Experimental Studies on Optimal Dosage of Self Curing Agent in Concrete

Vishnu. S
Anna University
Department of Civil Engineering
Udaya School of Engineering
Vellamodi, Kanyakumari Dsct.

Abstract:- **A detailed review of literature has been carried out and the literature relevant to Self Curing Concrete is presented in the report. The Self Curing Concrete (SCC) mixes have been designed by ACI method. Laboratory tests were conducted for various materials and they have been worked out and presented in this report. Hence to determine the strength and Young's modulus for various dosages of Poly Ethylene Glycol (PEG)-400 (.025%-1%) for different mixes (M20&M30 by using different grades of cement (53 grade OPC&53 grade PPC).**

CHAPTER 1

INTRODUCTION

1.1 Introduction to Self Curing Concrete

Excessive evaporation of water (internal or external) from fresh concrete should be avoided; otherwise, the degree of cement hydration would get lowered and thereby concrete may develop unsatisfactory properties. Curing operations should ensure that adequate amount of water is available for cement hydration to occur. We can achieve optimum cure of concrete without the need for applying external curing methods.

The ACI-308 Code states that "internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing Water." Conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e., curing is taken to happen 'from the outside to inside'. In contrast, 'internal curing' is allowing for curing 'from the inside to outside' through the internal reservoirs (in the form of saturated lightweight fine aggregates, superabsorbent polymers, or saturated wood fibers) Created. 'Internal curing' is often also referred as 'Self–curing.' When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, due to depercolation of the capillary porosity, for example, significant autogenous deformation and(early-age)crackingmayresult.

Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking. This situation is intensified in HPC (compared to conventional concrete) due to its generally higher cement content, reduced water/cement (w/ c) ratio and the pozzolanic mineral admixtures (fly ash, silica fume). The empty pores created during self-desiccation induce shrinkage stresses and also influence the kinetics of cement hydration process, limiting the final degree of hydration. The strength achieved by IC could be more than that possible under saturated curing conditions.

Often specially in SCC, it is not easily possible to provide curing water from the top surface at the rate required to satisfy the ongoing chemical shrinkage, due to the extremely low permeabilities often achieved. Some specific water-soluble chemicals added during the mixing can reduce water evaporation from and within the set concrete, making it 'self-curing.' The chemicals should have abilities to reduce evaporation from solution and to improve water retention in ordinary Portland cement matrix.

Curing can be defined as a procedure for insuring the hydration of the Portland cement in newly-placed concrete. It generally implies control of moisture loss and sometimes of temperature. Curing will increase concrete strength, increase concrete abrasion resistance, lessen the chance of concrete scaling, lessen the chance of surface dusting and lessen the chance of concrete cracking.

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties .However, good curing is not always practical in many cases. Several investigators asked the question whether there will be self-curing concrete. Therefore, the need to develop self-curing agents attracted several researchers .

The concept of self-curing agents is to reduce the water evaporation from concrete , and hence increase the water retention capacity of the concrete compared to conventional concrete . It was found that water soluble polymers can be used as self-curing agents in concrete .Concrete incorporating self-curing agents will represent a new trend in the concrete construction in the new millennium. Curing of concrete plays a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention.

Concrete curing is one of the most important processes in achieving the desired properties of the concrete.

The test cubes of any particular mix will be immersed in water till the day of testing. This is done in order to promote the hydration process of the concrete. The initial mixing water used to make concrete will not be sufficient to bring out the full performance of the concrete. However, the actual structures cannot be immersed in water. That is why the structures shall be covered with wet gunny sack or plastic sheet. The reason being that either we provide water (from gunny sack) to promote continuous hydration or we protect the initial water from evaporating. Then again, this is not as easy as it sounds. It is not widely practiced in construction industry (except in much regulated countries).

This is one of the main reasons why the concrete structure does not last throughout the design life (or at least half of it). Therefore, now it is time to think of a way to cure the concrete from inside without having to cover it with gunny sack or plastic sheet. This new technology is called self-curing concrete. As it name sounds, the concrete would be able to cure on its own without having to provide additional water. This concept is also known internal curing. How is that humanly possible? There have been many discoveries on this new technology, but not much commercial application.

