FOR INTERNAL CIRCULATION ONLY

LECTURE NOTES

ON

CONCRETE TECHNOLOGY

DIPLOMA 6th SEMESTER

COMPILED BY

ER.TEJASWINI DAS

ASSISTANT PROFESSOR

DEPARTMENT OF CIVIL ENGINEERING

UTKAL INSTITUTE OF ENGINEERING AND TECHNOLOGY
Affiliated to SCTE&VT, Govt. of Odisha
Approved by AICTE, Govt. of India

MODULE I CEMENT

Cement is a binder, a substance that sets and hardens and can bind other materials together. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. Non-hydraulic cement will not set in wet conditions or underwater, rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting. Hydraulic cement is made by replacing some of the cement in a mix with activated aluminum silicates, pozzolana, such as fly ash. The chemical reaction results in hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack (e.g., Portland cement).

Uses:-

- Cement mortar for Masonry work, plaster and pointing etc.
- Concrete for laying floors, roofs and constructing lintels, beams, weather- shed, stairs, pillars etc.
- Construction of water, wells, tennis courts, septic tanks, lamp posts, telephone cabins etc. Making joint for joints, pipes, etc.
- Manufacturing of precast pipes, garden seats, flower posts, etc. Preparation of foundation, water tight floors, footpaths, etc.

ORDINARY PORTLAND CEMENT:-

Ordinary Portland cement is the most common type of cement in general use around the world. This cement is made by heating limestone(calcium carbonate) with small quantities of other materials (such as clay) to 1450°C in a kiln, in a process known as calcinations, whereby a molecule of carbondioxideis liberated from the calcium carbonate to form calcium oxide,or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsuminto a powder to make 'Ordinary Portland Cement'(often referred to as OPC). Portland cement is a basic ingredient of concrete,mortarand most non-specialty grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate(graveland sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white.

- This type of cement use in construction when there is no exposure to sulphates in the soil or ground water.
- Lime saturation Factor is limited between i.e. 0.66 to 1.02.
- Free lime-cause the Cement to be unsound. Percentage of (AL_2O_3/Fe_2O_3) is not less than 0.66.
- Insoluble residue not more than 1.5%.
- Percentage of SO_3 limited by 2.5% when $C_3A < 7\%$ and not more than 3% when $C_3A > 7\%$.
- Loss of ignition -4%(max)
- Percentage of Mg0-5% (max.) Fineness -not less than 2250 cm^2/g.

Chemical constituents of cement:-

These are the different constituents which combine to make cement. These are their percentage content in order to give good cement.

Oxide	Per cent 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

Hydration of Cement:-

The chemical reaction between cement and water in a proportioning mix is called as hydration of cement. It may be in concrete mix or in the making of mortar in the field work.

SETTING OF CEMENT:-

The action of changing mixed cement from a fluid state to a solid state is called setting of cement and time required for it to set is called setting time of cement. Setting time of cement is same as setting time of concrete.

SETTING TIME OF CEMENT:-

1. Initial Setting Time

Initial Setting Time is defined as the period elapsing between the time when water is added to the cement and the time at which the needle of 1 mm square section fails to pierce the test block to a depth of about 5 mm from the bottom of the mould. A period of 30 minutes is the minimum initial setting time, specified by ISI for ordinary and rapid hardening Portland cements and 60 minutes for low heat cement.

2. Final Setting Time

Final Setting Time is defined as the period elapsing between the time when water is added to cement and the time at which the needle of 1 mm square section with 5 mm diameter attachment makes an impression on the test block. 600 minutes is the maximum time specified for the final set for all the above mentioned Portland cement. IS: 269-1976 specifies the strengths in compression on the standard mortar-cube.

STRUCTURE OF HYDRATED CEMENT:-

The desirable engineering characteristics of hardened concrete —strength, dimensional stability, and durability —are influenced not only by the proportion but also by the properties of the hydrated cement paste, which, in turn, depend on the micro-structural features (i.e., the type, amount, and distribution of solids and voids).

Fresh cement paste is a plastic network of particles of cement in water but, once the cement paste has set, its apparent or gross volume remains approximately constant.

At any stage of hydration, the hardened paste consists of hydrates of the various compounds, referred to collectively as gel, crystals of Ca(OH)2, some minor components, un hydrated cement and the residue of water-filled spaces in the fresh paste.

VARIOUS TESTS ON CEMENT:

Basically two types of tests are under taken for assessing the quality of cement. These are either field test or lab tests. The current section describes these tests in details.

Field test:

There are four field tests may be carried out to as certain roughly the quality of cement. There are four types of field tests to access the colour, physical property, and strength of the cement as described below.

Colour:

- The colour of cement should be uniform.
- It should be typical cement colour i.e. grey colour with a light greenish shade. **Physical properties:**

- Cement should feel smooth when touched between fingers.
- If hand is inserted in a bag or heap of cement, it should feel cool. **Presence of lumps:**

- Cement should be free from lumps.
- For a moisture content of about 5 to 8%, this increase of volume may be much as 20 to 40 %, depending upon the grading of sand. **Strength:**

- A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24 hours. It should set and not crack. **Physical properties:**

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Laboratory tests:

Six laboratory tests are conducted mainly for assessing the quality of cement. These are: fineness, compressive strength, consistency, setting time, soundness and tensile strength.

Fineness:

- This test is carried out to check proper grinding of cement.
- The fineness of cement particles may be determined either by sieve test or permeability apparatus test.
- In sieve test, the cement weighing 100 gm is taken and it is continuously passed for 15 minutes through standard BIS sieve no. 9.The residue is then weighed and this weight should not be more than 10% of original weight.
- In permeability apparatus test, specific area of cement particles is calculated. This test is better than sieve test. The specific surface acts as a measure of the frequency of particles of average size.

Compressive strength:

- This test is carried out to determine the compressive strength of cement.
- The mortar of cement and sand is prepared in ratio 1:3.
- Water is added to mortar in water cement ratio 0.4.
- The mortar is placed in moulds. The test specimens are in the form of cubes and the moulds are of metals. For 70.6 mm and 76 mm cubes, the cement required is 185gm and 235 gm respectively.
- Then the mortar is compacted in vibrating machine for 2 minutes and the moulds are placed in a damp cabin for 24 hours.
- The specimens are removed from the moulds and they are submerged in clean water for curing.
- The cubes are then tested in compression testing machine at the end of 3days and 7 days. Thus compressive strength was found out.

Consistency:

- The purpose of this test is to determine the percentage of water required for preparing cement pastes for other tests.
- Take 300 gm of cement and add 30 percent by weight or 90 gm of water to it.
- Mix water and cement thoroughly.
- Fill the mould of Vicat apparatus and the gauging time should be 3.75 to 4.25 minutes.
- Vicat apparatus consists of a needle is attached a movable rod with an indicator attached to it. There are three attachments: square needle, plunger and needle with annular collar.
- The plunger is attached to the movable rod.
- The plunger is gently lowered on the paste in the mould.
- The settlement of plunger is noted. If the penetration is between 5 mm to 7 mm from the bottom of mould, the water added is correct.
- If not process is repeated with different percentages of water till the desired penetration is obtained.
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<u>Setting time:</u>

- This test is used to detect the deterioration of cement due to storage. The test is performed to find out initial setting time and final setting time.
- Cement mixed with water and cement paste is filled in the Vicatmould.
- Square needle is attached to moving rod of Vicat apparatus.
- The needle is quickly released and it is allowed to penetrate the cement paste. In the beginning the needle penetrates completely. The procedure is repeated at regular intervals till the needle does not penetrate completely.(up to 5mm from bottom)
- Initial setting time =<30min for ordinary Portland cement and 60 min for low heat cement. The cement paste is prepared as above and it is filled in the Vicatmould.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus.
- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.
- Final setting time is the difference between the time at which water was added to cement and time as recorded in previous step, and it is =<10hours.

<u>Soundness:</u>

- The purpose of this test is to detect the presence of uncombined lime in the cement.
- The cement paste is prepared.
- The mould is placed and it is filled by cement paste.
- It is covered at top by another glass plate. A small weight is placed at top and the whole assembly is submerged in water for 24 hours.
- The distance between the points of indicator is noted. The mould is again placed in water and heat is applied in such a way that boiling point of water is reached in about 30 minutes. The boiling of water is continued for one hour. Themould is removed from water and it is allowed to cool down.

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- The mould is removed from water and it is allowed to cool down.
- The distance between the points of indicator is again measured. The difference between the two readings indicates the expansion of cement and it should not exceed 10 mm.

Tensile strength:

- This test was formerly used to have an indirect indication of compressive strength of cement.
- The mortar of sand and cement is prepared.
- The water is added to the mortar.
- The mortar is placed in briquette moulds. The mould is filled with mortar and then a small heap of mortar is formed at its top. It is beaten down by a standard spatula till water appears on the surface. Same procedure is repeated for the other face of briquette.
- The briquettes are kept in a damp for 24 hours and carefully removed from the moulds.
- The briquettes are tested in a testing machine at the end of 3 and 7 days and average is found out.

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- The briquettes are tested in a testing machine at the end of 3 and 7 days and average is found out.

Grade of cement:-

Grade of cement represents the specific 28 days compressive strength. The following three grades aregivenalongwiththeircompressive strengths

- 33Grade OPC –33MPa
- 43Grade OPC – 43MPa
- 53Grade OPC – 53MPa

ADMIXTURE

Admixture is a compound which is used in order to increase or decrease the initial and final setting time ofcement.

Admixtureanditstypes

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregatethose are added to the mix immediately before or during mixing. Producers use admixtures primarily toreduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure thequalityofconcreteduringmixing,transporting,placing,andcuring;andtoovercomecertainemergenciesduringconcreteoperations.

It isofvarioustypes-

Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5to 10 percent. Consequently, concrete containing a water-reducing admixture needs less water to reacharequired slump thanuntreatedconcrete.Thetreatedconcretecanhavealower water-cementratio.This usually indicates that a higher strength concrete can be produced without increasing the amount ofcement. Recent advancements in admixture technology have led to the development of mid-range waterreducers. These admixtures reduce water content by at least 8 percent and tend to be more stable over awider range of temperatures. Mid-range water reducers provide more consistent setting times thanstandardwaterreducers.

Retarding admixtures, which slow the setting rate of concrete, are used to counteract the acceleratingeffect ofhotweatheronconcretesetting.Hightemperaturesoftencausean increasedrateofhardeningwhich makes placing and finishing difficult. Retarders keep concrete workable during placement anddelay the initial set of concrete. Most retarders also function as water reducers and may entrain someairinconcrete.

