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STUDY ON COMPRESSIVE STRENGTH AND VARIATION OF THE PHYSICAL PROPERTIES OF CONCRETE USING ALUMINIUM SLAG, FLYASH AND SILICA FUME

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ABSTRACT
An experimental study on the compact effects of mineral admixtures on the properties of mechanical regarding concrete is presented in this abstract. Fly ash and silica fume were two examples of mineral admixtures that were included in the concrete mixes. Parameters like compressive strength, tensile strength, and durability were tested. The findings shed light on how mineral admixtures can improve the properties of concrete.The benefits of using admixtures such fly ash, silica fume, and granulated blast furnace slag in concrete are shown in this research. Various mechanical parameters, including compression, split tensile, and flexural strength, are measured for specimens of various classes. The M35 grade samples include fly ash (at 0.5, 0.10, and 0.15 concentrations), silica fume (at 0.5, 0.10, and 0.15 concentrations), and granulated blast furnace slag (at 0.5, 0.10, and 0.15 concentrations), all in lieu of cement. The ratio of water to cement used in all tests was 0.45. The chemical activity is slowed and the density is increased thanks to the ground granulated blast furnace sand. The use of a variety of admixtures in concrete results in improved performance in that material's construction. Compression, split tensile strength, and flexural strength are only some of the mechanical parameters that may be measured after 28 days.Therefore the findings are able to provide and compile valuable insights into the enhancement of "concrete properties" through the utilization of mineral admixtures. With the help of "incorporating mineral additives" like fly ash and silica fume into the concrete mixes, a series of fundamental tests were conducted and approved for the evaluation of parameters including compressive strength, tensile strength, and durability.

I. INTRODUCTION

1.1 GENERAL

Sustainable construction mainly aims at reduction of negative environmental impact resulted by construction industry which is the largest consumer of natural resources. The total amount of by-products generated by the industries worldwide every year exceeds 1000 million tonnes. Over a period of time, waste management had become one of the most complex and challenging problem in the world which is affecting the environment. The rapid growth of industrialization gave birth to numerous kinds of waste by-products like Aluminium slag, fly ash, silica fume and slagswhich are by-products formed in smelting, and other metallurgical and combustion processes from impurities in the of storage. Always, construction industry had been at vanguard in consuming these waste products in large quantities.

1.1.1 ALUMINIUM SLAG DEFINED

Aluminium slag is a mixture of free metal and non metal substances (e.g., aluminium oxide and salts).Slags as well as salt slags (or: salt cakes) are residues from aluminium industry. Aluminium slag is formed during refining and by air-oxidation of the liquid metal during melting, holding and casting operations. It consists of a complex conglomerate, including metallic oxides (e.g.: Al_2O_3, $Al_2O_3 \cdot MgO$, $Al_2O_3 \cdot SiO_2$, $Al_2O_3 \cdot FeO$ etc.), nitrides (e.g.: AlN), chlorides (e.g.: $AlCl_3$, $NaCl$, KCl), fluorides (e.g.: CaF_2, NaF, AlF_3, Na_3AlF_6 etc.), carbides (e.g.: Al_4C_3), sulphides (e.g.: Al_2S_3), phosphides (e.g.: AlP), dirt and impurities apart from metallic aluminium (between 80-20%). The formation of slag and the amount of slag formed depend on different factors like type and quality of input material (e.g.: aluminium scraps in secondary industry) operating conditions and type of technology and furnace applied. Depending on different conditions metals or ores being treated ,which are environmentally hazard and creates problems of storage. Always, construction industry had been at vanguard in consuming these waste products in large quantities.

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Fig: 1.1 BlackAluminium slag

Fig: 1.2. Sieved Black Aluminium slag

Aluminium nitrides and carbides may also be present, as well as metal oxides derived from the molten alloy (Manfredi et al. 1997) [12]. Slag may be classified by means of their metal content and slag with a high metal content (white, or wet, slag that is rich in free metal) typically occurs when scrap is re-melted with salts in an open – hearth furnace. This black, or dry, slag is usually granular with a high metal content in the coarse fraction and chiefly oxides and salt in the fines. The possibility for non-waste utilization of Aluminium slag and converting it into commercially useful products was investigated by Lucheve et al. (2005) [11]. Lack of comprehensive information on the characteristics of by-products is a major barrier to increased use of these materials. There is also a need to develop technologies to cost- effectively convert various wastes into usable feedstock and thus, new technologies that would minimize or eliminate the formation of slag and salt cake are encouraged. Minimization of slag and salt cake formation and the development of new uses for wastes and by-products should be the primary focus. The first can be accomplished by developing new melting processes that eliminate or minimize the formation of these wastes and, the development of economical technologies for turning aluminium waste such as red mud into usable feedstock for other processes that could eliminate this environmental problem. Valuable aluminium metal, oxides, salts, and other materials have been wasted because of the lack of viable processing technologies to convert this material to useful products.

1.1.2 SILICA FUME DEFINED

The American Concrete Institute (ACI) defines silica fume as "very fine non-crystalline silica produced in electric arc furnaces as a by-product of the productions of elemental silicon or alloys containing silicon" (ACI 116R). It is usually a graycoloured powder, somewhat similar to Portland cement or some fly ashes. Silica fume is usually categorized as a supplementary cementitious material. This term refers to materials that are used in concrete in Addition to portland cement. Silica fume is frequently referred to by other names:

• Condensed silica fume
• Micro-silica
• Volatilized silica

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys in smelters using electric arc furnaces. These metals are used in many industrial applications to include Aluminium and steel production, computer chip fabrication, and productions of silicones, which are widely used in lubricants and sealants. While these are very valuable materials, the by-product silica fume is of more importance to the concrete industry.