The basic concept of this technology is to provide water for concrete, so that it can continue the curing process on its own. This is done by embedding the water inside the materials used to make concrete. If the water just added as mixing water; this would lead to many other quality related problems, such as bleeding, segregation, and etc. Therefore, a special material shall be used; so that some of the water can be hidden into the material. This water will be released into the concrete over time after the concrete has been placed in the structure and hardened. By doing this the hardened concrete will be able to undergo continuous curing for a long time, which will promote towards a better hydration product. There are many types of material that can be used to impregnate the water. One example is by using feldspar; which is capable of hiding the water into its porous microstructure. The water impregnated feldspar can be used to replace part of sand for the concrete mix. One disadvantages of feldspar is the cost, which is much higher than the normal sand. A self-curing concrete is provided to absorb water from atmosphere from air to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete.

1.2POLY ETHYLENE GLYCOL -400 (PEG- 400)

- Polyethylene glycol (PEG-400) is a low molecular weight grade of polyethylene glycol. It is a clear, colourless, viscous liquid. Due in part to its low toxicity, PEG 400 is widely used in a variety of pharmaceutical formulations.

Chemical properties

- PEG 400 is strongly hydrophilic.
- PEG 400 is soluble in water, acetone, alcohols, benzene, glycerin, glycols, aromatic hydrocarbons and is slightly soluble in aliphatic hydrocarbon

1.3 OBJECTIVES OF THE PROJECT

a) To determine the strength (28th day and 56th day for cubes)
b) To determine the modulus of elasticity (28th day and 56th day for cylinders)
c) To determine the strength and Young's modulus for various dosages of Poly Ethylene Glycol (PEG)-400 (.025%-1%) for different mixes (M20& M30) by using different grades of cement (53 grade OPC&53 grade PPC.)

CHAPTER 2
LITERATURE REVIEW

1.THE USE OF LIGHTWEIGHT FINES FOR THE INTERNAL CURING OF CONCRETE By: George C. Hoff, D.ENG., P.E.August 20, 2002

Concrete shrinkage, over time, induces cracking that can severely reduce the life expectancy of concrete. Long-term drying shrinkage has typically been what is addressed in the literature and what is considered in structural design.. The components of both early-age and long-term shrinkage are drying, autogenous, and thermal shrinkage, with carbonation shrinkage also contributing to the overall long-term. To prevent autogenous shrinkage in HSC/HPC ,incorporate saturated lightweight fine aggregate into the concrete mixture to provide an internal source of water to replace that consumed by chemical shrinkage during hydration of the paste. With the LWA acting as a water reservoir, the pores of the cement paste absorb the water from the LWA by capillary suction. The unhydrated cement particles from the cement paste now have more free-water available for hydration. The new hydration products grow in the pores of the cement paste thus causing them to get smaller. The capillary suction, which is the inverse to the square of the pore radius, increases as the radius becomes smaller and thus enabling the pores to continue to absorb water from the LWA. This continues until all the water from the LWA has been transported to the cement paste. The use of mineral admixtures, such as fly ash and silica fume, tend to refine the pore structure towards a finer microstructure. If there is a finer microstructure, the water consumption will be increased and the autogenous shrinkage due to self-desiccation will be increased.

CONCLUSION

In general, LWAs are less stiff and strong than normal weight aggregates and thus may or may not slightly reduce the concrete strength depending on a number of considerations. Their contribution to strength depends on the type and quality of the LWA, the size fraction used, the amount of aggregate used, and the type and quality of the binder in the concrete. In general, crushed LWAs provide a better surface for binder interaction than do LWAs with a sealed surface that often results from a pelletizing process. The vesicular surface resulting from the crushing operation allows paste penetration and provides more surface area for any reaction between the aggregate and paste to occur. It is believed that the transition zone associated with a crushed aggregate has advantages over a more smooth and sealed surface.