Accelerating admixtures increase the rate of early strength development; reduce the time required forproper curing and protection, and speed up the start of finishing operations. Accelerating admixturesare especiallyusefulformodifyingthe propertiesofconcreteincoldweather.

Superplasticizers, alsoknownasplasticizersorhigh-rangewaterreducers(HRWR), reducewatercontentby12 to 30percentand can beaddedtoconcretewithalow-to-normalslump and water-cement ratio to make high-slump flowing concrete. Flowing concrete is a highly fluid but workableconcrete that can be placed with little or no vibration or compaction. The effect of super plasticizerslastsonly30to60minutes,dependingonthebrandanddosagerate,andisfollowedbyarapidlossinworkability. As a result of the slump loss, super plasticizers are usually added to concrete at thejobsite.

Corrosion-inhibiting admixtures fall into the specialty admixture category and are used to slowcorrosionofreinforcingsteelinconcrete.Corrosioninhibitorscanbeusedasadefensivestrategyforconcrete structures, such as marine facilities, highway bridges, and parking garages, that will beexposed to high concentrations of chloride. Other specialty admixtures include shrinkage-reducingadmixtures and alkali-silica reactivity inhibitors. The shrinkage reducers are used to control dryingshrinkage and minimize cracking, while ASR inhibitors control durability problems associated withalkali-silica reactivity.

DOSASES:-

Super plasticizers are commonly known as High Range Water Reducers because it permits low watercement ratio as well as the workability also affected. In very recent decades, super plasticizers createsmilestonein the advancementof chemical admixtures for Portland cementconcrete. The dramaticeffectof super plasticizer (SP) on propertiesoffresh and hardened concrete hasstudied and theproperties of concrete inspected are compressive strength and slump test. To determine the optimumdosage for the admixture, an experimental investigation conducted and the effect of over dosage of theSP admixture experimented, together with one control mixed. The viscosity of grout and hence theworkability of concrete influenced by the dosage of super plasticizer. From dosages of admixture, thedifference between concrete mixes comes, which used at amounts 400 ml/100 kg, 600 ml/100 kg, 800ml/100 kg, 1000 ml/100 kg and 1200 ml/100 kg of cement were prepared. By dosage 1.0% of SP,compressive strength is improved and after 28 days curing it is 57 N/mm^2, which is higher than that ofcontrolspecimen.

AGGREGATE

Aggregates are defined as inert, granular, and inorganic materials that normally consist of stone orstone -like solids. Aggregates can be used alone (in road bases and various types of fill) or can be usedwith cementing materials (such as Portland cement or asphalt cement) to form composite materials orconcrete.

Classificationofaggregatesbased on:GrainSize

Ifyou separateaggregatesbysize,therearetwooverridingcategories: • Fineaggregates

- Coarseaggregates

The size of fine aggregates is defined as 4.75mm or smaller. That is, aggregates which can be passedthrough a number 4 sieve, with amesh size of 4.75mm.Fine aggregates include things such as sand,siltand clay.Crushed stoneand crushed gravelmightalsofallunderthiscategory.
Typically,fineaggregatesareusedtoimproveworkabilityofaconcretemix.
Coarse aggregates measure above the 4.75mm limit. These are more likely to be natural stone or gravelthat has not been crushed or processed. These aggregates will reduce the amount of water needed for aconcretemix,whichmayalsoreduce workabilitybutimproveitsinnatestrength.Classificationofaggregatesbasedon: Density Therearethree weight-based variationsofaggregates:

- Lightweight
- Standard
- Highdensity

Different density aggregates will have much different applications. Lightweight and ultra lightweightaggregatesaremoreporousthantheirheaviercounterparts,so theycanbeputtogreatuseingreenroof

construction,forexample.
Theyarealsousedinmixesforconcreteblocksandpavements,aswellasinsulationandfireproofing.
Highdensityaggregatesareusedtoformheavyweightconcrete.Theyareusedfor whenhighstrength,durableconcretestructuresarerequired – buildingfoundationsorpipeworkballasting,forexample.Classificationofaggregatesbased on:GeographicalOrigin
Another wayto classifyaggregatesisbytheirorigin.You candothiswithtwogroups:

- Natural – Aggregates taken from natural sources,such as riverbeds, quarries and mines. Sand,gravel,stone and rockarethemostcommon,andthesecanbefineorcoarse.
- Processed – Also called 'artificial aggregates', or 'by-product' aggregates, they arecommonlytaken from industrial or engineering waste, then treated to form construction aggregates for highquality concrete. Common processed aggregatesinclude industrial slag, as well as burntclay.Processed aggregatesare usedforbothlightweightandhigh-densityconcrete mixes.Classificationofaggregatesbasedon: Shape

Shapeis one of themost effective waysof differentiating aggregates. The shape of your chosenaggregates will have a significant effect on the workability of your concrete. Aggregates purchased inbatchesfrom a reputable suppliercanbe consistentin shape,if required,butyou can alsomixaggregate shapesifyouneedto.Thedifferentshapesofaggregatesare:

- Rounded – Natural aggregates smoothed by weathering, erosion and attrition. Rocks, stone, sandand gravel found in riverbeds are your most common rounded aggregates. Rounded aggregates arethe mainfactorbehindworkability.
- Irregular – These are also shaped by attrition, but are not fully rounded. These consist of smallstonesandgravel,andofferreducedworkabilitytoroundedaggregates.
- Angular – Used for higher strength concrete, angular aggregates come in the form of crushed rockand stone. Workability is low,but this can be offset by filling voids with rounded or smalleraggregates.
- Flaky – Defined as aggregates that are thin in comparison to length and width. Increases surfaceareainaconcretemix.
- Elongated – Also addsmore surface area toa mix– meaningmore cementpasteis needed.Elongatedaggregatesarelongerthantheyare thickorwide.
- Flaky and elongated – A mix of the previous two – and the least efficient form of aggregate withregardstoworkability.

Particleshapeand Texture:-

Aggregateparticle shape and surface texture are important for proper compaction, deformationresistance,and workability.However, the ideal shape for HMA and PCC is different because aggregates serve different purposes in each material. In HMA, since aggregates are relied upon toprovide stiffness and strength by interlocking with one another, cubic angular-shaped particles with arough surface texture are best. However, in PCC, where aggregates are used as an inexpensive high- strength material to occupy volume, workability is the major issue regarding particle shape.
Therefore,inPCCroundedparticlesarebetter.Relevantparticleshape/texturecharacteristicsarediscussedbelow.

Rounded particles create less particle-to-particle interlock than angular particles and thus provide betterworkability andeasier compaction.However, in HMA less interlock is generally a disadvantage asrounded aggregate will continue tocompact, shove and rutafter construction. Thus angular particlesare desirable for HMA (despite their poorer workability), while rounded particles are desirable for PCCbecause oftheirbetterworkability.

FlatorElongatedParticles
Theseparticlestendtoimpedecompactionorbreakduringcompactionandthus,maydecreasestrength.

Smooth-SurfacedParticles Theseparticleshavealowersurface-to-volumeratiothanroughsurfacedparticlesandthusmaybeeasier to coat with binder. However, in HMA asphalt tends to bond more effectively with rough- surfaced particles, and in PCC rough-surfaced particles provide more area to which the cementpastecanbond.Thus,rough-surface particlesare desirableforbothHMAand PCC.

ENGINEERINGPROPERTIESOFAGGREGATES:-

Aggregatesareusedinconcreteto provideeconomyin thecostofconcrete.Aggregatesactasfilleronly.Thesedonotreactwithcementandwater.

Buttherearepropertiesorcharacteristicsofaggregatewhich influencethepropertiesofresultingconcrete mix.Theseare asfollow.

1. Composition
2. Size &Shape
3. SurfaceTexture
4. SpecificGravity
5. Bulk Density
6. Voids
7. Porosity&Absorption
8. BulkingofSand
9. FinenessModulusofAggregate
10. Surface IndexofAggregate
11. DeleteriousMaterial
12. CrushingValueofAggregate13.ImpactValueofAggregate
14.AbrasionValue ofAggregate

1. COMPOSITION

Aggregatesconsistingofmaterialsthatcanreactwithalkaliesincementandcauseexcessiveexpansion, cracking and deterioration of concrete mix should never be used. Therefore it is required totestaggregatestoknowwhetherthereispresenceofanysuchconstituentsinaggregateornot.

2. SIZE&SHAPE

The size and shape of the aggregate particles greatly influence the quantity of cement required inconcrete mix and hence ultimately economy of concrete. For the preparation of economical concretemix on should uselargestcoarse aggregates feasiblefor the structure. IS-456 suggests followingrecommendationtodecidethemaximumsizeofcoarseaggregateto beusedinP.C.C&R.C.Cmix.

Maximumsizeofaggregateshouldbelessthan

- One-fourthoftheminimumdimensionoftheconcretemember.
- One-fifthoftheminimumdimensionofthereinforcedconcretemember.
- The minimum clear spacingbetween reinforcedbars or 5mm less than the minimum coverbetweenthereinforcedbarsandform,whicheveris smallerforheavilyreinforcedconcretememberssuchas the ribs ofthemainbars.

Remember that the size& shape of aggregate particles influence the properties of freshly mixedconcrete moreas comparedtothoseofhardenedconcrete.

3. SURFACETEXTURE

The development of hard bond strength between aggregate particles and cement paste depends uponthesurface texture,surface roughness andsurface porosityoftheaggregateparticles.

If the surface is rough but porous, maximum bond strength develops. In porous surface aggregates, the bondstrengthincreasesduetosettingofcementpaste inthe pores.

4. SPECIFICGRAVITY

The ratio of weight of oven dried aggregates maintained for 24 hours at a temperature of 100 to 110^{0}C,to the weight of equal volume of water displaced by saturated dry surface aggregate is known asspecificgravityofaggregates.

Specificgravitiesareprimarilyoftwotypes.

- Apparentspecificgravity
- Bulkspecific gravity

Specific gravity is a mean to decide the suitability of the aggregate. Low specific gravity generallyindicates porous, weak and absorptive materials, whereas high specific gravity indicates materials ofgoodquality.Specific gravityofmajoraggregatesfallswithinthe rangeof2.6to2.9.

Specificgravityvaluesarealsousedwhiledesigningconcretemix.

5.BULKDENSITY

It is defined as the weight of the aggregate required to fill a container of unit volume. It is generallyexpressedinkg/litre.

Bulk densityofaggregatesdependsupon thefollowing 3factors.