Fig: 1.3 Silica Fume

Fig: 1.4 Silica Fume

II. LITERATURE REVIEW

2.1 General :

In the literature, there are several studies to use these industrial waste residues in construction applications as the replacement of sand or cement, to produce concrete blocks, to manufacture aluminate cement or as filler in asphalt products, strength gain in concrete with the use of silica fume and fly ash. The results proved that the concrete products can be prepared by using the salt as the replacement of sand or cement without causing deleterious effects on concrete characteristics, and the calcium aluminate cement can be produced by using the salt cake as sources of CaO and Al_2O_3.

In this chapter, only literature concerning those aspects related to this particular research i.e. the mechanical and durability properties of hardened concrete incorporating fly ash, silica fume and Aluminium slag as a mineral Admixtures Added to concrete made with the Portland cement are discussed.

A.Go´mez1, N.B.Lima and J.A.Teno´rio(2008)carried a work on *"*Quantitative analysis of Aluminium slag by the Rietveld method*"*.Aluminium white slag is a valuable material principally due to its high metallic aluminium content. The aim of this work is to develop a method for quantitative analysis of aluminium white slag with high accuracy. Initially, the material was separated into four granulometric fractions by means of screening. Two samples of each fraction were obtained, which were analyzed by means of X-ray fluorescence and energy dispersive spectroscopy in order to determine the elements present in the samples. The crystalline phades aluminium, corundum, spinel, defect spinel, diaoyudaoite, aluminium nitride, silicon and quartz low were identified by X-ray diffraction. The quantitative phade analysis was performed by fitting the X-ray diffraction profile with the Rietveld method using the GSAS software. The following quantitative results were found: 77.8% aluminium, 7.3% corundum, 2.6% spinel, 7.6% defect spinel, 1.8% diaoyudaoite, 2.9% aluminium nitride, and values not significant of quartz and silicon.

K.E.Lorber and H.Antrekowitsch (2009) carried a work on "Treatment and disposal of residues from Aluminium slag recovery". Basically, slag could be disposed on special types of hazardous waste landfills relatively safely, as long as water and moisture is strictly kept away. But due to insufficient base linear systems and inadequate surface capping of elder landfills, in reality pollution of ground water (e.g.: F-, Cl-, NH_4 +, CN-, high pH and electric conductivity values) and ambient air (e.g.: CH_4, H_2, NH_3) can be observed in many cases, when slag was land filled. Investigations done on a former industrial landfill for residues coming from a secondary aluminium plant, showed high concentrations (e.g.: >4 Vol% H_2, >7 Vol% CH_4, >2 Vol%, NH_3) of dangerous gases in soil air. It also turned out, that the pollution found in ground water (e.g. NH_4 +, F-, Cl-) did not result from percolation of precipitation water but from bottom – leaching of the landfill, caused by capillary diffusion. Top and bottom layer of the site are relatively wet and compacted, the space in between is filled up with dry, dust like slag material. This makes sense, because slag will immediately react with water according. For a 20 year old sample of slag material taken from a site-depth between 4-5m, the gas formation potential was determined over 21 days. As shown in Fig. 3, the sample was showing a linear development of degassing, with a rather constant gas formation potential of 8.4 N ml/kg DM per day.

B. Lipowska, J. Witek and K. Stec 2010, had done research work on "Aluminium slag-based insulating and exothermic materials for metallurgical industry", in the conducted investigations, Aluminium slag was a basic component of raw mixes used to obtain insulating and exothermic materials. Two types of slag were used: waste produced in the process of aluminium chips melting (slag A) and waste produced in the process of beverage can melting (slag B). Due to a potential reaction of the alloy with alkaline metal salts contained chiefly in the dust fraction, 0.5÷2 mm grain size distribution was applied. The chemical composition of these types of slag indicates that they differ chiefly in Al contents, both in a metallic and oxide form. Thermo-hardening resins were used as binders: solid novolak and liquid carbamide-formaldehyde resin. The material was obtained by filtrating the slurry. To this end, suitable amounts of selected raw materials and binder were used to prepare a water suspension, which was filtrated at the pressure of ca 0,1MPa. In the conducted investigations, the influence of the type of slag and binder as well the impact of the share of quartz sand and mineral wool on the material's basic properties was determined: apparent density and compression strength after drying and firing at 1450 C as well as refractoriness. The investigations were carried out for samples in a form of =h=50mm cylinders, moulded in the process of slurry filtration. It was found (Table 2) that the type of slag and binder used does not influence basic properties, i.e. Apparent density and compression strength of the obtained materials, both after binders hardening at 150^0 C and after their firing. Refractoriness of the examined materials reached 1570^0 C. Increasing the share of mineral wool from 10 to 15% (batch 3) reduced the material's refractoriness by 20^0 C. Moreover, investigations into thermal properties of the obtained materials were conducted in a device which allows determining the amounts of heat carried away or supplied in the measuring process. The results were recorded in a form of graphs showing the loss of heat of the examined material sample versus time. The result of heat loss measurement for the model sample made of technically pure $Al_2O_3$was assumed as the reference level. On the basis of the obtained dependencies, the duration of exothermic effect and FIV (Final Insulating Value) was determined – the loss of heat from an examined sample of material after measurement, i.e. after 45 min. Trials were carried out to test the possibility of using slag –waste formed in the production or recycling of aluminium – to obtain an insulating and exothermic material for riser head sleeves applied in the metallurgical industry. Properly composed raw mixes, among others containing slag, raw materials which are necessary in exothermic reactions and ensure a material with suitable mechanical and thermal properties, enabled obtaining a material characterized by good thermal properties as well as sufficient mechanical strength, both at the stage of installation and alloy casting. The trials conducted in semi-technical conditions, using prototype sleeves, revealed their good quality and effectiveness in the metallurgical process, comparable to the currently applied sleeves. The conducted tests confirmed the fact that the obtaining of an insulating-exothermic material may be one of the directions in the utilization of Aluminium slag, which being arduous waste for the environment is currently stored at dumping grounds.