2. Self-curing concrete: Water retention, hydration and moisture transport by A.S. El-Dieb; Construction and Building Materials 21 (2007) 1282–1287

The aim of the investigation is to evaluate the use of water-soluble polymeric glycol as self-curing agent. In this study water retention and hydration of concrete containing self-curing agents is investigated and compared to conventional concrete. Also, water transport through this concrete is evaluated and compared to conventional concrete continuously moist-cured and air-cured. Concrete weight loss and internal relative humidity measurements with time were carried out in order to evaluate the water retention ability. Non-evaporable water at different ages was measured to evaluate the hydration of self-curing concrete. The water transport, as durability index, is evaluated by measuring water absorption%, permeable voids%, water sorptivity and water permeability. The cement used was ordinary Portland cement. The coarse aggregate was crushed stone with two sizes; S1 (5– 20 mm particle size) and S2 (10–25 mm particle size). The two coarse aggregate sizes were mixed with a 1:1 ratio. The sand used was natural sand with fineness modulus of 2.58. The self-curing agent used in the study was water soluble polymeric glycol (i.e., polyethylene-glycol) . Water retention for the concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time. Self-curing concrete suffered less self-desiccation under sealed conditions compared to conventional concrete. Self-curing concrete resulted in better hydration with time under drying condition compared to conventional concrete. Water transport through self-curing concrete is lower than air-cured conventional concrete

CONCLUSION

Water retention for the concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time. Self-curing concrete suffered less self-desiccation under sealed conditions compared to conventional concrete. Self-curing concrete resulted in better hydration with time under drying condition compared to conventional concrete. Water transport through self-curing concrete is lower than air-cured conventional concrete. Water sorptivity and water permeability values for self curing concrete decreased with age indicating lower permeable pores% as a result of the continuation of the cement hydration.

3. Properties of Self Compacting Concrete at Different Curing Condition and their Comparison with properties of Normal Concrete by J. R. Al-Feel N. S. Al-Saffar ;Civil Engineering Department, Mosul University

The experimental investigation carried out is to study the effect of curing methods on the compressive, splitting, and flexural strengths (modulus of rupture) of self compacting concrete in comparison to those of normal concrete. The self-compacting concrete consisted of Portland cement (P.C) limestone powder (L.S) (L.S 8% / 92% P.C),sand, gravel and super-plasticizer. The specimens were cured in the air and water, for the period of 7, 14, and 28 days. Three specimens were tested for each point of each property. The results showed that the water cured specimens gave highest compressive strength, splitting tensile strength and flexural strength than specimens cured by air about 11%, 10% and 11% for self compacting concrete at 28 days respectively .The results also show that self compacting concrete gave high early strength i.e. strength before 28-days.The failed specimens indicated that there was no segregation and a good bond between aggregate and matrix Concrete is designed to flow under its own weight without mechanical compaction.SCC must be designed to resist segregation [1, 2]; SCC has high content of fine materials to provide stability of the mix resulting in resistance against bleeding and segregation. The fine materials such as fly ash, silica fume, granulated blast furnace slag, or limestone filler in SCC contributes significantly towards its fresh and hardened properties as well as reducing its cost [3]. It shows that scaling resistance of SCC depends on type of used admixture. Very good results are recorded with slag and also with limestone [4].SCC usually contains super plasticizer to maintain the fluidity;.It is estimated that SCC may result in up to 40% faster construction than using normal concrete [5, 6]. The elastic modulus and shrinkage of SCC did not differ significantly from the corresponding properties of normal concrete .

CONCLUSION

The compressive and tensile strength of Self-Compacting Concrete were higher than those of ordinary concrete at all considered ages and for all curing condition.The SCC gave high early strength (before 28-days).The water cured specimens gave slightly highest compressive strength values than those specimens cured by air for SCC, this indicate that curing condition not so effective .The failure specimens showed that there was no segregation in the mix constituents and good bond between aggregate and matrix.