- Degreeofcompaction
- Gradingofaggregates
- Shapeofaggregateparticles

6. VOIDS

The empty spaces between the aggregate particles are known as voids. The volume of void equals thedifference between the gross volume of the aggregate mass and the volume occupied by the particlesalone.

7. POROSITY&ABSORPTION

The minute holes formed in rocks during solidification of the molten magma, due to air bubbles, areknownas pores.Rockscontainingpores arecalledporousrocks.

Water absorption may be defined as the difference between the weight of very dry aggregates and theweightofthesaturatedaggregates withsurfacedryconditions.

Dependingupontheamountofmoisturecontentinaggregates,itcanexistinanyofthe4conditions.

- Verydryaggregate (havingnomoisture)
- Dryaggregate(containsomemoistureinitspores)
- Saturatedsurfacedryaggregate(porescompletelyfilledwithmoisturebutnomoistureonsurface)
- Moistorwetaggregates(poresarefilledwithmoistureandalsohavingmoistureonsurface)

8. BULKINGOFSAND

It can be defined as in increase in the bulk volume of the quantity of sand (i.e.fine aggregate) in amoist condition over the volume of the same quantity of dry or completely saturated sand. The ratio ofthevolume ofmoistsanddueto the volume ofsandwhendry,iscalled bulkingfactor.

Finesands bulkmorethancoarsesand
When water is added to dry and loose sand, a thin film of water is formed around thesand particles. Interlocking of air in between the sand particles and the film of water tends to push the particles apartdue to surface tension and thus increase the volume. But in case of fully saturated sand the water filmsare brokenandthevolumebecomes equaltothatofdrysand.

9. FINENESSMODULUS

Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregateretained on each of the standard sieves ranging from 80 mm to 150 micron and dividing this sum by100.

Fineness modulus is generally used to get an idea of how coarse or fine the aggregate is. More finenessmodulus value indicates that the aggregate is coarser and small value of fineness modulus indicates thatthe aggregateisfiner.

10. SPECIFICSURFACE OFAGGREGATE

The surface area per unit weight of the material is termed as specific surface. Thisis an indirectmeasure of the aggregate grading. Specific surface increases with the reduction in the size of aggregateparticle.Thespecificsurfaceareaofthefineaggregateis verymuchmorethanthatofcoarseaggregate.

11. DELETERIOUSMATERIALS

Aggregates should not contain any harmful material in such a quantity so as to affect the strength anddurabilityoftheconcrete.Suchharmfulmaterialsarecalleddeleteriousmaterials.Deleteriousmaterialsmaycauseoneofthefollowingeffects

- Tointerferehydrationofcement
- Topreventdevelopmentofproperbond
- To reducestrengthanddurability
- Tomodifysettingtimes

Deleterious materialsgenerallyfoundinaggregates,maybegroupedasunder

- Organicimpurities▪ Clay,silt&dust
- Saltcontamination

12. CRUSHINGVALUE

The aggregates crushing value gives a relative measure of resistance of an aggregate to crushing undergradually applied compressive load. The aggregate crushing strength value is a useful factor to knowthe behaviourofaggregates whensubjectedtocompressiveloads.

13. IMPACTVALUE

The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shockorimpact.Theimpactvalueofanaggregateissometimeused asanalternativetoitscrushingvalue.

14. ABRASIONVALUE OFAGGREGATES

The abrasion value gives a relative measure of resistance of an aggregate to wear when it is rotated in acylinderalongwithsomeabrasive charge.
SIEVEANALYSIS:-
Sieveanalysisisatechniqueusedtodeterminetheparticlesizedistributionofapowder.Thismethod is performed by sifting a powder sample through a stack of wire mesh sieves, separating it into discretesizeranges.Asieveshakerisusedtovibratethesievestackfora specificperiod oftime.
Sieve analysis is important for analyzing materials because particle size distribution can affect a widerange of properties, such as the strength of concrete, the solubility of a mixture, surface area propertiesandeventheirtaste.

FINENESSMODULUS:-

The *Fineness Modulus*(FM) is an empirical figure obtained by adding the total percentage of thesample ofanaggregate retainedoneachofaspecifiedseriesofsieves,anddividingthe sumby100.

Fineness modulus of sand (fine aggregate) is an index number which represents the mean size of theparticles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulativepercentageretained oneachsieveisadded and subtractedby100 givesthevalueoffinenessmodulus.

Fineness modulus is generally used to get an idea of how coarse or fine the aggregate is. More finenessmodulus value indicates that the aggregate is coarser and small value of fineness modulus indicates thatthe aggregateisfiner.

THEGRADINGCURVE:-

The grading curve graphically represents the proportion of different grain sizes which the aggregate iscomposed of and which form part of the shortcrete mix. It provides useful information to find out:Whetherthedistributionofthe differentaggregatesizesissuitableforpumping.

GRADINGOFAGGREGATES:-

Grading of aggregates is determining the average grain size of the aggregates before they are used inconstruction. Thisis applied toboth coarse andfine aggregates. The aggregate sample is sievedthroughasetofsievesandweightsretainedoneachsieveinpercentagetermsare summedup.

GAPGRADINGAGGREGATE:-

Gap grading isdefined as a grading inwhich one ormore intermediate size fractions are absent. Onagradingcurve,itrepresentsa horizontal lineoverthe rangeofsizesthatareabsent.

MAXIMUM AGGREGATE SIZE:-

Typically, coarse aggregate sizes are larger than 4.75 mm (5 mm in British code), while fine aggregatesform the portion below 4.75 mm. A maximum size up to 40 mm is used for coarse aggregate in moststructural applications, while for mass concreting purposes such as dams, sizes up to 150 mm may beused.

MODULE II

FRESHCONCRETE

Workability is the property of concrete which determines the amount of internal work necessary toproduce full compaction. It is a measure with which concrete can be handled from the mixer stage toits finalfullycompactedstage.

FACTORSAFFECTINGWORKABILITYOFCONCRETE:-

01. WaterContentoftheConcreteMix:

Water content will haveimportant influences on the workability in given volume of concrete. Thehigher thewatercontentpercubicmeterofconcrete,thehigherwillbethefluidityofconcrete,whichaffecttheworkabilit y.

Waterrequirementismainlyassociatedwithabsorptionbyaggregatessurface&fillingupthevoidsbetweenagg regates.

- Thestrengthofthe concretemaygetreduced.
- Morequantityofwatercomesoutfromthesurfaceofconcreteresultingintobleeding.
- Cementslurryalsoescapesthroughthejointsofformworkresultingintothelossofcementfromconcrete.

02. TheSizeof Aggregates:

Workabilityismainlygovernedbythemaximumsizeofaggregates.Water andpasterequire,willbenot less if a chosen size of aggregates for concrete is bigger. Consequently, for a given quantity ofwatercontent&paste,biggersizeaggregate willgivehigherworkability.

Note: Onthesite, themaximumsizeof aggregateto beusedwilldepend upon themanyfactorssuch asthehandling,mixingandplacing equipment,thethicknessofsection and quantityofreinforcement.Latertwoareveryimportant.

03. TheshapeofAggregates:

Angular,flaky& elongatedaggregatereducestheworkabilityofconcrete.

Roundedorsub-rounded aggregatesincreasetheworkabilitydueto thereductionofsurfaceareaforagivenvolumeorweight.Therefore,anexcesspasteisavailabletogivebetter lubricatingeffect.

Roundedshapeaggregatehas lessfrictionalresistanceandgivesahighworkabilityascomparedtoangular,flakyorelongatedaggregates.

Note: Riversand &gravelprovidegreaterworkabilitytoconcretethancrushedsand.

04. SurfaceTextureofAggregates:

Theroughlytexturedaggregateshavemore surfaceareathansmoothlyroundedaggregatesofthesamevolume. Smooth rounded or glassy aggregates will give better workability than roughly texturedaggregates. A reduction of inter particle frictional resistance offered by smooth aggregates alsocontributestohigherworkability.

05. ThePorosityofAggregates:
Porous and non-saturated aggregate will require more water than non-absorbent aggregates. For thesame degree of workability, latter will require less water. Overall, this factor is only of secondaryimportance.

06. GradingofAggregates:

Grading of aggregates has the greatest influence on workability. The better the grading of aggregates,the less is the amount of void in concrete so well-graded aggregates should be used. When total voidsare lessinconcrete,the excesspaste is available togive betterlubricatingeffect.
With excess amount of concrete paste present in the mixture, it becomes cohesive and fatty thatpreventssegregationofparticles &leastamountofcompactingeffortsisrequiredtocompacttheconcrete.

Foragivenworkability,
thereisonevalueofcoarseaggregate/Fineaggregateratio,whichneedsthelowerwatercontent.

07. UsesofConcreteAdmixtures:

This is one of the commonly used methods to enhance the workability of concrete.
Concreteadmixturessuchasplasticizer and superplasticizersgreatlyimprovetheworkability.

Air entraining agents are also used to increase the workability. Air entraining agents creates a largenumber ofverytinyair bubbles.Thesebubblesgetdistributed throughoutthemassofconcreteand actasrollers andincrease theworkability.

MineraladmixtureslikePozzolanicmaterialsarealsousedtoimprovetheworkabilityofconcrete.

08. AmbientTemperature:

Inhotweather, iftemperatureincreases, theevaporationrateofmixingwateralsoincreasesandhencefluid viscosity increases, too. This phenomenon affects the flowability of concrete and due to fasthydrationofconcrete;itwillgainstrengthearlierwhichdecreasesthe workabilityoffreshconcrete.

MeasurementofWorkability:-

The followings tests for workability of concrete gives a measure of workability, which is applicablespecifically concerning some particular methods. They bear no relationship to any of the commonmethods of placing and compacting concrete. So, the test results are only relative and should not begiven any absolute measurement.We need tounderstand thateach test has theirimportance, andassuch there is no unique test to measure the workability of concrete in total. The significant advantage isthe simplicity of the procedure with an ability to detect variation in the uniformity of a mix of givennominalproportion.