S.Maropoulos, D.Kountouras,X.Voulgaraki, S.Papanikolaou(2011) carried a work on "A Characterization Method for Al Recovery from Slag Based on Compression at Elevated Temperatures".When aluminium or its alloys are melted, considerable amounts of slag are produced. The alloy type and the method used in the production of aluminium products play an important role in the amount of slag that will result as a by-product. The current needs of the Al industry as well as economic and environmental factors demand the recovery of the pure material that is lost during slag removal by simple and efficient methods that can be applied within the foundry. Most cases of Al recovery employ methods of slag compression at high temperatures. This investigation attempts to develop a mathematical model to characterize the efficiency of the recovery process that can be implemented for any slag collection method or even compression device, facilitating the direct comparison of recovery methods.

AndinaSprince, LeonidsPakrastinsh and AleksandrsKorjakins 2011, "Experimental Study on Creep Of New Concrete Mixtures", This experimental study proves that lamp glass powder and small clay particles can be successfully used in the production of concrete, thus potentially decreasing the amount of deposited waste and the use of cement, which would less to a reduction of carbon dioxide release into the atmosphere. In order to decrease the dispersion of the results, the number of specimens and tests should be increased. In the future, the physical and mechanical properties of this new concrete containing lamp glass powder and small clay particles should be investigated in a more detailed way. The results of this experiment can be used to predict creep deformations. Long-term deformations testing was carried out, and the modulus of elasticity, the compression strength of ordinary concrete and of concrete containing lamp glass powder and small clay particles were determined. The basic creep test results were summarized on the 90th day. Lamp glass powder caused a long-term hardening effect. The specimens in which cement was partially replaced by lamp glass powder showed a larger increase of the compression strength than the reference concrete specimens, and the compression strength of 58 days old concrete specimens containing LGP was larger than that of the reference concrete specimens. The reference concrete specimens and specimens containing SCP showed a similar increase of the compression strength at both ages. The modulus of elasticity in dry conditions was larger for the reference concrete specimens. For the specimens containing LGP the larger modulus of elasticity was achieved by hardening in moist conditions. The modulus of elasticity in dry conditions was larger for the reference concrete specimens but in moist conditions the larger modulus of elasticity was for the specimens containing SCP. Creep strain increases with time at a decreasing rate. In the period immediately

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after initial loading, creep develops rapidly, but with time the rate of increase slows significantly. The concrete specimens cured in moist conditions showed larger increase of basic creep deformations.

III. MATERIALS AND METHODOLOGY

3.1 MATERIALS

3.1.1 Ordinary Portland Cement (53 grade):-

Cement may be described as a material with Adhesive and cohesive properties that make it capable of bonding, mineral fragments into a compact whole. Most cement used today is Portland cement. This is carefully proportioned and specially processed combination of lime, silica, iron oxide and alumina. It is usually manufactured from limestone mixed with shale, clay. Properly proportioned raw materials are pulverized into kilns where they are heated to a temperature of 1300 to 1500˚C. The clinker is cooled and ground to fine powder with Addition of about 3 to 5% of gypsum. The OPC (53 grade) used in the present work is of Anjanicement.The cement used in the casting of cubes and cylinders meets the following specifications as per IS 12269-1987.

QUALITY PARAMETERS

Table: 3.1 Fineness of Ordinary Portland cement

Trail No.	1	2	3
Weight in cement (g)	100	100	100
Quantity of Cement Retained (%)	6	7	6

Table: 3.2 Soundness of Ordinary Portland cement

Test physical requirement	AnjaniO.P.C 53 grade	IS 12269-1987
Lechatlier Method(mm)	1	<10

Table: 3.3 Normal Consistency of Ordinary Portland cement

Test physical requirement	AnjaniO.P.C 53 grade	IS 12269-1987
Normal Consistency (%)	34	Not Specified

Table: 3.4 Setting Time of Ordinary Portland cement

Test physical requirement	Anjani OPC 53 grade	IS 12269-1987
Initial setting time(min)	50	>30
Final setting time(min)	320	<600

Table: 3.5 Chemical Requirements of Ordinary Portland cement

S.No	Oxide composition	Percent content
1	Lime, CaO	63
2	Silica, SiO_2	20
3	Alumina, Al_2O_3	6
4	Iron oxide, Fe_2O_3	3
5	Magnesia, MgO	1.5
6	Sulphur-trioxide, SO_3	2
7	Potassium oxide, K_2O	1
8	Sodium oxide, Na_2O	1
9	Tricalcium silicate, C_3S	54.1
10	Dicalcium silicate, C_2S	16.6
11	Tricalcium aluminate, C_3A	10.8
12	Tetra calcium aluminoferrite, C_4AF	9.1

3.1.2 Fine aggregate

Naturally available sand is used as fine aggregate in the present work. The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. The sand is free from clayey matter, silt and organic impurities etc. Hence used as a fine aggregate in concrete. The size of sand is that passing through 4.75 and retained on 150 micron IS sieve. The specific gravity of Sand is taken as 2.62. Sand is tested for specific gravity, in accordance with IS: 2386-1963.