4. AIR CURING SELF-COMPACTING CONCRETE by H. E. Seleem; Strength of materials Dept., Housing &Building National Research Centre, Cairo

The present experimental program extended over three main stages to explore the possibility of dispensing water curing by means of Latex addition to the self-compacting concrete (SCC) mixtures constituents. Two latex dosages, based on the latex solid part, were employed in the first stage of work, namely 3%, and 5%. The validity of this approach was evaluated through compressive strength results of cube specimens having different curing regimes. Through the remaining stages, the minimum dosage was adopted as suitable for the purpose of this work from the technical and economical viewpoints. Further enhancement of the Latex modified concrete (LMC) mixture by fibers addition to the mixtures was thoroughly investigated in the second stage of work in terms of the performance criteria of the generated SCC mixes. It is generally agreed that the fibers have a pronounced contribution to the hardened concrete mechanical strengths. It was found here that owing to the increased viscosities of the mixtures incorporating Latex, it is possible to utilize the fibers benefits in the hardened state without significantly impairing the sought performance criteria in the fresh.

5. Effect of Different Curing Techniques on Compressive Strength of High Strength Self Compacting Concrete by L. A. Qureshi & I. A. Bukhari, University of Engineering & Technology, Taxila, Pakistan M. J. Munir, Bahaudin University Multan Pakistan

In this paper variation in compressive strength of high strength, self compacted concrete by curing with 3 different techniques is discussed. First of all several trials were carried out for appropriate mix design to create self compacting and high strength concrete. Three batches of concrete cylinders consisting of 24 cylinders in each batch were cast as per ASTM standard. Slump Test and Flow Test were carried out on each batch in order to ascertain concrete flow for self compacting concrete. Mix. ratio, water cement ratio and admixture dose were kept constant as calculated by Mix. Design. First batch, declared as control, was cured in a temperature controlled curing tank in the laboratory. The second batch was cured under prevailing site conditions. The 3rd batch was cured by the application of a curing compound. It was noted that 28-days compressive strength of cylinders cured under site conditions was 89% of the compressive strength of cylinders cured in water tank in the laboratory (i.e., 11% less). Similarly compressive strength of cylinders cured by applying curing compound was 93% of the compressive strength of cylinders cured in the laboratory (i.e., 7% less). So it was concluded that in areas with shortage of water, curing compounds can be effectively used with improved strength and sustainability of water.

6. SELF-COMPACTING / CURING/COMPRESSING CONCRETE by Roberto Troli, Antonio Borsoi, Saveria Monosi, Glenda Fazio, 6th International Congress, Global Construction, Ultimate Concrete Opportunities, Dundee,U.K. – 5-7 July 2005

The pratice of using expansive agents has been recommended to manufacture shrinkage compensating concrete provided that an adequate wet curing is carried out. On the other hand, shrinkage-reducing admixture (SRA), based on the use of poly-glycol products in the concrete mixes, has been more recently suggested to reduce the risk of cracking in concrete structures caused by drying shrinkage.The mechanism of this admixture is based on a physical change (reduction of the surface tension of the mixing water) rather than on a reduction of water evaporation. This technology can reduce the drying shrinkage but it is not able to completely remove it. In the present paper some innovative experimental tests will be described on the combined use of CaO-based expansive agents and SRA. This combination surprisingly allow to manufacture shrinkage-compensating concretes even in the absence of any early water curing. This technique manufacture a very innovative concrete which is "*3 times self*": self-compacting, self-curing and self-compressing concrete. The type of CaO based expansive agent has been adapted in order to produce an effective expansion mainly after the cement hardening process, so that the expansion loss which occurs in concrete in the fresh or plastic state is reduced and the useful expansion in the hardened state is increased

CONCLUSION

There is a synergistic effect in the combined use of SRA and a CaO-based expansive agent in terms of more effective expansion in the absence of wet curing. Moreover, there is a lower shrinkage after removing the polyethylene sheet used to simulate the protection from drying before demoulding the concrete structure on the job site. However, these effects are significantly reduced when a self-compacting concrete is used because of the prolonged fluid and plastic state of this mixture. This is also due to the higher dosage of super plasticizer in the self-compacting concrete with respect to that used in ordinary super plasticized concrete .However, a change in the cement with a higher strength can reduce the setting time and then increase the restrained expansion which occurs only when a steel-concrete bond exists. Alternative ways can be adopted to produce Self-Compacting Concrete which is also a Self-Compressing and Self-Curing concrete ("*3-time self*"): to use a superplasticizer with a reduced retarding effet or to use an expansive agent based on CaO produced at higher temperature (>1100°C) so that the restrained expansion occurs later and then in a hardened concrete.