Typesoftestsforworkability:-

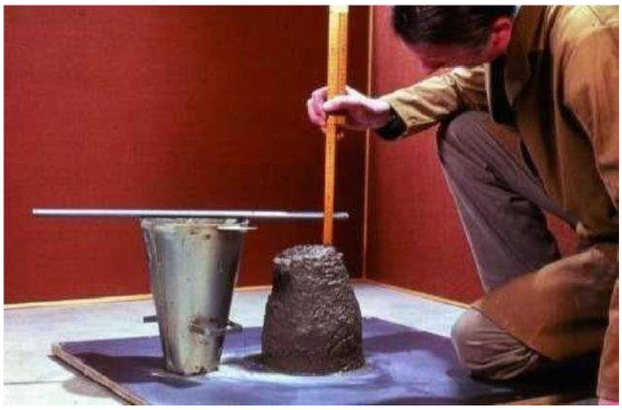
- SlumpTest
- CompactingFactorTest FlowTest
- Vee-BeeConsistometerTest

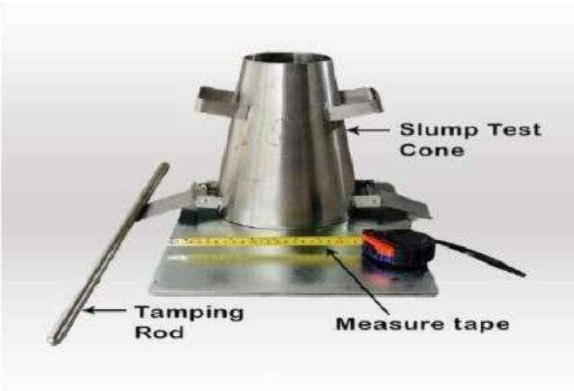
SLUMPTEST:-

The slump test isa means of assessing the consistency of fresh concrete. It is used, indirectly, as ameansofcheckingthatthe correctamountofwaterhasbeenaddedtothemix.

The steel slump cone is placed on a solid, impermeable, level base and filled with the fresh concrete inthree equal layers. Each layer is rodded 25 times to ensurecompaction. The third layer is finished offlevel with the top of the cone. The cone is carefully lifted up, leaving a heap of concrete that settles or'slumps' slightly.The upturned slump coneis placed on thebase to act as a reference,and thedifference in level between its top and the top of the concrete is measuredandrecorded to thenearest10mmtogivethe slumpoftheconcrete.

When the cone is removed, the slump may take one of three forms. In a true slump the concrete simplysubsides, keeping more or less to shape. In a shear slump the top portion of the concrete shears off andslips sideways. In a collapse slump the concrete collapses completely. Only atrue slump is of any usein the test. If a shearorcollapseslumpis achieved,afresh sampleshouldbe taken andthe testrepeated. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for whic h th e flow tes t (see separate entry) is more appropriate.





CompactingFactorTest:-

The compacting factor test is designed primarily for use in the laboratory but it can also be used in thefield. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes ofvery low workability as are normallyused when concrete is to be compacted by vibration. Such dryconcrete areinsensitivetoslumptest.

The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted. The sample ofconcrete to be tested is placed in the upp r hopper up to the brim. The trap-door is opened so that theconcrete falls into the low r hopper. Then the trap-door of the lower hopper is opened and the concreteis allowed to fall into the cylinder. In the case of a dry-mix, it is likely that the concrete may not fall onopening the trap-door. In such a case, a slight poking by a rod may be required to set the concrete inmotion. The excess concrete remaining above the top level of the cylinder is then cut off with the helpof plane blades supplied with the apparatus. The outside of the cylinder is wiped clean. The concrete isfilled up exactly up to the top level of the cylinder. It is weighed to the nearest 10 grams. This weight isknownas—Weightofpartiallycompactedconcrete.

Thecylinderisemptiedandthenrefilledwiththeconcretefromthesamesampleinlayersapproximately 5 cm deep. The layers are heavily rammed or preferablyvibrated so as to obtain fullcompaction. The top surface

of the fully compacted concrete is then carefully struck off level with thetop of the cylinder and weighed to thenearest 10 gm. This weightis known as Weight of fullycompactedconcrete.
Thecompactionfactor=WeightofpartiallycompactedconcreteWeight offullycompacted concrete

FLOWTEST

Thisisalaboratorytest,whichgivesanindicationofthequalityofconcretewithrespecttoconsistency, cohesiveness a d the proneness to segregation. In this test, a standard mass of concrete issubjected to joint.The spread or theflow of theconcrete is measured and this flow is related toworkability.
It can be seen that the apparatus consists of flow table, about 76 cm. in diameter over which concentriccircles are marked. A mould made from smooth metal casting in the form of a frustum of a cone is usedwith the following internal dimensions. The baseis 25 cm. in diameter, upper surface 17 cm. indiameter, and height of the cone is 12 cm. The table top is cleaned of all gritty material and is wetted.The mould is kept on the centre of the table, firmly held and is filled in two layers. Each layer is rodded25 times with a tampingrod 1.6 cm in diameter and 61 cm long rounded at thelower tamping end.After the top layer is rodded evenly, the excess of concrete which has over flowed the mouldisremoved. The mould is lifted vertically upward and the concrete stands on its own without support. Thetable is then raised and dropped 12.5 mm 15 times in about 15 seconds. The diameter of the spreadconcrete is measured in about 6 directions to the nearest 5 mm and the average spread is noted. Theflow of concrete is the percentage increase in the average diameter of the spread concrete over the basediameterofthemould.

- Flowper cent=Spreaddiameterincm – 25X100

25

The value could range anything from 0 to 150 per cent. A close look at the pattern of spread of concretecanalso givea goodindicationofthe characteristicsof concretesuchastendencyforsegregation.

- VEE-BEE CONSISTOMETERTEST

Thisisagoodlaboratory testtomeasureindirectly theworkability of concrete.Thistestmetalcylindrical pot of the con istomeconsists of a vibrating table, a metal pot, a sheet metal cone, a standardiron rod. Slump test as described earlier is performed, placing the slump cone inside the sheetter. The glass disc attached to the swivel armis turned and placed on the top of the concrete in the pot.
Theelectricalvibratoristhenswitchedonandsimultaneouslya stopwatchstarted.

The vibration is continued till such a time as the conical shape of the concrete disappears and theconcrete assumes a cylindrical shape. This can be judged by observing the glass disc from the top fordisappearance of transparency. Immediately when the concrete fully assumes a cylindrical shape, thestop watch is switched off. The time required for the shape of concrete tochange from slump coneshape to cylindrical shape in seconds is known as Vee Bee Degree. This method is very suitable forvery dry concrete whose slump value cannot be measured by Slump Test but the vibration is toovigorousforconcrete witha slumpgreaterthanabout50mm.

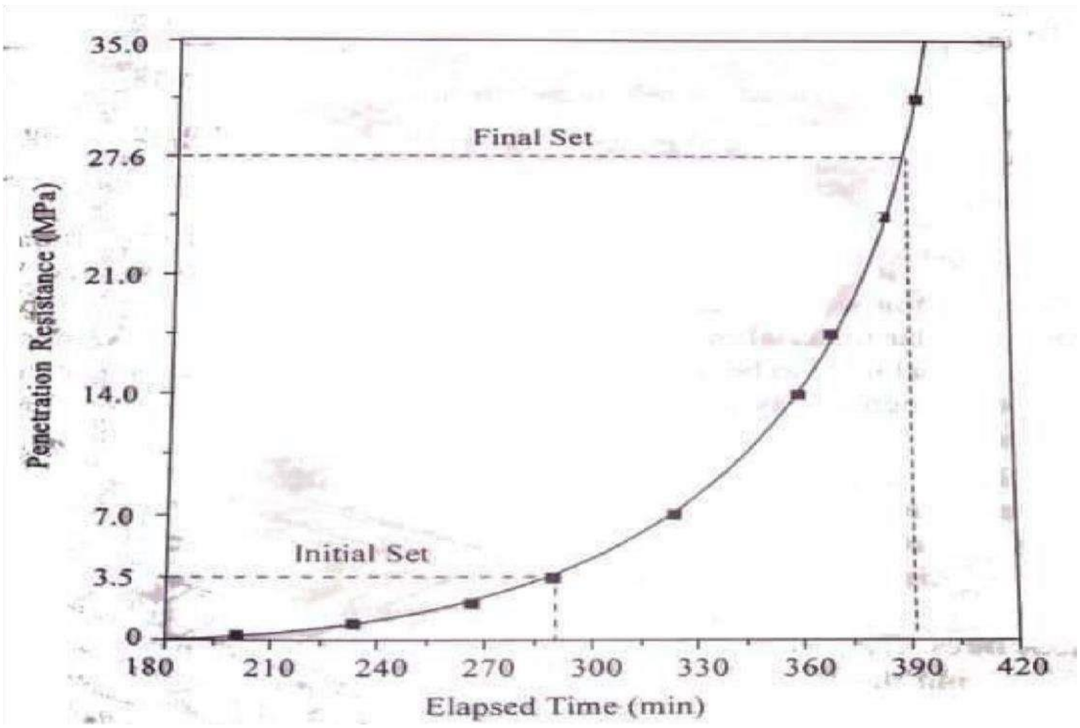
SETTINGTIMEOFCEMENT:-

The concrete setting time mostly depends upon the w/c ratio, temperature conditions, type of cement,use of mineral admixture, use of plasticizer, in particular, retarding plasticizer. The significance ofsetting parameter of concrete is more important for site engineers than setting time of cement. Forkeeping the

concrete we use retarding plasticizers, which increases setting time and the duration up towhichconcreteremainsinthe plasticconditionis ofspecialinterest.
Theconcretesettingtimeisdeterminedbyusingapenetrometertest.

The testprocedureinvolves,

1. Takingasufficientquantityoffreshconcretemixsampleandsievesitthrough4.75 mmsieve.
2. Themortarsamplepassedthroughthesieveiscollected.
3. This mortaristhencompactedbyrodding, tapping,rockingorbyvibrating.
4. Levelthesurfaceandkeepitcoveredtopreventthelossofmoisture.
5. Removebleedingwater,ifany,usingapipette.Insertaneedleofappropriatesize, dependinguponthedegree ofthe settingofthemortarinthefollowingmanner.
6. Bringthebearingsurfaceoftheneedleincontactwiththemortarsurface.
7. Graduallyanduniformlyapplyaverticalforcedownwardsontheapparatus untiltheneedlepenetratestoadepthof25± 1.5on,as indicatedbythescribemark.
8. Thetimeistakentopenetrate25mmdepthcould beabout10seconds.
9. Recordtheforcerequiredtoproduce25mmpenetrationandthetimeofinsertingfromthetowaterisaddedtothec ement.
10. Calculate the penetration resistance by dividing the recorded force by the bearing area ofthe needle.Thisisthepenetrationresistance.



- Plotagraphofpenetrationresistanceasordinateandelapsedtimeasabscissa.
- Testconductedmustdetermine6penetrationresistances.
- Continuethetestsuntilonepenetrationresistanceofatleast27.6MPaisreached.
- Plotthesepenetrationresistancevaluesonthegraphand connecteach point.
- Nowdrawahorizontallinefrompenetrationresistanceequalto3.5MPa.
- Thepoint ofintersectionofthiswiththesmoothcurveisread onthex-axiswhichgivestheinitialsettingtime.