Table:3.6Properties of fine aggregate

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Sl. No	Properties	Unit	Results
1	Specific gravity	-	2.7
2	Bulking of sand	%	4
3	Partial size variation	mm	0.15 to 4.75

Table:3.7 Grain Size Distribution of Fine Aggregate

Sieve ze	Weight Retained (gm)	Cumulative % Retained	Cumulative % Passing	Zone - Specifications as per IS:383-1970 for % Passing			
				I	II	III	IV
4.75 mm	12	1.2	98.8	90-100	90-100	90-100	95-100
2.36 mm	103	11.5	88.5	60-95	75-100	85-100	95-100
1.18 mm	316	43.1	56.9	30-70	55-90	75-100	90-100
600 μ	205.5	63.65	36.35	15-34	35-59	60-79	80-100
300 μ	296.5	93.3	6.7	5-20	8-30	12-40	15-50
150 μ	62	99.5	0.5	0-10	0-10	0-10	0-10
Pan	2	100	0	---	---	---	---

Fineness Modulus of Fine Aggregate=312.25/100=3.12

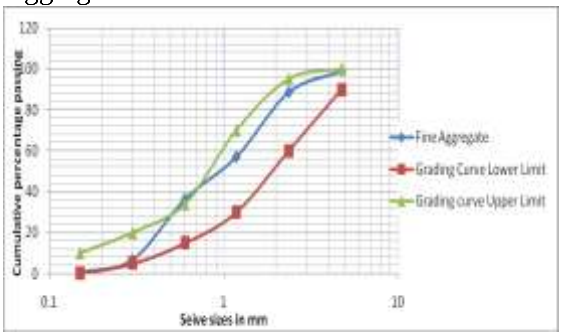

Fig :3.0 Particle Size Distribution of Fine Aggregate

3.1.2.1 Bulking of Sand

Observations

Weight of empty container = 818 g

Weight of container with oven dried sand = 1618 g

Weight of sand = 800 g

Height of dry sand (h) = 7 cm

Table:3.8 Bulking of Sand

Percentage of water Added by weight of sand	Height of moist sand (h') (cm)	Percentage bulking of sand $\frac{h'-h}{h} * 100$
1	7.8	11.43
2	8.4	20
4	9.1	30
6	8.6	22.8
8	7.7	10

3.1.3 Coarse aggregate

The coarse aggregate is free from clayey matter, silt and organic impurities etc. Coarse aggregate is tested for specific gravity, in accordance with IS: 2386-1963. The maximum size of 20 mm is used as a coarse aggregate in concrete. For most of building constructions, the coarse aggregate consists of gravel or crushed stone up to 20mm size. However, in massive structures, such as dams, the coarse aggregate may include natural stones or rock.

Table:3.9 Properties of Coarse Aggregate

S. No	Properties	Unit	Results
1	Specific gravity	-	2.8
2	Particle size variation	Mm	6.3 to 20

Table:3.10 Grain Size Distribution of Coarse Aggregate

IS Sieves(mm)	Weight Retained (gm)	%Weight Retained	Cumulative % Weight Retained	% Passing
20	2520.5	50.41	50.41	49.59
12.5	2364.5	47.29	97.7	2.3
10	103	2.06	99.76	0.24
4.75	12.5	0.25	100	0
2.36	-	-	100	0
1.18	-	-	100	0
0.6	-	-	100	0
0.3	-	-	100	0
0.15	-	-	100	0

Fineness Modulus of Coarse Aggregate=800/100=8.00

IV. MIX DESIGN

4.1 MIX DESIGN FOR PRESENT INVESTIGATION:

In the present work the Indian standard method (IS METHOD) had been used to get proportions for normal strength concrete. The concrete mix design for M_{20} were carried out according to Indian standard recommendation method as per IS 10262-1982.

4.2 MIXTURE PROPORTIONING PROCEDURE

The basic steps involving in the Indian standard method of design of concrete can be summarized as follows

Steps 1: determination of target mean strength or field strength

Formula for calculating target means strength as follows

$F_t=f_{ck}+ks$

Where f_t = target mean compressive at 28 days

f_{ck}= characteristic compressive strength at 28 days

k = statically value depending upon the accepted portions of flow results and the number of tests.

S= Assumed standard deviation

Note: As per IS: 456-2000, the value of k is taken 1.65, assuming that characteristic strength is expected to fall not more than 5 percent of test results. And value of s is also taken from IS 456-2000 table. This is given for each grade of concrete. The value of s for M_{20} and M_{25} is 4Mpa and 5Mpa.

STEP2: WATER-CEMENT RATIO

The water-cement ratio is chosen from table no. IS: 456-2000(36). Which specify the minimum cement content, maximum water cement ratio and minimum grade of concrete for the different exposure conditions with normal maximum size aggregate is 20mm. The value selected is compared with available relations in SP: 23-1982(35). For the determination of w/c ratio for the target mean compressive strength at 28 days.

It is noted here that w/c ratio for the determined target mean compressive strength at 28 days gives lower value than specified maximum value in table of IS 456-2000.

STEP3: ESTIMATION OF REQURIED WATER

The approximate water content is selected from the table 35 and 38 of SP. 23-1982, applied for normal concrete mix, which considers the aggregate type (whether crushed or uncrushed), maximum size of the aggregate and required slumps as a measure of level of workability.

STEP4: ESTIMATION OF AIR CONTENT

The estimated entrapped air content is taken (2%) from table No. 41 of SP 23-1982, based on nominal maximum size of the aggregate.

STEP5: DETERMINATION OF CEMENT CONTENT

The cement content is calculated from the selected w/c ratio and estimated water content. The cement content calculated is compared with the minimum required cement content as per the durability consideration as stipulated in the IS 456-2000. The greater of the two values is adopted. It is noted that the quantity Adopted is inclusive of the Addition of part supplementary cementitions material to OPC.

