*663 kg / cu.m*
Fine aggregate	*717 kg / cu.m*
Coarse aggregate	*808 kg / cu.m*

Table – 3.6 Proportions Obtained

By performing various workability tests on the above obtained values the W/C ratio and the Super plasticizer dosage is determined based on the obtained results from the workability tests.

The below are the trial mixes tested for the determination of W/C ratio and Super plasticizer content

Materials	Mix 1	Mix 2	Mix 3
Cement	663 kg/cu.m	663 kg/cu.m	663 kg/cu.m
Fine aggregate	717 kg/cu.m	717 kg/cu.m	717 kg/cu.m
Coarse aggregate	808 kg/cu.m	808 kg/cu.m	808 kg/cu.m
W/C ratio	0.2	0.25	0.3
SP dosage	3 %	5 %	6 %

Table – 3.7 Composition of Trial mixes

The workability tests that are being performed on the self compacting concrete are V – funnel, Flow test, J ring, L box.

3.8.1 V – funnel :-

Aim :-

This test gives account of the filling capacity (flow ability).

Equipment :-

V-funnel, Stopwatch, Straightedge, Buckets.

Fig 3.8.1 V – funnel test

Procedure :-

- *Place the cleaned V-funnel vertically on a stable and flat ground, with the top opening horizontally positioned*
- *Wet the interior of the funnel with the moist sponge or towel and remove the surplus of water, e.g. through the opening. The inner side of the funnel should be 'just wet'.*
- *Close the gate and place a bucket under it in order to retain the concrete to be passed 4. Fill the funnel completely with a representative sample of SCC without applying any compaction or rodding*
- *Remove any surplus of concrete from the top of the funnel using the straightedge. Open the gate after a waiting period of (10 ± 2) seconds. Start the stopwatch at the same moment the gate opens.*
- *Look inside the funnel and stop the time at the moment when clear space is visible through the opening of the funnel. The stopwatch reading is recorded as the V-funnel flow time.*
- *Do not touch or move the V-funnel until it is empty.*

Interpretation of result :-

This test measures the ease of flow of concrete, shorter flow time indicates greater flow ability. For SCC a flow time of 10 seconds is considered appropriate. The inverted cone shape restricts the flow, and prolonged flow times may give some indication of the susceptibility of the mix to blocking.

Fig 3.8.2 Concrete in V – funnel

3.8.2 Flow Test :-

***Aim :-** of fresh concrete.*

The flow table test or flow test is a method to determine the consistence

Equipment :-

Flow table, Abrams cone, Tamping rod, Scale for measurement

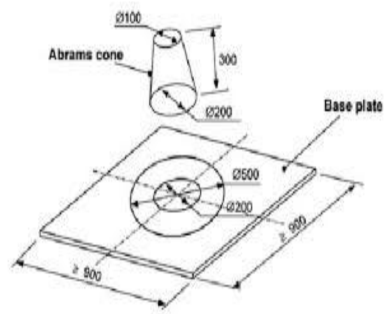


Fig 3.8.3 Flow table

Procedure :-

- *The flow table is wetted.*
- *The cone is placed on the flow table and filled with fresh concrete in two layers, each layer 25 times tamp with tamping rod.*
- *The cone is lifted, allowing the concrete to flow.*
- *The flow table is then lifted up several centimeters and then dropped, causing the concrete flow a little bit further.*
- *After this the diameter of the concrete is measured in a 6 different direction and take the average.*

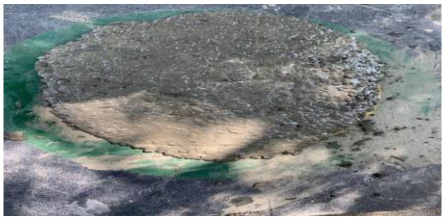


Fig 3.8.4 Concrete on Flow Table

3.8.3 J ring :-

Aim :-

The J-ring test aims at investigating both the filling ability and the passing ability of SCC.