7.The effect of chemical admixtures and mineral additives on the properties of self-compacting mortars by Mustafa Sahmaran,Heru Ari Christianto,Ismail O¨ zgu¨ r Yaman ;Cement & Concrete Composites 28 (2006) 432–440

Mortar serves as the basis for the workability properties of self-compacting concrete (SCC) and these properties could be assessed by self-compacting mortars (SCM). In fact, assessing the properties of SCM is an integral part of SCC design. The objective of this study was to evaluate the effectiveness of various mineral additives and chemical admixtures in producing SCMs. For this purpose, four mineral additives (fly ash, brick powder, limestone powder, and kaolinite), three superplasticizers (SP), and two viscosity modifying admixtures (VMA) were used. Within the scope of the experimental program, 43 mixtures of SCM were prepared keeping the amount of mixing water and total powder content (portland cement and mineral additives) constant. Workability of the fresh mortar was determined using mini V-funnel and mini slump flow tests. The setting time of the mortars, were also determined. The hardened properties that were determined
included ultrasonic pulse velocity and strength determined at 28 and 56 days. It was concluded that among the mineral additives used, fly ash and limestone powder significantly increased the workability of SCMs. On the other hand, especially fly ash significantly increased the setting time of the mortars, which can, however, be eliminated through the use of ternary mixtures, such as mixing fly ash with limestone powder. The two polycarboxyl based SPs yield

approximately the same workability and the melamine formaldehyde based SP was not as effective as the other two.

CONCLUSION

The workability of SCM depends mainly on the type of SPs used. In this study new generation superplasticizers, especially the modified polycarboxylate based SP2, showed better results in improving the workability of SCMs, as determined by both workability tests. Among the mineral additives considered, use of FA and LP improved the workability properties of SCMs. BP and K, however, could not be used alone as they adversely affect the workability. When the particle sizes of the mineral additives are compared,it can be seen that LP is the finest and FA is the coarsest. However, both of these additives increased the workability of SCMs. Therefore, it can be concluded that fineness is not the only parameter of a mineral additive to improve the workability of a SCM. Smooth surface characteristics and spherical shape of the FA is also important to improve the workability characteristics of SCM mixtures.Both the chemical admixtures and mineral additives adversely affect the setting time of mortars. Among the mineral additives, however, FA increased the setting time of the mortars the most, due to a spherical geometry and a coarse particle size, causing a reduction in the surface area to adsorb free water. In order to hinder the disadvantages of a mineral additive, another mineral additive can also be added forming ternary mixtures. Among the ternary mixtures considered in this study, FA–LP mixtures increased the workability

8. Water-entrained cement-based materials II. Experimental observations byOle Mejlhede Jensen, Per Freiesleben Hansen Cement and Concrete Research 32 (2002) 973–978*

This paper concerns a new concept for the prevention of self-desiccation in hardening cement-based materials. The concept is based on using fine, superabsorbent polymer (hydrogel, SAP) particles as a concrete admixture. This permits a controlled formation of water-filled macropore inclusions water entrainment in the fresh concrete. In the paper, experimental observations in relation to this technique are described and discussed. The observations show that self desiccation can be controlled by water entrainment. The paper forms the second part of a series. In the first part, the theoretical background was presented

CONCLUSION

The results presented in this paper show that it is possible to avoid self-desiccation in hardening HPC by means of water entrainment. Autogenous RH change and autogenous shrinkage after setting, as well as cracking during restrained hardening, can be avoided when SAPs are used as a water entraining admixture. A large number of cement paste and concrete properties need to be examined before this technique can be implemented in practice. Mechanical properties such as compressive strength and cracking due to long-term shrinkage may be of primary interest. Potential problems with SAP addition include change of setting time and rheology, separation of SAP particles, and grinding of SAP particles during mixing due to aggregate particles. Complete elimination of autogenous shrinkage based on water entrainment may not be necessary. Optimally, only the amount of water entrainment required to avoid cracking due to restrained autogenous shrinkage should be used. This will be more economically attractive and will minimize possible negative side effects such as residual shrinkage or adverse influence on the rheological properties.