STEP 6: ESTIMATION OF PERCENTAGE OF SAND IN TOTAL AGGREGATE

The percentage of sand in total aggregate depends upon the grading of sand to be incorporated in the mix. The general guideline is obtained from the figure 45 of SP 23-1982(35).

This is based on maximum size of coarse aggregate and the required slump value targeted. It is to be noted that concrete with super plasticizers will have different percentage of sand than concrete without super plasticizers for the same w/c ratio. Apartfrom the guidelines given in the figure 45 of the SP: 23-1982(35) for the calculation of the percentage of sand in total aggregate percentages of fine aggregates is also seen in relation to the ratio of total fine contents (cement plus fly ash plus fine aggregate) to total coarse aggregate content per m^3 of mature. If it was not found in the specified range then the percentage is adjusted accordingly. The ratio of total fines to aggregate is a very important factor which influence the quality of concrete very much, varies with the W/C ratio of concrete for a given slump range values.

It is noted that the W/C ratio 0.5 was kept for the production of M_{20} concrete for slump range 80-120 mm in this project work.

STEP 7: DETERMINATION OF FINE AND COARSE AGGREGATES

Cement, fly ash, water and percentage of sand in total aggregate already determined, the

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content of fine aggregates and coarse aggregates is calculated from the following equations:

$V= [W+C/S_C+ (1/P)*(f_S/ S_{fa})] \times 1/1000$ - (2) for FA

$V= [W + C/S_C + \{1/ (1-p)\} * (C_S / S_{CA})] \times 1/1000$ - (3) for CA

Where V= absolute volume of fresh concrete i.e. gross volume (1 m^3) minus the volume of entrapped air,

W= mass of water (kg) per m^3 of the concrete,

C= mass of cement (kg) per m^3 of the concrete,

S_c= specific gravity of cement,

F = mass of fly ash (kg) per m^3 of the concrete,

P = ratio of fine aggregate to total aggregate by the absolute volume

f_a = total mass of fine aggregate (kg) per m^3 of the concrete,

S = specific gravity of saturated surface dry fine aggregate,

C_s = total mass of coarse aggregate (kg) per m^3 of the concrete,

S_{ca} = specific gravity of saturated surface dry coarse aggregate

STEP 8: ADJUSTMENT OF THE TRIAL MIXTURE PROPORTIONS

The trial mixture proportions were Adjusted according to the following guidelines to achieve targeted slump (as a measure of workability).

(A) Moisture content – as a part of quality control during production of concrete. It is necessary to provide moisture content correction to dry batching. In this project work sand and coarse aggregate are dried in room temperature after sufficient amount of water sprinkled on the aggregate to avoid further absorption of water from the estimated mixing water quantity. The same quality control was maintained for each batch of concrete produced.

(B) Initial slump – if initial slump is not achieved in the desired range, then the mixing water is adjusted so as to maintain water – cement ratio same. With a change in mixing water quantity, sand quantity is also adjusted accordingly.

STEP 9: SELECTION OF OPTIMUM MIXTURE PROPORTIONS

Once trial mixes have adjusted, test specimens i.e. 150mm x 150mm x150mm cubes are cast from concrete produced and finally from the strength tests result of the specimens, optimum of proportioning of mixture is suggested.

4.3 CALCULATIONS FOR M20 MIX DESIGN:

(As per IS 10262-2009& IS 456-2000)

4.3.1 STIPULATIONS FOR PROPORTIONING

1. Grade designation = M_{20}
2. Type of cement confirming to IS 12269-1987 = OPC 53 grade
3. Maximum nominal aggregate size =20 mm
4. Minimum cement content (MORT&H 1700-3 A) = 250 kg/m^3
5. Maximum water cement ratio (MORT&H 1700-3 A) = 0.5
6. Workability (MORT&H 1700-3 A)= 25 mm (slump)
7. Exposure condition = Normal
8. Degree of supervision = Good
9. Type of aggregate crushed=Angular Aggregate
10. Maximum cement content (MORT&H Cl. 1703.2) = 540 kg/m^3
11. Chemical Admixture type super plasticizer co to IS-9103

4.3.2 TEST VALUE FOR MATERIAL

1. Anjani cement used OPC = 53 grade
2. Specific gravity of cement = 3.3
3. Specific gravity of water = 1.00
4. Chemical Admixture = Not Used
5. Specific gravity of coarse aggregate = 2.8

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6. Specific gravity of fine aggregate = 2.7
7. Water absorption of coarse aggregate = 0.5%
8. Water absorption of fine aggregate = 1.0%
9. Free (surface) moisture of coarse aggregate = Nil
10. Free (surface) moisture of sand = Nil

4.3.3 TARGET STRENGTH FOR MIX PROPORTIONING:

1. **Target mean strength** = 28.25 N/mm^2
   $f'_{ck} = f_{ck} + 1.65S$
2. **28 days of Characteristic strength** = 20 N/mm^2
3. **Maximum water cement (10262-table-2)** = 186 Lit
4. **Estimated water content for 25 mm slump** = 145 Lit
5. **Superplasticiser used** = Nil

4.3.4 CALCULATIONS OF CEMENT CONTENT

1. **Water cement ratio** = 0.5
2. **Cement content (186/0.5)** = 372 kg/m^3
   This is greater than 250 kg/m^3

4.3.5 PROPORTION OF VOLUME OF FINE AGGREGATE & COARSE AGGREGATE CONTENT:

1. Volume of coarse aggregate as per table 3 of IS 10262 = 62.00%
   Providing volume of coarse aggregate = 65.00%
2. Adopting volume of fine aggregate (1-0.65) = 35.00%