- Similarly, ahorizontallineisdrawnfromthepenetrationresistanceof27.6MPaandpointitcutsthesmoothcurveisreadonthe x-axis whichgives thefinalset.

Effectoftimeandtempinworkability:-

Temperature decreases the setting time by increasing hydration rate and that increase the early agestrengthoftheconcrete.Thisisanadvantagethatlesstimewillberequiredbeforeremoving offormworksonsite,butthisdecrease the use ofproperplacementofconcrete intheinitialstages.

It indicates that the temperature has a negative effect on the workability of concrete as well as strengthup tosome extent. Temperature decreases the setting time by increasing hydration rate andthatincreasetheearlyagestrengthoftheconcrete.
This is an advantage that less time will be required before removing of form works on site, but thisdecrease the use of proper placement of concrete in the initial stages. And if concrete is not properlylaid,thenstrengthdistributionwillnotremainthesamethroughoutthecross-section.

SEGREGATION:-

Thetendencyofseparationofcoarseaggregatesgrainsfromteconcretemassiscalled segregation.

BLEEDING:-

Thetendencyofwaterto risetothesurface offreshlylaid concreteisknownasbleeding.

MIXING ANDVIBRATIONOFCONCRETE:

Mixing is the uniform incorporation of the ingredients within the concrete mix and vibration usuallymeans the mechanical process to assistin the removal of any entrapped air. The air entrapment causes ahoneycombeffectwhichweakens theconcrete,

There are calculations and processes for concrete to allow for movement, which often translates tovibrationduetofrictionorthedissimilarityofmaterials,aseriousconcernasitwouldbethecauseforstructuralfatigueandfailure.

The stagesofconcrete productionare:

1. Batchingormeasurementofmaterials
2. Mixing
3. Transporting
4. Placing
5. Compacting
6. Curing
7. Finishing

BatchingofMaterials

For good quality concrete a proper and accurate quantity of all the ingredients should be used.The aggregates, cement and water should be measured wit h an accuracy of 3 per cent of batch quantityand the admixtures by 5 per cent of the batch quantity. There are two prevalent methods of batchingmaterials, the volume batching and the weigh batching. The factors affecting the choice of batchingmethodare the size of job, required production rate, and required standards of batching performance.Formostimportantworks weighbatchingisrecommended.

a) VolumeBatching
b) Weigh
BatchingMixing

1. HandMixing
2. MachineMixing

a) TiltingMixers
b) Non-tiltingMixer
c) ReversingDrumMixer
d) Pan-typeorStirringMixer
e) TransitMixer

ChargingtheMixerandMixingTime
Theorderoffeedingtheingredientsintothemixerisas follows:

About 25 per cent of water required for mixing is first introduced into the mixer drum to prevent anysticking of cement on the blades and bottom of the drum. Then the ingredients are discharged throughthe skip. In the skip the sequence ofloading shouldbe to add first half the coarse aggregate then halfthe fine aggregate and over this total cement and then the balance aggregates. After discharging theingredients into the drum the balance water is introduced. The mixing time is counted from the instantcomplete waterisfedintothemixer.

The speed of the mixers is generally 15 to 20 rpm. For proper mixing, the number of revolutions perminute requiredbythe drumare25to30.Time ofmixingalsodependsoncapacityofmixer.

A poor quality of concrete is obtained if the mixing time is reduced. On the other hand if the mixingtime is increased it is uneconomical. However, it is found that if the mixing time is increased to 2minutesthecompressivestrengthofconcreteproducedisenhancedandbeyondthistimetheimprovementin compressive strength is insignificant. A prolonged mixing may cause segregation.Also, due to longer mixing periods the water may get absorbed by the aggregates or evaporate resultinginloss ofworkabilityandstrength. Transporting

Concreteshouldbetransportedtotheplaceofdepositionattheearliestwithoutthelossofhomogeneity obtained at the time of mixing. A maximum of 2 hours from thetime of mixingispermittedif truckswithagitatorand1hourif truckswithoutagitators are usedfortransportingconcrete. Also it should be ensured that segregation does not take place during transportation andplacement. The methods adopted for transporting concrete depend upon the size and importance of thejob, thedistance of the deposition place from the mixing place,and the nature of the terrain. Some ofthe methodsoftransportingconcreteareasbelow:

a. MortarPan
b. WheelBarrow
c. Chutes
d. Dumper
e. BucketandRopeway

f. Beltconveyor
g. Skipand Hoist
h. Pumping

Placing:

To achieve quality concrete it should be placed with utmost care securing the homogeneityachieved during mixing and the avoidance of segregation in transporting. Research has shown that adelayed placing of concrete results in a gain in ultimate compressive strength provided the concrete canbe adequately compacted. For drymixesin hot weather delay of half to one hour isallowed whereasforwetmixesincoldweatheritmaybeseveralhours.

Compaction

After concrete is placed at the desired location, the next step in the process of concrete production isits compaction. Compaction consolidates fresh concrete within the moulds or frameworks and aroundembedded parts and reinforcement steel. Considerable quantity of air is entrapped in concrete during itsproduction and there is possible partial segregation also. Both of these adversely affect the quality ofconcrete.Compactionoftheconcreteistheprocesstogetridoftheentrappedairandvoids,elimination of segregation occurred and to form a homogeneousdensemass. Ithas been found that 5per centvoidsin hardened concrete reduce the strength by over 30 per cent and 10 per centvoidsreduce thestrengthbyover50percent.Therefore,thedensityandconsequentlythe strengthand durabilityof concrete largely depend upon the degree of compaction. For maximum strength driestpossible concreteshouldbe compacted100percent.

Thecompactionofconcretecanbeachievedbythefollowingmethods.

1. HandCompaction
2. Compaction byVibration
    a. NeedleVibrator:
    b. Formwork Vibrator
3. CompactionbySpinning
4. CompactionbyJolting
5. Compaction by Rolling Curing

Cement gains strength and hardness because of the chemical action between cement and water.This chemical reaction requires moisture, favourable temperature and time referred to as the curingperiod. Curing of freshly placed concrete is very important for optimum strength and durability. Themajor part of the strength in the initial period is contributed by the clinker compound C_3S and partly byC_2S, and is completed in about three weeks. The later strength contributed by C_2S is gradual and takeslong time. As such sufficient water should be made available to concrete to allowit to gain fullstrength. *The process of keeping concrete damp for this purpose is known as curing*. The object is toprevent the loss of moisture from concrete due to evaporation or any other reason, supply additionalmoisture or heat and moisture to accelerate the gain of strength. Curing must be done for at least threeweeksandinnocaseforlessthantendays.

Approximately 14 litres of water is required to hydrate each bag of cement. Soon after the concrete isplaced, the increase in strength is very rapid (3 to 7 days)and continues slowly thereafter for anindefinite period. Concrete moist cured for 7 days is about 50 per cent stronger than that which isexposed todry air for the entire period. If the concreteis keptdamp for one month, the strengthisaboutdoublethanthatofconcreteexposedonlytodryair.

MethodsofCuring:

Concrete may be kept moist by a number of ways. The methods consist in either supplyingadditional moisture to concrete during early hardening period by ponding, spraying, sprinkling, etc. orby preventing loss of moisture from concrete by sealing the surface of concrete by membrane formedbycuringcompounds.Followingare someoftheprevalentmethodsofcuring.

1. WaterCuring
2. SteamCuring
3. CuringbyInfraRedRadiation:
4. ElectricalCuring
5. ChemicalCuring:

Finishing:

Concrete is basically used because of its high compressive strength. However, the finish of theultimate product is not that pleasant. In past couple of decades efforts have been made to developsurfacefinishes togive a betterappearance toconcretesurfacesandare asfollows.

1. FormworkFinishes
2. SurfaceTreatments

3. AppliedFinishes

QUALITYOFMIXINGWATER:-

The common specifications regarding quality of mixing water is water should befitfor drinking.Such water should have inorganic solid less than 1000 ppm. This content lead to a solid quantity 0.05%ofmassofcementwhenw/cratioisprovided0.5resultingsmalleffectonstrength.

HARDENEDCONCRETE

The water–cementratio isthe ratio ofthe weight ofwater tothe weight ofcementused inaconcretemix. A lower ratio leads to higher strength and durability, but may make the mix difficult toworkwithandform.Workabilitycanberesolvedwiththeuseofplasticizersorsuper-plasticizers.

A maximum of 0.5 ratio when concrete is exposed to freezing and thawing in a moist condition or todeicing chemicals, and a maximum of 0.45 ratio for concrete in a severe or very severe sulphatecondition.

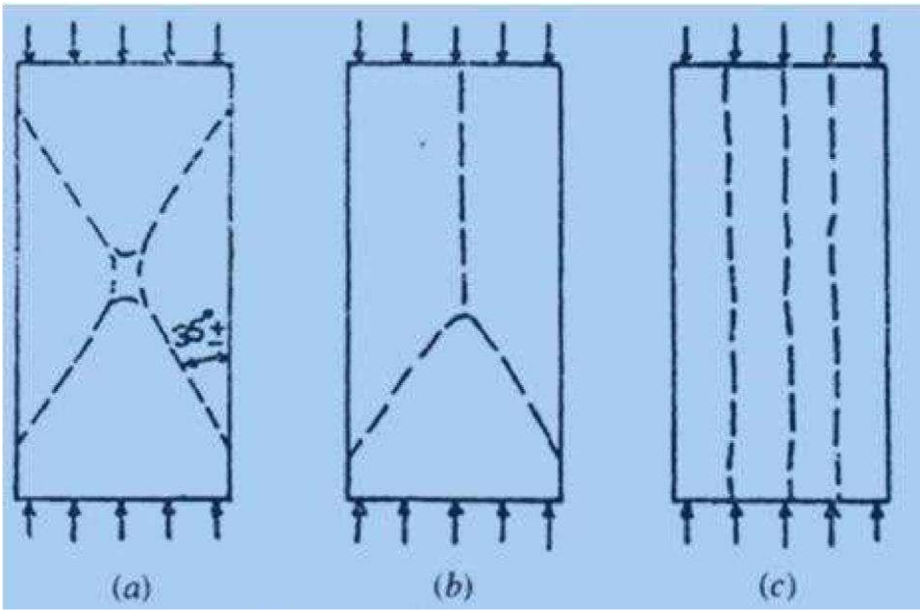
However, a mix with a ratio of 0.35 may not mix thoroughly, and may not flow well enough to beplaced. More water is therefore used than is technically necessary toreact with cement. Water– cementratios of 0.45 to 0.60 are more typically used. For higher-strength concrete, lower ratios are used, alongwithaplasticizertoincreaseflow ability.