Apparatus :-

J-ring, Base Plate

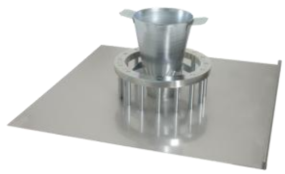


Fig 3.8.5 J ring apparatus

Procedure :-

- *Place the cleaned base plate in a stable and level position*
- *Fill the bucket with 6~7 litres of representative fresh SCC and let the sample stand still for about 1 minute (± 10 seconds).*
- *Under the 1 minute waiting period pre-wet the inner surface of the cone and the test urface of the base plate using the moist sponge or towel, and place the cone in the centre on the 200 mm circle of the base plate on the top of the cone to keep it in place.*
- *Place the J-ring on the base plate around the cone*
- *Fill the cone with the sample from the bucket without any external compacting action such as rodding or vibrating. The surplus concrete above the top of the cone should be struck off, and any concrete remaining on the base plate should be removed*
- *Check and make sure that the test surface is neither too wet nor too dry. No dry area on the base plate is allowed and any surplus of the water should be removed – the moisture state of the plate shall be 'just wet'.*
- *After a short rest (no more than 30 seconds for cleaning and checking the moist state of the test surface), lift the cone perpendicular to the base plate in a single movement, in such a manner that the concrete is allowed to flow out freely without obstruction from the cone, and start the stopwatch the moment the cone loose the contact with the base plate.*
- *Stop the stopwatch when the front of the concrete first touches the circle of diameter 500 mm. The stopwatch reading is recorded as the T50J value. The test is completed when the concrete flow has ceased.*
- *Measure the largest diameter of the flow spread, dmax, and the one perpendicular to it, dperp, using the ruler (reading to nearest 5 mm). Care should be taken to prevent the ruler from bending*

Expression Of Results :-

The J-ring flow time T50J is the period between the moment the cone leaves the base plate and SCC first touches the circle of diameter 500 mm. T50J is expressed in seconds to the nearest 1/10 seconds

Fig 3.8.6 Concrete in J Ring

3.8.4 L box :-

Aim :-

The method aims at investigating the passing ability of SCC.

Apparatus :-

Two types of gates can be used, one with 3 smooth bars and one with 2 smooth bars. The gaps are 41 and 59 mm, respectively, Suitable tool for ensuring that the box is level i.e. a spirit level, Suitable buckets for taking concrete sample

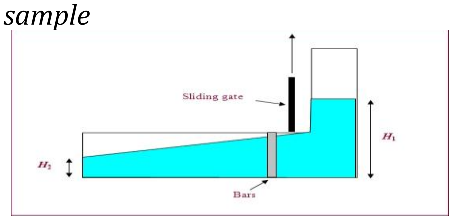


Fig 3.8.7 L box test

Procedure :-

- *Place the L-box in a stable and level position*
- *Fill the vertical part of the L-box, with the extra adapter mounted, with 12.7 liters of representative fresh SCC*
- *Let the concrete rest in the vertical part for one minute (± 10 seconds). During this time the concrete will display whether it is stable or not (segregation).*
- *Lift the sliding gate and let the concrete flow out of the vertical part into the horizontal part of the L-box.*
- *When the concrete has stopped moving, measure the average distance, noted as Δh, between the top edge of the box and the*

concrete that reached the end of the box, at three positions, one at the centre and two at each side.

Fig 3.8.8 Concrete in L – box

Based on the results obtained from the workability tests the water – cement ratio is adopted to be 0.3 and the Super plasticizer dosage is adopted as 6%. Thus the mix design obtained for the M80 self compacting concrete is as follows

Materials	Quantity
Cement	663 kg / cu.m
Fine aggregate	717 kg / cu.m
Coarse aggregate	808 kg / cu.m
W/C ratio	0.3
SP dosage	6 %

Table – 3.8 Mix Design of Self Compacting Concrete

From the above obtained quantities cubes of dimensions 150mm x 150mm x 150mm are casted and are tested for the compressive strength for 7 days and 28 days. From the result of compressive strength the mix design obtained is verified to be correct.

Then the cement is replaced by weight as 10 % and 20 % in order to find the optimum replacement for the metakaolin and ground granulated blast furnace slag is derived from the compressive strength results of the concrete blended by metakaolin and ground granulated blast furnace slag individually.