4.3.6 MIX CALCULATION

1. Volume of concrete = 1.0
2. Volume of cement in m^3 = 0.11
   (Mass of concrete) / (specific gravity of cement) x 1000
3. Volume of water in m^3 = 0.186
   (Mass of water) / (specific gravity of water) x 1000
4. Volume of Admixtures @ 0% in m^3 = Nil
   (Mass of Admixtures) / (specific gravity of Admixtures) x 1000
5. Volume of all in aggregate in m^3 = 0.745
   Serial number 1 – (serial number 2+3+4)
6. Volume of coarse aggregate in m^3 = 0.484
   Serial number 5 x 0.65
7. Volume of fine aggregate in m^3 = 0.261
   Serial number 5 x 0.35
8. Mass of coarse aggregate in kg/m^3 = 980.80
   (0.745x0.484x2.72x1000)
9. Mass of fine aggregate in kg/m^3 = 515.30
   (0.745x0.261x2.65x1000)

4.3.7 MIX PROPORTIONS:

1. Mass of water = 186kg/m^3
2. Mass of cement = 372 kg/m^3

3. **Mass of fine aggregate** = 644 kg/m^3
4. **Mass of coarse aggregate** = 1155 kg/m^3
5. **Mass of Admixture** = Nil
6. **Water cement ratio** = 0.5

Table 4.1: Quantities of Ingredient per cum of M20 grade concrete

S.NO	Cement (%)	AS (%)	FA (%)	SF (%)	Water (lit)	Cement (kg)	AS (kg)	FA (kg)	SF (kg)	Fine Aggregate	Coarse Aggregate
1	100	0	0	0	186	372	0	0	0	644	1155
2	95	5	0	0	186	353.4	4.75	0	0	644	1155
3	90	10	0	0	186	334.8	9	0	0	644	1155
4	80	20	0	0	186	297.6	16	0	0	644	1155
5	85	5	10	0	186	316.2	4.25	8.5	0	644	1155
6	75	5	20	0	186	279	3.75	15	0	644	1155
7	80	10	10	0	186	297.6	8	8	0	644	1155
8	70	10	20	0	186	260.4	7	14	0	644	1155
9	85	5	0	10	186	316.2	4.25	0	8.5	644	1155
10	75	5	0	20	186	279	3.75	0	15	644	1155
11	80	10	0	10	186	297.6	8	0	8	644	1155
12	70	10	0	20	186	260.4	7	0	14	644	1155

V. RESULTS AND DISCUSSION

5.1 GENERAL

The results of the present investigation are presented both in tabular and graphical forms in order to facilitate the analysis, interpretation of the results is results obtained is based on the current knowledge available in the literature as well as on the nature of results obtained. The significance of the results is assessed with reference to the standards specified by the relevant IS codes.

1. The normal consistency of cement sample prepared with different replacement by 5%, 10% and 20% of Aluminium slag are compared with ordinary cement and also normal consistency of cement paste sample by partial replacement with constant Aluminium slag of 5% and different proportions of 10% and20% of silica fume and fly ash and at the same time another cement paste sample keeping Aluminium slag at 10% constant and different proportions of 10% and 20% of silica fume and fly ash.
2. Both the initial and final setting time of cement sample prepared with different replacement by 5%,10%,20% of Aluminium slag are compared with ordinary cement and also the initial and final setting time of cement paste sample by partial replacement with constant Aluminium slag of 5% and different proportions of 10% and 20% of silica fume and fly ash and at the same time another cement paste sample keeping Aluminium slag constant at 10% and different proportions of 10% and 20% of silica fume and fly ash. If the difference is less than 30 minutes, the change is considered to be insignificant and if it is more than 30 minutes, the change is considered to be significant.
3. The sieve analysis of fine and coarse aggregate which is used for the present experimental work.
4. The average compressive strength of concrete of at least three cubes (150×150×150 mm) prepared with mineral Admixtures under consideration is compared with that of three cubes prepared with ordinary cement (for 3 days, 14 days, 28 days, 56 days and 90 days). If the difference in the strength is less than 10%, it is considered to be insignificant and if it is greater than 10%, it is considered to be significant.

5.2 NORMAL CONSISTENCY

5.2. 1Normal consistency of 100% cement

Table: 5.1 Normal consistency of 100% cement

S.No	Water percentage (%)	Depth not penetrated (mm)
1	28	36
2	30	32
3	32	14
4	34	6

Normal consistency of cement = 34%.

5.2.2Normal consistency of 80%cement +20% Aluminium slag

Table: 5.1.1 Normal consistency of 80% C + 20% AS

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S.No	Water percentage (%)	Depth not penetrated (mm)
1	28	25
2	30	19
3	32	17
4	34	14
5	36	13
6	38	10

Normal consistency of 80% cement + 20% Aluminium slag = 38 %.

5.2.3Normal consistency90% cement + 10% Aluminium slag

Table: 5.1.2Normal consistency of 90% C + 10%AS

S.No	Water percentage (%)	Depth not penetrated (mm)
1	28	40
2	30	40
3	32	21
4	34	10

Normal consistency of 90% cement + 10% Aluminium slag = 34%.

5.2.4.Normal consistency 95% cement + 5% Aluminium slag

Table: 5.1.3Normal consistency of 95% C + 5% AS

S.No	Water percentage (%)	Depth not penetrated (mm)
1	28	39
2	30	23
3	32	11
4	34	6

Normal consistency of 95% cement + 5% Aluminium slag = 34%.