Natureofstrengthofconcrete:-

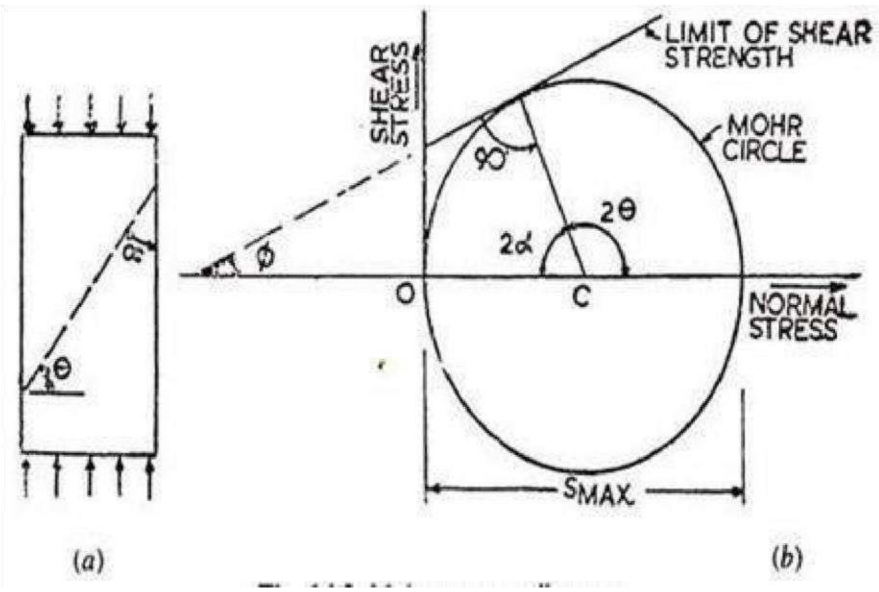
The strength can be defined as the ability to resist force. With-regard to concrete for structural purposesit can be defined as the unit force required to cause rupture. Strength is a good index of most of theother properties of practical importance. In general stronger concretes are stiffer, more water tight andmore resistanttoweatheringetc.

Rupture of concrete may be caused by applied tensile stress, shearing stress or by compressive stress ora combination of two of the above stresses. Concrete being a brittle material is much weaker in tensionand shear than compression andfailures of concrete specimens under compressive load are essentiallyshearfailures onoblique planes as shown infig.

It is called as shear or cone failure. As the resistance to failure is due to both cohesion and



internalfriction,theangleofruptureisnot45°(planeofmaximumshearstress),butisafunctionoftheangleof internal friction. It can be shown mathematically that the angle ϕ which the plane of failure makeswiththeaxisofloadingisequalto (45° – ϕ/2)asshowninfig.



The angle of internal friction ϕ of concrete beingof the order of 20°, the angle of inclination of theconeoffailureinthe conventionaltestspecimenisapproximately35°asshown in fig.

Maturityofconcrete:-

Concrete maturity is an index value that represents the progression of concrete curing. It is based on anequation that takes into account concrete temperature, time, and strength gain. Concrete maturity is anaccurate waytodeterminereal-timestrengthvaluesofcuringconcrete.

TensionVs.CompressionofConcrete:-

Concrete has enormous compressive strength, the ability to withstand heavy weights or forces on it. Italso gains strength as it ages. Concrete will solidify in a few hours and harden or set in a few days, butcontinues to gain strength for at least 28 days.Some very thick concrete structures, like dams, willcontinue togainstrengthformonths oryears.

Concrete has almost no tensile strength, the ability to withstand pressing or stretching. Put a boardbetween two supports and press down on the centre. It will bend. The top of the board is undercompression, the bottom which bends is under tension. Concrete can resist the compression, but willbreak under the tension. Concrete cracks in roads and slabs are largely due to tension; different weightsindifferentareas producetensileforces.

The tension to compression ratio for concrete is about 10 to 15 percent. That is, it can withstand about10 times the pushingforce or compression of the pullingforce or tension. Both strengths increasewith age, but the ratio is steady. Portland cement concrete less than a year old has compressionstrength of 1,000 pounds per square inch (psi) and tension strength of 200 psi. Concrete more than ayearoldhas compressionpsiof2,000pounds andtensionpsiof400. Factorsaffectingstrengthofconcrete:

Concrete strength is affected by many factors, such as quality of raw materials, water/cement ratio,coarse/fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity andcuringofconcrete.

Relation betweentensile and compressive strengthofconcrete:-

The theoretical compressive strength of concrete is eight times larger than its tensile strength. Thisimpliesafixed relation betweenthecompressiveand tensilestrengthofconcrete.Infactthereisacloserelation but not a direct proportionality. The ratio of tensile to compressive strength is lower for highercompressive strengths.

Thismaybeduetothefollowingtworeasons:

(a) Formationofinferior qualitygelduetoimpropercuring.

(b) Developmentofmoreshrinkagecracksduetoimpropercuring.Theusesofpozzolanicmaterialshave showntheincreaseintensilestrength.

CuringofConcrete:-

Curing of Concrete is a method by which the concrete is protected against loss of moisture required forhydration and kept within the recommended temperature range. Curing will increase the strength anddecrease thepermeabilityofhardenedconcrete.

MOD III

TESTINGOFHARDENEDCONCRETE

Thecompressivestrengthofconcreteisconsideredthebasiccharacteroftheconcrete.Consequently, it is known as the characteristic compressive strength of concrete (fck) which is definedas that value below which not more than five percent of test results are expected to fall based on IS:456-2000.Inthis definitionthetestresultsarebasedon150mmcubecuredinwaterundertemp.of27±2°C for28daysandtestedinthemostsaturatedconditionunderdirectcompression.

Other strength like, direct tensile stress, flexural stress, shear stress and bond stress also are directlyproportional to the compressive stress. Higher is the compressive stress, higher is other stresses also.Not only stresses, other properties for example modulus of elasticity, abrasion and impact resistances,durabilityarealsotakentoberelatedtothecompressivestrength, hence, thecompressivestrengthis anindexofoverallqualityofconcrete.

FactorsAffectingCompressiveStrength:-

Among the materials and mix variables, water -cement ratio is the most important parameter governingthecompressivestrength. BesidesW/Cratio, followingfactorsalsoaffectthecompressivestrength.

I. Thecharacteristicsofcement.
II. Thecharacteristicsand propertiesofaggregates.III.Thedegreeofcompaction
IV. Theefficiencyofcuring
V. Ageatthetimeoftesting.VI.Co nditionsoftesting.

TENSILESTRENGTH:

- Tensile strength of concrete underdirecttensionis verysmall and generally neglectedinnormal design practice. Although the value ranges from 8 to 12% of its compressive strength.An average value 10% is the proper choice. The direct tension method suffers the problem likeholding the specimen properly in the testing machine and the application of uniaxial tensile loadnotbeingfreeofeccentricity.
- Thetensilestrengthcanbecalculatedindirectlybyloadingaconcretecylindertothecompressiveforce alongthe twoopposite ends(withitsaxishorizontal)
- Due to uniform tensile stress acting horizontally along the length of cylinder, the cylinder splitsinto two halves. The magnitude of this tensile stress (acting in a direction perpendicular to theline ofactionofappliedcompression)isgivenby

The indirecttensilestressisknownassplittingtensile strength.

FLEXURALSTRENGTH

- The maximum tensile stress resisted by the plain concrete in flexure (bending) is called flexuralstrength(ormodulus ofrupture)expressedinN/mm2orkg/m^2.
- The most common plain concrete subjected to flexure is a highway/runway pavement. Thestrengthofpavementconcreteisevaluatedbymeansofbendingonbeamspecimen.
- The flexural strength (modulus of rupture) is determined by testing standard test specimens of150 mm x 150 mm x 700 mm over a span of 600 mm or 100 mm x 100 mm x 500 mm over aspanof400min.undersymmetricaltwopointloading.

SHEARSTRENGTH:

- Shear strength is the capacity of concrete to resist the sliding of the section over the adjacentsection. A good amount of shear strength capacity is possessed by concrete depending upon thegrade ofconcreteandpercentage oftensile reinforcementinthesection.
- It is difficult to obtain shear strength of concrete but I.S. code suggeststhe value for differentgradeofconcrete.

PULLOUTTESTOFCONCRETE:

The pullouttest producesawelldefinedinthe concrete and measureastaticstrengthpropertyof concrete. The equipmentis simple toassemble and operate. The compressive strength canbeconsideredasproportionaltotheultimatepulloutforce.Thereliabilityofthetestisreportedasgood.

NON-DESTRUCTIVETESTINGOFCONCRETE(NDTONCONCRETE):-

Non destructive test is a method of testing existing concrete structures to assess the strength anddurability of concrete structure. In the non destructive method of testing, without loading the specimento failure (i.e. without destructing the concrete) we can measure strength of concrete. Now days thismethod has become a part of quality control process. This method of testing also helps us to investigatecrackdepth,microcracks anddeteriorationofconcrete.

Non destructive testing of concrete is a very simple method oftesting but it requires skilled andexperienced persons having some special knowledge to interpret and analyze test results. DIFFERENT METHODSOFNON-DESTRUCTIVETESTINGOFCONCRETE:-

Various non-destructive methods of testing concrete have been developed to analyze properties ofhardenedconcrete,whicharegivenbelow.

1. SURFACEHARDNESSTEST

These are of indentation type, include the Williams testing pistol and impact hammers, and are usedonlyforestimation ofconcretestrength.

2. REBOUNDHAMMERTEST

The rebound hammer test measures the elastic rebound of concrete and is primarily used for estimationofconcretestrengthandforcomparativeinvestigation.

3. PENETRATIONANDPULLOUTTECHNIQUES

These include the use of the simbi hammer, spit pins, the Windsor probe, and the pullout test. Thesemeasure the penetration and pullout resistance of concrete and are used for strength estimation, but theycanalsobeusedforcomparativestudies.

NDT testonconcrete

4. DYNAMICORVIBRATIONTESTS

Theseincluderesonantfrequencyand mechanicalsonicandultrasonicpulsevelocitymethods.Theseare used to evaluate durability and uniformity of concrete and to estimate its strength and elasticproperties.

5. COMBINEDMETHODS

Thecombined methodsinvolvingultrasonicpulse velocityandrebound hammerhave beenusedtoestimatestrengthofconcrete.