The below is mix for replacement of cement by metakaolin

Materials	Mix 1	Mix 2
Cement	596.7 kg / cu.m	530.4 kg/cu.m
Metakaolin	66.3 kg	132.6 kg/cu.m
Fine aggregate	717 kg / cu.m	717 kg / cu.m
Coarse aggregate	808 kg / cu.m	808 kg / cu.m
W/C ratio	0.3	0.3
SP dosage	6 %	6 %

Table – 3.9 Mix proportion for Metakaolin

The below is the mix for replacement of cement by ground granulated blast furnace slag

Materials	Mix 1	Mix 2
Cement	596.7 kg / cu.m	530.4 kg/cu.m
GGBS	66.3 kg	132.6 kg/cu.m
Fine aggregate	717 kg / cu.m	717 kg / cu.m
Coarse aggregate	808 kg / cu.m	808 kg / cu.m
W/C ratio	0.3	0.3
SP dosage	6 %	6 %

Table – 3.10 Mix proportion for GGBS

Based up on the results obtained from the individual blends the double blend mix is obtained by replacing the cement by metakaolin and ground granulated blast furnace slag. From the results obtained the metakaolin mix has increased compressive strength at 20 % replacement and it is more at 10% replacement of ground granulated blast furnace slag. So a total replacement of cement by weight is 30 % i.e 20 % metakaolin and 10% ground granulated blast furnace slag.

Materials	Quantity
Cement	464.1 kg/cu.m
Metakaolin	132.6 kg/cu.m
GGBS	66.3 kg/cu.m
Fine aggregate	717 kg / cu.m
Coarse aggregate	808 kg / cu.m
W/C ratio	0.3
SP dosage	6 %

Table – 3.11 Mix proportion for Double Blended SCC

Fig 3.8.9 Mixing of concrete

Fig 3.8.10 Concrete Preparation

3.9 Compression Test :-

AIM :-
To determination of the compressive strength of given concrete mixes.
APPARATUS :-
Testing Machine, Specimen mould, tamping rod
SPECIMEN :-
Cement concrete cubes of size 15cm, prepared from the given cement, fine aggregates & coarse aggregates, water.

Fig 3.8.11 Compression Testing machine

PROCEDURE :-

- *Calculate the material required for preparing the concrete of given proportions (1 : 1.08 : 1.21).*
- *Mix them thoroughly in mechanical mixer until uniform color of concrete is obtained*
- *Pour concrete in the oiled with a medium viscosity oil. Fill concrete is cube moulds in two layers each of approximately 75mm and ramming each layer with 35 blows evenly distributed over the surface of layer.*
- *Fill the moulds in 2 layers each of approximately 50mm deep and ramming each layer heavily.*
- *Struck off concrete flush with the top of the moulds.*
- *Immediately after being made, they should be covered with wet mats.*
- *Specimens are removed from the moulds after 24hrs and cured in water 28 days*
- *After 24hrs of casting, cylinder specimens are capped by neat cement paste 35 percent water content on capping apparatus. After 24 hours the specimens are immersed into water for final curing.*
- *Compression tests of cube and cylinder specimens are made as soon as practicable after removal from curing pit. Test-specimen during the period of their removal from the curing pit and till testing, are kept moist by a wet blanket covering and tested in a moist condition.*
- *Place the specimen centrally on the location marks of the compression testing machine and load is applied continuously, uniformly and without shock.*
- *Also note the type of failure and appearance cracks.*

3.10 Split Tensile strength :-

AIM :-
To determine the split tensile strength of concrete of given mix proportions.
APPARATUS :-
Compression testing machine weighing machine mixer, tamping rods
PROCEDURE :-
1. The material should be sufficient for casting three cylinders of the size 150mm diameter X 300 mm length. In mixing by hand cement and fine aggregate be first mixed dry to uniform colour and then coarse aggregate is added and mixed until coarse aggregate is uniformly distributed throughout the batch. Now the water shall be added and the ingredients are mixed until resulting concrete is uniform in colour. Mix at least for two minutes.
2. Pour concrete in moulds oiled with medium viscosity oil. Fill the cylinder mould in four layers each of approximately 75 mm and ram each layer more than 35 times with evenly distributed strokes.
3. Remove the surplus concrete from the top of the moulds with the help of the trowel.
4. Cover the moulds with wet mats and put the identification mark
5. Remove the specimens from the mould after 24 hours and immerse them in water for the final curing. The test is usually conducted at the age of 7-28 days. The time age shall be calculated from the time of addition of water to the dry ingredients.
6. Test at least three specimens for each age of test.