9.High-strength self-curing low-shrinkage concrete for pavement applications by M. Lopeza, L.F. Kahnb and K.E. Kurtisb; International Journal of Pavement Engineering ;Vol. 11, No. 5, October 2010, 333–342

High-performance concretes (HPC) that are designed to possess high early strength, self-curing capabilities and low shrinkage may potentially improve rigid pavement performance. A multi-scale experimental programme examined mechanical properties and shrinkage behaviour of a low water-to-cementitious materials ratio concrete containing prewetted lightweight aggregate for self-curing; results were compared with companion HPC prepared with air-dry lightweight aggregate and with normal weight, normal strength concrete. The use of pre-wetted lightweight aggregate enhanced hydration and strength development during the first year, and limited autogenous shrinkage and substantially reduced drying shrinkage. Digital image analysis revealed that shrinkage was concentrated in the paste rather than in the aggregate in both the normal strength concrete and HPC. The image analysis also showed that strain concentrations at the aggregate/paste interface were less apparent in the HPC, presumably due to the reduced strain mismatch with the use of the lower modulus lightweight aggregate. These observations suggest that the use of HPC containing pre-wetted lightweight aggregate can potentially reduce microcracking and enhance overall pavement performance

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CONCLUSION

While both HPCs examined exhibited significantly higher early strength than the NSC mixtures, selfcuring in the HPC with pre-wetted lightweight aggregate (LWW) resulted in increased compressive strength and elastic modulus as compared to the LWD concrete.In addition to greater mechanical properties, the HPC mixture with pre-wetted lightweight aggregate (LWW) exhibited lower shrinkage due to the reduction in autogenous shrinkage and expansion due to enhanced hydration. By providing internally stored water, through the use of pre-wetted aggregate, it is proposed that early-age shrinkage and cracking may be decreased. Finally, while image analysis revealed that shrinkage occurs primarily in the paste-rich zones in the NSC and HPC, the NSC showed the greatest variability in deformation between the aggregate and the paste, which was manifested as high-strain concentrations in the interfacial zone

10. Effects of different viscosity agents on the properties of self-leveling concrete; Sébastien Rols, Jean Ambroise, Jean Péra Cement and Concrete Research 29 (1999) 261–266

It has already been reported that a suitable quantity of welan gum, a kind of natural water soluble polysaccharide, is very effective in stabilizing the rheology of self-consolidating concrete. The main problem of this product is its cost. Therefore, new viscosity agents were investigated in the present study: starch, precipitated silica, and a waste from the starch industry. Associated with a sulfonated melamine-formaldehyde superplasticizer, these agents were used to develop self-leveling concrete at low cost (20% higher than that of concrete used in building construction). This paper presents the influence of the type of viscosity agent on various properties of concrete: workability, segregation, bleeding, compressive strength, shrinkage, and permeability. Precipitated silica and starch were found to lead to the best performances.

CONCLUSION

Precipitated silica and, to a less extent, starch could be good alternatives for welan gum as
Viscosity agents for self-levelling concrete .These products allow the development of concretes
with limited bleeding after 5 h and high resistance to segregation. The mechanical performance of self-levelling concrete is high (more than 40 MPa at 28 days) despite a cement content limited at 260 kg/m3 and a water-to cement ratio of 0.68.. The drying shrinkage strains of self- leveling concrete are about 50% greater than those of ordinary concrete containing the same amount of cement. To prevent cracking, it is necessary to cure self-levelling concreting field applications .The water permeability of self- levelling concrete is limited to 2 3 10212 m/s and allows expectation of good durability.