6. RADIOACTIVEANDNUCLEARMETHODS

These include the X-ray and Gamma ray penetration tests for measurement of density and thickness ofconcrete. Also, the neutron scattering and neutron activation methods are used for moisture and cementcontentdetermination.

7. MAGNETICANDELECTRICAL METHODS

The magnetic methods are primarily concerned with determining cover of reinforcement in concrete,whereas the electrical methods, including microwave absorption techniques, have been used to measuremoisturecontentandthickness ofconcrete.

8. ACOUSTICEMISSIONTECHNIQUES

Thesehavebeenusedto studytheinitiationandgrowthofcracksinconcrete.

ELASTICITY,CREEP,SHRINKAGE

Modulus of Elasticity of Concrete can be defined as the slope of the line drawn from stress of zero to acompressive stress of 0.45f'_c. As concrete is a heterogeneous material. The strength of concrete isdependentontherelative proportionandmodulusofelasticityofthe aggregate.

Dynamic modulus is the ratio of stress to strain under vibratory conditions (calculated from dataobtainedfromeitherfreeorforcedvibrationtests,inshear,compression, orelongation). Itisapropertyofviscoelasticmaterials.

DynamicModulus:-

The value of modulus of elasticity $E_c$determined by actual loading of concrete is known as staticmodulus of elasticity. This method of testing is known as destructive method as the specimen isstressed or loaded till its failure. The static modulus of elasticity does not represent the true elasticbehaviour ofconcreteduetothephenomenonofcreep.Athigher stressesthemodulusofelasticityisaffectedmoreseriously.

Thus a non-destructive method of testing known as dynamic method is adopted for determining themodulus of elasticity. In this case no stress is applied on the specimen. The modulus of elasticity isdeterminedbysubjectingthespecimento longitudinalvibrationattheir naturalfrequencythatiswhythisis knownas dynamicmodulus.

Poisson'sratio:-

Poisson's ratio isthe ratio oflateralstraintolongitudinalstraininamaterial subjectedtoloading. Poisson's ratio varies between 0.1 for high strength concrete and 0.2 for weak mixes. It isnormallytakenas 0.15forstrengthdesignand0.2forserviceabilitycriteria.

Creep:-

Creep in concrete is defined as the deformation of structure under sustained load. Basically, long termpressure or stress on concrete canmake it change shape.This deformation usually occursin thedirection theforce is being applied. Like a concrete column getting more compressed, or a beambending. Creep does not necessarily cause concrete to fail or break apart. When a load is applied toconcrete, it experiences an instantaneous elastic strain which develops into creep strain if the load issustained.

Creepis factoredinwhenconcretestructuresaredesigned.

FactorsAffectingCreep:-

These are thefactorswhichaffectscreepofconcrete.

1. Aggregate2.MixProportions
3. Age ofconcrete

The magnitudeof creep strain is one to three times the value of the instantaneous elastic strain, it isproportional to cement-paste content and, thus, inversely proportional to aggregate volumetric content.The magnitude of creep is dependent upon the magnitude of the applied stress, the age and strength ofthe concrete, properties of aggregates and cementitious materials, amountof cement paste, size andshape of concrete specimen, volume to surface ratio, amount of steel reinforcement, curing conditions,andenvironmentalconditions.

1. InfluenceofAggregate:

Aggregate undergoes very little creep. It is really the paste which is responsible for the creep. However, the aggregate influences the creep of concrete through a restraining effect on the magnitude of creep.The paste which is creeping under load is restrained by aggregate which do not creep. The stronger theaggregate the more is the restraining effect and hence the less is the magnitude of creep. An increasefrom65to 75%ofvolumetriccontentoftheaggregatewilldecreasethecreepby10%.

The modulus of elasticity of aggregate is one of the important factors influencing creep. It can be easilyimagined that the higher the modulus of elasticity the less is the creep. Light weight aggregate showssubstantiallyhighercreepthannormalweightaggregate.

2. InfluenceofMixProportions:

The amount of paste content and its quality is one of the most important factors influencing creep. Apoorer paste structure undergoes higher creep. Therefore,it can be said that creep increases withincrease in water/cement ratio. In other words, it can also be said that creep is inversely proportional tothe strength of concrete. Broadly speaking, all other factors which are affecting the water/cement ratioare alsoaffectingthecreep.

3. InfluenceofAge:

Age at which a concrete member is loaded will have a predominant effect on the magnitude of creep.This can be easily understood from the fact that the quality of gel improves with time. Such gel creepsless, whereas a young gel under load being not so stronger creeps more. Whatis said above is not avery accurate statement because of the fact that the moisture content of the concrete being different atdifferentagealsoinfluencesthemagnitude ofcreep.

Unlike brittle fracture, creep deformation does not occur suddenly upon the application of stress.Instead, strain accumulates as a result oflong-term stress. Therefore, creep is a "timedependent"deformation.It worksontheprincipleofHooke'slaw(stressisdirectlyproportionalto strain).

EffectsofCreeponConcreteandReinforcedConcrete:-

- In reinforced concrete beams, creep increases the deflection with time and may be a criticalconsiderationindesign.
- Ineccentricallyloadedcolumns,creepincreasesthedeflectionandcanloadtobuckling.
- In case of statically indeterminate structures and column and beam junctions creep may relievethe stress concentration induced by shrinkage, temperatures changes or movement of support.Creep property of concrete will be useful in all concrete structures to reduce the internal stressesdue tonon-uniformloadorrestrainedshrinkage.
- In mass concrete structures such as dams, on account of differential temperature conditions attheinteriorandsurface, creepisharmfulandbyitselfmaybeacauseofcrackingintheinterior ofdams. Therefore, all precautions and steps must be taken to see that increase in temperaturedoesnottakeplaceintheinteriorofmassconcretestructure.
- Lossofpre stressdue to creepofconcreteinpre stressedconcretestructure.
- Becauseofrapidconstructiontechniques,concretememberswillexperienceloadsthatcanbeas large as the design loads at very early age; these can cause deflections due to cracking andearly age low

elastic modulus. So, creep has a significant effect on both the structural integrityandthe economicimpactthatitwillproduceifpredictedwrong.

Shrinkage:-

Thevolumetricchangesofconcretestructuresdueto thelossofmoisturebyevaporationisknownasconcreteshrinkageorshrinkageofconcrete.Itisatimedependentdeformationwhichreducesthevolume ofconcretewithouttheimpactofexternalforces.TypesofShrinkageinConcrete:

Tounderstandthisaspectmoreclosely,shrinkagecanbeclassified inthefollowingway:

(a) PlasticShrinkageinconcrete

(b) DryingShrinkageinconcrete

(c) AutogeneousShrinkageinconcrete

(d) CarbonationShrinkageinconcrete

TheTypesofshrinkageareexplainedasbelow:

a. PlasticShrinkage:

Plastic shrinkage is contraction in volume due towater movement from the concrete while still in theplastic state, or before it sets. This movement of water can be during the hydration process or from theenvironmental conditionsleadingtoevaporation of water thatresideson thesurfaceon thewetconcrete. So, the more the concrete bleeds, the greater the plastic shrinkage should be. Plastic shrinkageisproportionaltocementcontentand,therefore,inverselyproportionaltothe w/c ratio.

Plastic shrinkage in concrete can be reduced mainly by preventing the rapid lossof water from surface.Thiscanbedonebycoveringthesurfacewithpolyethylenesheetingimmediatelyonfinishingoperation ; by fog spray that keeps the surface moist; or by working at night. Use of small quantity ofaluminium powder is also suggested to offset the effect of plastic shrinkage. Similarly, expansivecementor shrinkage compensating cement also can beused for controlling the shrinkage duringthe settingofconcrete.

b. DryingShrinkage:

Just as the hydration of cement is an everlasting process, the drying shrinkage is also an everlastingprocess when concrete is subjected to drying conditions. The drying shrinkage of concrete is analogousto the mechanism of drying of timber specimen. The loss of free water contained in hardened concrete,does not result in any appreciable dimension change. It is the loss of water held in gel pores that causesthe change in the volume. Under drying conditions, the gel water is lost progressively over a long time,as long as the concrete is kept in drying conditions. Cement paste shrinks more than mortar and mortarshrinks more than concrete. Concrete made with smaller size aggregate shrinks more than concretemade with biggersize aggregate. The magnitude of drying shrinkageis also a function of the finenessofgel.Thefinerthe gelthemoreistheshrinkage.

c. AutogeneousShrinkage:

Autogeneous shrinkage, also known as "basic shrinkage," is the shrinkage due to chemical reactionsbetween cement with water, known as hydration, and do not include environmental effects such astemperature and moisture changes. Its magnitude is usually ignored in concretes with w/c more than0.40.

In a conservative system i.e. where no moisture movement to or from the paste is permitted, whentemperature is constant some shrinkage may occur. The shrinkage of such a conservative system isknown as autogeneous shrinkage. Autogeneous shrinkage is of minor importance and is not applicableinpractice tomanysituationsexceptthatofmassofconcrete intheinteriorofa concrete dam.

d. CarbonationShrinkage:

Carbon dioxide presentin the atmosphere reactsin the presence of water withhydrated cement.Calciumhydroxide[$Ca(OH)^2$] getsconvertedtocalciumcarbonateandalsosomeothercementcompounds are decomposed. Such a complete decomposition of calcium compound in hydrated cementis chemically possible even at the low pressure of carbon dioxide in normal atmosphere. Carbonationpenetrates beyond the exposed surface of concrete very slowly. The rate of penetration of carbondioxide depends also on the moisture content of the concrete and the relative humidity of the ambientmedium.Carbonation isaccompaniedbyan increaseinweight oftheconcrete and byshrinkage.

Carbonation shrinkage is probably caused by the dissolution of crystals of calcium hydroxide anddeposition of calcium carbonate in its place. As the new product is less in volume than the productreplaced, shrinkage takes place. Carbonation of concrete also results in increased strength and reducedpermeability, possibly because water released by carbonation promotes the process of hydration andalso calcium carbonate reduces the voids within the cement paste.As the magnitude of carbonationshrinkage is very small when compared to long term drying shrinkage, this aspect is not of muchsignificance

MODULE IV

MIXDESIGN

Thevariousfactorsaffectingthechoiceofconcretemixdesignare:

1.Compressivestrengthofconcrete

- Concretecompressivestrengthconsideredasthemostimportantconcreteproperty.Itinfluencesmanyotherdescribablepropertiesofthehardenedconcrete.
- Themeancompressivestrength(fcm)requiredataspecificage,usually28days,determines thenominal water-cementratioofthemix.
- ISO 456-200, British Standard, and Eurocode utilize the term mean compressivestrength which is slightly greater than characteristic compressive strength.However,ACI Codedonotusesuchterm.