PRECAUTIONS :-

The mould and base plate must be oiled lightly before use
The specimen should be made and cured as per IS 516-1959
The specimen should be tested immediately on removal from the water
The specimen should be placed in testing machine centrally
Load should be applied without shock

Fig 3.8.1 Compressed Specimens

4. RESULTS

The results for the above all experiments is listed down and compared

Physical properties of Cement

Test		Result
Fineness		8 %
Specific gravity		3.15
Consistency		32 %
	Initial	32 min
	Final	600 min
Soundness		2 mm

Table – 4.1 Physical Properties of Cement

Test on Fine aggregate

Test	Result
Sieve analysis	Well graded
Bulking	6 %

Table – 4.2 Test on Fine aggregate

Test on Coarse aggregate

Test	Result
Specific gravity	2.6
Impact test	17.3 %

Table – 4.3 Test on Coarse aggregate

Workability test on Self Compacting Concrete

Mixes	V – funnel	Flow Test	J Ring	L - box
	(sec)	T_{50} (sec)	J_{50} (sec)	H_2 / H_1
Trial Mix – 1	25	10	14	0.57
Trial Mix – 2	15	8	10	0.79
Trial Mix – 3	8	4	6	0.90
Blend Mix – 1	8	4	5	0.91
Blend Mix – 2	7	3	5	0.94
Blend Mix – 3	8	4	6	0.93
Blend Mix – 4	7	5	5	0.94
Double Blend Mix	7	3	5	0.95

*B.M-1 = M80+10% Metakaolin, B.M-2 = M80+20% Metakaolin, B.M-3 = M80+10% GGBS, B.M-4 = M80+20% GGBS

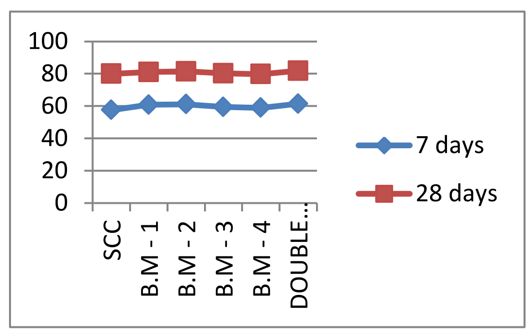
Table – 4.4 Workability Tests

Compression test and Split Tensile test

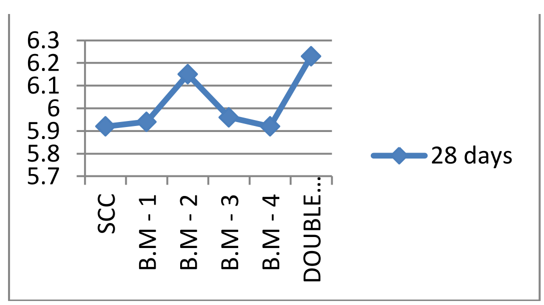
Mixes	Compressive Strength		Split Tensile Strength
	7 days	28 days	28 days
Self Compacting Concrete	57.5	79.87	5.92
Blend Mix – 1	60.735	80.98	5.94
Blend Mix – 2	61.02	81.37	6.15
Blend Mix – 3	59.37	80.23	5.96
Blend Mix – 4	58.87	79.71	5.92
Double Blend Mix	61.34	81.79	6.23

*B.M-1 = M80+10% Metakaolin, B.M-2 = M80+20% Metakaolin, B.M-3 = M80+10% GGBS, B.M-4 = M80+20% GGBS

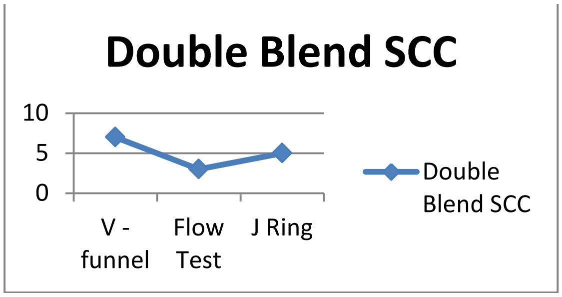
Table – 4.5 Compression and Split Tensile Test