CHAPTER 3

DESIGN OF CONCRETE MIXES

3.1 LABORATORY TEST RESULTS OF MATERIALS

Table 1: SPECIFIC GRAVITY OF COARSE AGGREGATE

Size of Aggregate	20 mm	
Weight of container (W$_1$)	4.22 kg	
Weight of Coarse aggregate + Container (W$_{2}$)	21.1 kg	
Weight of Coarse aggregate + Container + Water (W$_3$)	26.47 kg	
Weight of Container + Water (W$_4$)	15.06 kg	
Specific Gravity $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$	2.89	

Result:-

1. Specific Gravity of 20 mm aggregate is 2.89

Table 2: SPECIFIC GRAVITY OF FINE AGGREGATE

Size of Aggregate	20 mm	
Weight of container W$_1$	4.23 kg	
Capacity of Container V	11.02 liter	
Container + Aggregate W$_2$	21.1 kg	
Bulk Density $\frac{W_2 - W_1}{V}$	1437.3 kg/m^3	

Result:-
Specific Gravity of fine aggregate is 2.63

Table 3: BULK DENSITY OF COARSE AGGREGATE
Result:-

1. Bulk Density of 20 mm aggregate is 1437.3 kg/m^3

Table 4: GRADING OF FINE AGGREGATE

IS Sieve Size	Weight Of Aggregate	Percentage Retained	Cumulative Percentage Retained	Percentage Passing
	Kg			
4.75 mm	.027	2	2	98
2.36 mm	.02	2	14	96
1.18 mm	.16	16	20	80
600µ	.42	42	62	38
300 µ	.18	18	80	20
150 µ	.18	18	98	2
Pan	.02	2	100	0

Sum of cumulative percentage retained up to 150µ sieve = 266
Fineness modulus of Fine aggregate = 2.66
Since the Fineness Modulus is 2.66, the sample of sand tested is a medium sand
The Grading Zone is II

Result:-
The given sample of sand is having fineness modulus of 2.66. It is a medium sand falling under Zone II.

3.2 MIX DESIGN

ACI METHOD

M20

Input Data
Characteristic strength of concrete - 20 N/mm^2
Maximum size of coarse aggregate - 20 mm
Degree of quality control - Good
Type of exposure - Mild

Specific gravity of cement - 3.15
Specific gravity of coarse aggregate - 2.89
Specific gravity of fine aggregate - 2.63
Slump - 50 mm
Dry rodded bulk density of coarse aggregate - 1437.3 kg/m^3
Fineness modulus of fine aggregate - 2.66

Step 1:- Calculation of Average design strength

$\overline{fck}$ = fck + t × s

[As per IS 10262 – 1982, cl- 2.2, page 56]

From table 2, for 1 in 20, t= 1.65

From table 1, for good quality control and M20 concrete s = 4.5 N/mm^2

Thus $\overline{fck}$ = 20+1.65x4.5 = 27.4 N/mm^2

Step 2:- Water Cement Ratio

The w/c for design strength of 27.4 N/mm^2 is 0.5

Referring to table 4, w/c corresponding to I a is 0.58

The least w/c among the two values is 0.5

Step 3:- Determination of Water content

For non- air entrained concrete containing 20 mm aggregate, water content is 185 kg/m^3

Step 4:- Determination of Cement content

w/c =0.5

water = 185 kg/m^3

Cement = 185/0.5 = 370 kg/m^3

Step 5:- Weight of coarse aggregate

From table 2, for 20mm coarse aggregate and fine aggregate of fineness modulus 2.66, the bulk volume of rodded coarse aggregate per unit volume of concrete is 0.634

Density of Coarse aggregate = 1437.3 kg/m^3

Weight of coarse aggregate = 1437.3 x 0.634 = 911.24 kg/m^3

Step 6:-Density of fresh concrete

For 20 mm aggregate and for non-air entrained concrete, the first estimate of density of fresh concrete = 2355 kg/m^3