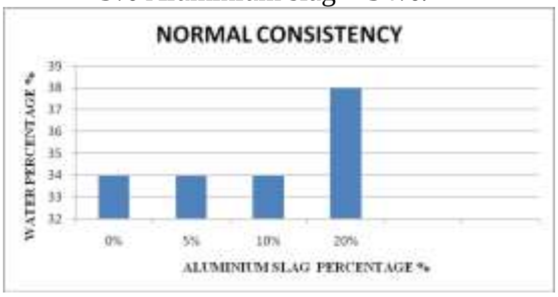

Fig: 5.1 Effect on Normal Consistency for different replacement of OPC with AS

5.2.5Normal consistency of cement with replacement of 5% Aluminium slag and 10% and 20% of silica fume.

The variation of normal consistency of cement paste with addition of silica fume and Aluminium slag is shown in the table 5.2**.** The normal consistency test shows a very slight decrease with the partial replacement of cement with 10%,20% silica fume and keeping the Aluminium slag at constant dosages of 5% in ordinary Portland cement which are 3% decreased at 10% &20%SFdosages respectively.

Table 5.2: Normal consistency of cement with replacement of different percentages of silica fume and 5% of Aluminium slag.

S.NO	Details of Material	Normal Consistency (%)
1	100% cement + 0% AS+0% SF	34
2	85% cement +5% AS +10% SF	33
3	75% cement +5% AS +20% SF	33

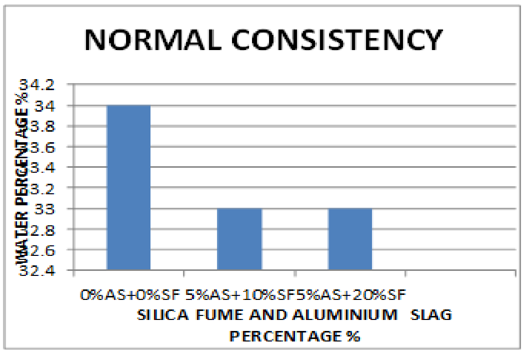

Fig: 5.1.1 Effect on Normal Consistency for different replacement of OPC with 5%AS and 10% and 20% of silica fume.

5.2.6Normal consistency of cement with replacement of 10% Aluminium slag and 10% and 20% of silica fume.

The variation of normal consistency of cement paste with Addition of silica fume and Aluminium slag is shown in the table 5.2.1**.** The normal consistency test shows a very slight increase with the partial replacement of cement by 20%SF.

Table 5.2.1: Normal consistency of cement with replacement of 10%Aluminium slag and silica fume.

S.NO	Details of Material	Normal Consistency (%)
1	100% cement + 0% AS+0% SF	34
2	80% cement +10% AS +10% SF	34
3	70% cement +10% AS +20% SF	35

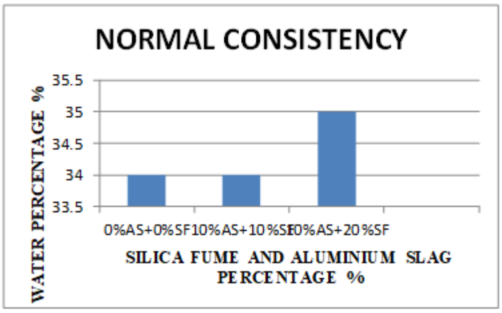

Fig: 5.1.2 Variation of Normal Consistency for different replacement of OPC with 10% AS and 10% and 20% of silica fume.

5.2.7 Normal consistency of cement with replacement of 5% Aluminium slag and 10% and 20% of fly ash.

The variation of normal consistency of cement paste with Addition of fly ash and Aluminium slag is shown in the table 5.3**.** The normal consistency test shows a very slight increase with the partial replacement of cement by 20% fly ash and keeping the Aluminium slag at constant dosages of 5% in ordinary Portland cement.

Table 5.3: Normal consistency of cement with replacement of Aluminium slag and fly ash.

S.NO	Details of Material	Normal Consistency (%)
1	100% cement + 0% AS+0% FA	34
2	85% cement +5% AS +10% FA	34
3	75% cement +5% AS +20% FA	35

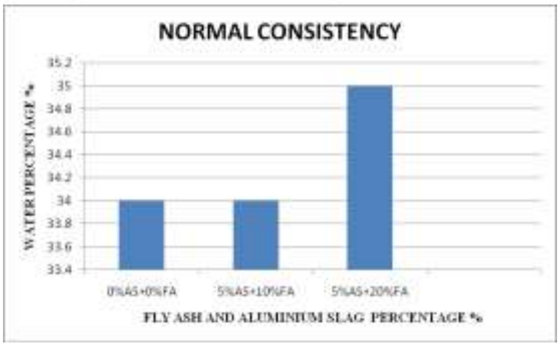

Fig: 5.1.3 Variation of Normal Consistency for different replacement of OPC with 5%AS and 10%, 20% of Fly ash.

5.2.8 Normal consistency of cement with replacement of 10% Aluminium slag and 10%, 20% of fly ash.

The variation of normal consistency of cement paste with Addition of fly ash and Aluminium slag is shown in the table 5.3.1**.** The normal consistency test shows a very slight decrease with the partial replacement of cement by 10%,20% fly ash and keeping the Aluminium slag at constant dosages of 10% in ordinary Portland cement which are 3% at 70% OPC+10%AS+20%FA respectively.

Table 5.3.1: Normal consistency of cement with replacement of Aluminium slag and fly ash.