Graph – 1 Compressive strength of different mixes



Graph – 2 Split tensile strength of different mixes



Graph – 3 Workability Tests on SCC

5. CONCLUSIONS

- *Workability and flow ability are important in Self Compacting Concrete. In the present investigation on double blended Self Compacting Concrete, the workability and flow ability are improved due to presence of 30% mineral admixtures.*
- *Using mineral admixtures as partial replacement to cement in SCC reduces the permeability.*
- *During the hydration of cement $Ca(OH_2)$ will be produced, it, By replacing cement with MetaKaolin, $Ca(OH_2)$will be converted into (C-S-H) gel, this will help to develop to additional compressive strength and makes the concrete stronger by blocking existing pores.*
- *The size of coarse aggregate controls the test results of L- Box test and hence it signifies that greater the size of aggregate less is the flow ability through the heavily reinforced structures.*
- *Trail mixes have to be made for maintaining flow ability, self-compatibility and obstruction clearance.*
- *A double-blend approach to high performance concrete mix design can enable cost savings, increased performance and improved sustainability*
- *There was an increase in the strength of SCC when the cement is replaced by metakaolin and ground granulated blast furnace slag up to 30%. This also reduces the cement content by increasing the metakaolin and ground granulated blast furnace slag thus reducing the further cost of SCC mixes developed.*
- *The metakaolin and ground granulated blast furnace slag in place of cement shall be very economical and can also help in the utility of Industrial wastes and in maintaining the ecological balance, thus reducing the consumption of cement.*
- *Higher dosages of super plasticizer are required for high strength concrete mixes particularly when mineral admixtures and were employed to maintain workability.*
- *The compressive strength, flexural strength and split tensile strength have been increased upto 30% replacement of cement by 20% Metakaolin, 10% GGBS.*
- *In addition, the application of SCC is also benefit for making eco-friendly concrete and promoting the development of other types of ultrahigh performance concrete.*
- *It can solve the problems brought by poorly compacted concrete, including unsatisfying physical appearance, strength, or durability issues.*
- *In the present experimental investigation, doule blending of ordinary Portland cement was carried out so as to arrive at a mix with optimum properties.*

6. REFERENCES

[1] Okamura, H. and Ozawa, K., (1995), "Mix-design for self-compacting concrete," Concrete Library, JSCE, Vol. 25, pp.107-120.

[2] S. Mahesh (2014) ,Self Compacting Concrete and Its Pṙ'erties. International Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 4, Issue 8 (Version 7), pp.72-80.

[3] T.Jeevetha, S.Krishnamoorthi, G.S.Rampradheep (2014), Study on Strength Properties of Self-Compacting Concrete with Micro Silica, International Journal of Innovative Research in Science, Engineering and Technology Vol. 3, Issue 4, April 2014 ISSN: 2319-8753.

[4] Ankit J. Patel , Dixitkumar D. Patel, Dhruvkumar H. Patel, Vivek A. Patva (2014), Self-Compacting Concrete with use of waste material, International Journal For Technological Research In Engineering Volume 1, Issue 9, May-2014 ISSN (Online): 2347 – 4718.

[5] Heba A. Mohamed (2011) ,Effect of fly ash and silica fume on compressive strength of self-compacting concrete under different curing ċnditiṅs. Ain Shams Engineering Journal, 79–86.

[6] U. N. Shah, Dr C. D. Modhera (2014) ,Pṙcess Fly Ash effect on harden properties of Self Compacting Ċncrete. International Journal of Engineering, Business and Enterprise Applications, pp. 145-148 ISSN (Online): 2279-0039.

[7] Pradyna P Urade ,Chandrakanth U Mehetre and Shiram H Mahure(2014), Ċm'arative Study of Properties of Self Compacting Concrete with Ground Granulated Blast Furnace Slag and Fly Ash as Admixtures, International Journal of Civil , Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN(P): 2249-6866; ISSN(E): 2249-7978 Vol . 4, Issue 2, 127-138.

[8] Nan Su , Buquan Miao(2003),A new method for the mix design of medium strength flowing concrete with low cement ċntent, Cement & Concrete Composites 215–222.

[9] *IS 2386 -1963 part I to VIII, Indian Standard Methods of test for Aggregate Concrete. Bureau of Indian Standards, New Delhi.IS 383:1970, Specification for coarseand fine aggregate from natural sources for concrete, Bureau of Indian standards, New Delhi, India.*

[10] *Specification and Guidelines for Self Compacting Ċncrete, (2002) EFNARC, ISBN 0953973344.*

E-references *:-*

[1] *file:///C:/Users/sundar.sundarprathima/Desktop/Major%20Project/triple%20blended%202.pdf*

[2] *http://www.trp.org.in/wp-content/uploads/2016/12/AJEAT-Vol.5-No.2-July-Dec-2016-pp.15-21.pdf*

[3] *http://www.ijsrp.org/research-paper-0715/ijsrp-p4306.pdf*