Step 7:- Weight of ingredients of concrete

Weight of water = 185 kg/m^3
Weight of cement = 370 kg/m^3
Weight of coarse aggregate = 911.24 kg/m^3
Weight of fine aggregate by absolute volume method

Ingredients	Weight in kg/m^3	Absolute Volume
Cement	370	370x10^3/3.15
Coarse Aggregate	911.24	911.24x10^3/2.89
Water	185	185x10^3

Total = 617.76x10^3

Absolute volume of fine aggregate = (1000-617.76)x10^3
= 382.24x10^3

Weight of fine aggregate = 2.63 x 382.24 = 1005.29 kg/m^3

Adding all quantities = 370+ 185+ 911.24+ 1005.29 = 2355kg/m^3

Density of concrete is 2355 kg/m^3 as against 2355 as read from table 6.

Material	Cement	Fine Aggregate	Coarse Aggregate	Water
Quantity	370	1005.29	911.24	185
Proportions	1	2.71	2.46	0.5

Step 8:- Mix proportions

M30

Input Data

Characteristic strength of concrete - 30 N/mm^2
Maximum size of coarse aggregate - 20 mm
Degree of quality control - Good
Type of exposure - Mild
Specific gravity of cement - 3.15
Specific gravity of coarse aggregate - 2.89
Specific gravity of fine aggregate - 2.63
Slump - 50 mm
Dry rodded bulk density of coarse aggregate - 1437.3 kg/m^3
Fineness modulus of fine aggregate - 2.66

Step 1:- Calculation of Average design strength

$\overline{fck}$ = fck + t × s

[As per IS 10262 – 1982, cl- 2.2, page 56]

From table 2, for 1 in 30, t= 1.65

From table 1, for good quality control and M30 concrete s = 6 N/mm^2

Thus $\overline{fck}$ = 30+1.65x6 = 39.9 N/mm^2

Step 2:- Water Cement Ratio

The w/c for design strength of 39.9 N/mm^2 is 0.43

Referring to table 4, w/c corresponding to I a is 0.5

The least w/c among the two values is 0.43

Step 3:- Determination of Water content

For non- air entrained concrete containing 20 mm aggregate, water content is 185 kg/m^3

Step 4:- Determination of Cement content

w/c =0.43

water = 185 kg/m^3

Cement = 185/0.43 = 430.2 kg/m^3

Step 5:- Weight of coarse aggregate

From table 2, for 20mm coarse aggregate and fine aggregate of fineness modulus 2.66, the bulk volume of rodded coarse aggregate per unit volume of concrete is 0.634

Density of Coarse aggregate = 1437.3 kg/m^3

Weight of coarse aggregate = 1437.3 x 0.634 = 911.24 kg/m^3

Step 6:-Density of fresh concrete

For 20 mm aggregate and for non-air entrained concrete, the first estimate of density of fresh concrete = 2355 kg/m^3

Step 7:- Weight of ingredients of concrete

Weight of water = 185 kg/m^3
Weight of cement = 430.2 kg/m^3
Weight of coarse aggregate = 911.24 kg/m^3

Weight of fine aggregate by absolute volume method

Ingredients	Weight in kg/m^3	Absolute Volume
Cement	430.2	$430.2x10^3/3.15$
Coarse Aggregate	911.24	$911.24x10^3/2.89$
Water	185	$185x10^3$

Total = $636.88x10^3$

Absolute volume of fine aggregate = $(1000-636.88)x10^3$
= $363.12x10^3$

Weight of fine aggregate = 2.63 x 363.12 = 955 kg/m^3

Adding all quantities = 430.2+ 185+ 911.24+ 955 = 2481.44kg/m^3

Density of concrete is 2481.44 kg/m^3 as against 2355 as read from table 6.

Step 8:- Mix proportions

Material	Cement	Fine Aggregate	Coarse Aggregate	Water
Quantity	430.2	955	911.24	185
Proportions	1	2.21	2.11	0.43

Material Cement Fine Aggregate Coarse Aggregate
Water
Quantity 430.2 955 911.24 185
Proportions 1 2.21 2.11 0.43