S.NO	Details of Material	Normal Consistency (%)
1	100% cement + 0% AS+0% FA	34
2	80% cement +10% AS +10% FA	34
3	70% cement +10% AS +20% FA	33

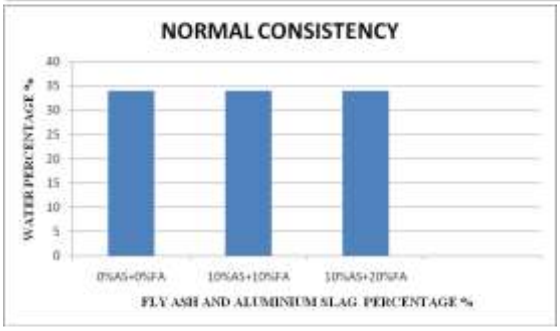

Fig: 5.1.4 Variation of Normal Consistency for different replacement of OPC with 10%AS and 10%,20% of Fly Ash**.**

5.3 RESULTS OF INITIAL AND FINAL SETTING TIME

5.3.1 Initial and final Setting time of cement with replacement of AS and FA.

The variations in the initial and final setting times of cement with Addition of fly ash and 5%Aluminium slag.

From table 5.4 it is observed that both the initial and final setting times got retarded andAccelerated by replacement of fly ash and

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Aluminium slag in the ordinary Portland cement.

Table 5.4:Initial and Final setting time values cement with replacement of fly ash and Aluminium slag.

S.NO	Details of Material	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% OPC +0%AS+ 0% FA	40	380
2	85% OPC +05%AS+ 10% FA	50	280
3	75% OPC +05%AS+20% FA	60	260

5.3.2 Initial and final Setting time of cement with replacement of Aluminium slag and silica fume

The variations in the initial and final setting times of cement with Addition of silica fume.

From table 5.4.1 it is observed that both the initial and final setting times got retardedand accelerated by replacement of silica fume in the ordinary Portland cement.

Table 5.4.1: Initial and Final setting time values cement with replacement of 5% Aluminium slag and10%, 20%of silica fume

S.NO	Details of Material	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% OPC +0%AS+ 0% SF	40	380
2	85% OPC +05%AS+ 10% SF	45	300
3	75% OPC +05%AS+20% SF	45	320

5.3.3 Initial and final Setting time of cement with replacement of Aluminium slag and silica fume

From table 5.5 it is observed that both the initial and final setting times got retardedand accelerated by replacement of silica fume in the ordinary Portland cement.

Table: 5.5Initial and Final setting time values cement with replacement of 10% Aluminium slag and10%, 20% of silica fume

S.NO	Details of Material	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% OPC +0%AS+ 0% SF	40	380
2	80% OPC +10%AS+ 10% SF	50	260
3	70% OPC +10%AS+20% SF	60	280

VI. CONCLUSION

The normal consistency tests were performed on concrete.

1.The normal consistency for replacement of 20% aluminium slag in cement has considerable increase in consistency

2.the normal consistency test shows a very slight decrease in consistency the partial replacement of cement with 10%,20% silica fume and keeping the aluminium slag at constant dosage of 5%

3.The normal consistency for the combination of 20% silica fume and 10% aluminium slag has slight increase in consistency

4.The normal consistency of test shows a very slight increase with partial replacement of cement by 20% fly ash and 5%aluminium slag

5.The normal consistency for combination of 10% aluminium slag and 20% fly ash has slight decrease in consistency .

Initial and final setting time test were performed on concrete

1.Initial and final setting time for the combination of aluminium slag and silicafume has retarded and accelerated

2.Initial and final setting time for the combination of aluminium slag and fly ash has also retarded and accelerated

3.The replacement of aluminium slag in cement,it is clearly obsorved that when the percentage of aluminium slag is increase in concrete,the initial serring time increased considerably and the final setting time decrease considerably by increasing the persantage of aluminium slag

Soundness test were performed on concrete

1.The replacement of aluminium slag in cement is increased then the soundness increased considerably

2.The replacement of silica fume in cement increases by keeping the aluminium slag at

constant dosage of 5% and 10%respectively then the soundness also increases considerably
3.The replacement of fly ash in cement increases by keeping the aluminium slag at constant dosage of 5% and 10% then the soundness also increases considerably Compressive Strength and Acid attack tests were performed on concrete
1.specimens prepared with Aluminium slag 5%,10%,20%and varying Fly Ash and Silica Fume with 10% and 20% . Using the test results , it can be concluded that for Aluminium Slag 5% the strength increased and further there is a rapid decrease with additional increase in Aluminium Slag (i.e. 10%,20%)
2.The compressive strength for combination of 5%AS and 20%FAhas shown considerable increase in strength. All other combinations with Fly Ash has no increase.
3.It is observed that combination of AS 5% and 10%SF the compressive strength increased but further increase in aluminium slag and Silica Fume content compressive strength reduced when compared to control concrete.
4.The compressive strength of cubes after Acid attack for controlled concrete is observed to loose 7.78% of strength and with replacement of AS with 5%,10%,20% , the percentage of strength loss further increase to 17.82,24.73and 25.07 respectively.
5. The combination of 10% AS and 10% FA is observed to have better resistance against Acid attack and the combination of 10% AS and 10% SF is also observed to have better resistance against Acid attack.All other Combinations of FA and SF had relatively lesscompressive strength after Acid attack.
6.Hence it is recommended to replace AS to improve the Compressive Strength properties and combination of AS with FA and SF can also be employed to achieve more compressive strength.

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7.1. IS Codes

1) IS 456-2000 -Code of practice for plain & reinforced cement concrete.
2) IS 12269-1987-Specification for OPC 53 grade.
3) IS 10262-1982-Recommended guide line for concrete mix design.
4) IS 3812-1981-Specifications of Aluminium slag for use as pozzolana&Admixture (First Revision).
5) IS 3812(Part1)-2003-Specifications for pulverized fuel ash for use as cement, cement mortar and concrete (Second Revision).
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7) IS 516-1965-Method of Test for Strength of Concrete.
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9) IS 650-1966-Specification for standard sand for testing of cement.
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