Other factorswhichinfluences theconcretecompressivestrengthatgiventimeandcuredataspecifiedtemperatureiscompactiondegree.

- Concretecompressivestrengthisinverselyproportionaltothewater-cementratio.

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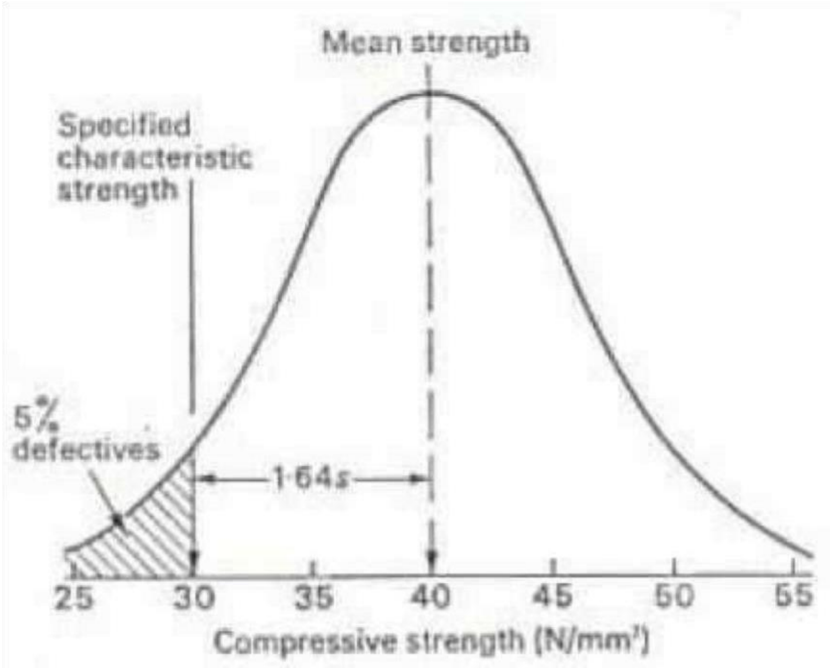

Fig.1:Means compressivestrengthvs characteristiccompressivestrength


Fig.2:compressivestrengthof concrete

2. Workabilityofconcrete

- Concreteworkabilityforsatisfactoryplacementandcompactiondependsonthesizeand shapeof the section to be concreted, the amount and spacing of reinforcement,andconcretetransportation; placement;andcompaction technique. Additionally, use highworkability concrete for the narrow and complicated sectionwithnumerouscornersorinaccessibleparts.Thiswillensuretheachievementoffullcompactionwithareasonableamountofeffort.

- Slumptestvaluesusedtoevaluateconcreteworkability.
- Slumptestvaluesforvariousreinforcedconcretesectionsrangesfrom25mmto175mm.

3. Durabilityofconcrete

- The ability of concrete to withstand harmful environmentconditions termed asconcrete durability.
- High strengthconcreteisgenerallymoredurablethanlowstrengthconcrete.
- In the situations when the high strength is not necessary but the conditions ofexposure are such that high durability is vital, the durability requirement willdeterminetheutilizedwater-cementratio.
- Concretedurabilitydecreaseswiththeincreaseofw/cratio.

4. Maximumnominalsizeofaggregate

- Reinforcementspacingcontrolsmaximumaggregatesize.
- Aggregatesizeis inverselyproportionaltocementrequirementforwatercementratio.Thisisbecausework abilityisdirectlyproportionaltosizeofaggregate
- However, the compressive strength tends to increase with the decrease in size ofaggregate. Smaller aggregate size offers greater surface area for bonding with mortarmixthatgiveshigherstrength.
- IS456:2000andIS1343:1980recommendsthatthenominalsizeoftheaggregateshouldbeas largeaspossible.
- Finally,inaccordancewithACIcode,maximumaggregatesizeshallnotexceedminimumrei nforcement spacing,bar diameter,or25mm.

Fig.3:Maximumaggregatesize

5. Gradingandtypeofaggregate

- Aggregategradinginfluencesthemixproportionsforaspecifiedworkabilityandwatercementratio.
  Therelativeproportionsbetweencoarseandfineaggregateinconcretemixinfluenceconcret e strength.
- Wellgradedfineandcoarseaggregateproduceadenseconcretebecauseoftheachievement ofultimatepackingdensity.
- Ifavailableaggregate,whichobtainedfromnaturalsource,doesnotconfirmtothespecifiedgrading,theproportioningoftwoormoreaggregatebecomeessential.
- Additionally, for specific workability and water to cement ratio, type of aggregateaffectsaggregatetocementratio.
- Lastly,Animportantfeatureofasatisfactoryaggregateistheuniformityofthegradingthatachievedbymixingdifferentsizefractions.

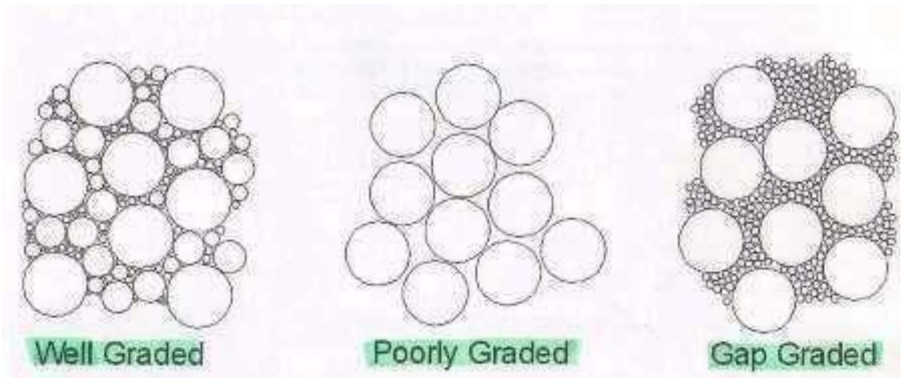

Fig.7:aggregategradingtypes

6. QualityControlatsite

- Thedegreeof controlcouldbeevaluatedbythevariationsintestresults.
- The variation in strength results from the variations in the properties of the mixingredients,inadditiontolackofcontrolofaccuracyinbatching,mixing,placing,curingandtesting.
- Finally, the lower the difference between the mean and minimum strengths of themixlowerwillbethecementcontentrequired.Thefactorcontrollingthisdifferenceistermedas qualitycontrol.

ACCEPTANCECRITERIAFORDESIGN MIXCONCRETE

Theconcreteshallbedeemedtocomplywiththestrengthrequirementsif:

a) Everysamplehasateststrengthnotlessthanthecharacteristicvalue;or

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b) Thestrengthofoneormoresamplesthoughlessthanthecharacteristicvalue,isineachcasenotless thanthegreaterof:

1) Thecharacteristicstrengthminus1.35timesthestandarddeviation;and
2) 0.80timesthecharacteristicstrength ; andtheaveragestrengthofallthesamplesis notlessthanthecharacteristicstrengthplus

$$\left[1.65 - \frac{1.65}{\sqrt{\text{No. of samples}}}\right]$$

timesthestandarddeviation.

II.Theconcreteshallbedeemednottocomplywiththestrengthrequirementsif:

a)Thestrengthofanysampleis less thanthegreaterof:

1) thecharacteristicstrength mix is1.35timesthestandard deviation;and

2) 0.80timesthecharacteristicstrength ;or

b)Theaveragestrengthofallsamplesislessthanthecharacteristicstrength

plus

$$\left[1.65 - \frac{3}{\sqrt{\text{No. of samples}}}\right]$$

timesthestandarddeviation.

IIIConcretewhichdoesnotmeet

thestrengthrequirementsasspecifiedinI,buthasastrengthgreaterthanthatrequiredbyIImay,atthediscretionof

thedesigner,be

acceptedasbeingstructurallyadequatewithoutfurthertesting.

IV. Concreteofeachgradeshallbeassessed separately.

VConcreteshallbeassesseddailyfor compliance.

VI. Concrete is liable to be rejected if it is porous or honey-combed; its placing has been interruptedwithoutprovidinga properconstructionjoint;thereinforcementhasbeen

$$f_{ck} + \left\{1.65 - \frac{1.65}{\eta}\right\} \times s$$

displacedbeyondthetolerancesspecified;orconstructiontoleranceshavenotbeenmet. However,thehardenedconcrete maybeacceptedaftercarryingoutsuitable remedial

measurestothesatisfaction.

VIII.Wherethevalue ofthe averagestrengthofthe tests(preferably30 testsor15tests)islessthan

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shallberejected.

CONCRETEMIXPROPERTIONING:-

Determinationoftheproportionoftheconcreteingredientssuchascement,fineaggregate,coarseaggregate, water and admixtures is called concrete mix. • A proper mix design only can gives thespecified propertiessuchasworkability,strength,permeabilityand durabilitywitheconomy.

MethodsofProportioning Concrete

- ArbitraryMethodofProportioning Concrete.
- FinenessModulusMethod ofProportioningConcrete.
- MinimumVoidMethod.
- MaximumDensityMethod:
- Water – CementRatioMethodofProportioningConcrete.

ARBITRARYMETHODOFPROPORTIONINGCONCRETE:-

Thegeneralexpressionforthepropertionsofcement,sandandcoarseaggregarein1:n:2nby volume.

- 1:1:2and1:1.2::2.4forveryhighstrength
- 1:1.5:3and1:2:4fornormalworks
- 1:3:6and1:4:8forfoundationsandmassconcreteworks.

Recommendedmixesofconcrete: TheconcreteasperIS 456:2000,thegrades ofconcretelowerthanM20arenottobeusedinRCCwork.

M10	1:3:6
M15	1:2:4
M20	1:1.5:3
M25	1:1:2

FinenessModulusMethodofProportioningConcrete:-

The term fineness modulus is used to indicate an index number which is roughlyproportionaltotheaveragesizeoftheparticleintheentirequantityof aggregates.

The fineness modulus is obtained by adding the percentage of weight of the materialretainedonthefollowingsieveanddividedby100.

Thecoarsertheaggregates,thehigherthefinenessmodulus. Sieveisadoptedfor:

Allaggregates:80mm,40mm,20mm,10mm,andNos.480,240,120,60,30and15.

Coarseaggregates:mm,40mm,20mm,10mm,andNo.480.

Fineaggregates:Nos.480,240,120,60,30and15.

Proportionofthefineaggregatetothecombinedaggregatebyweight

$$R = \frac{P_2 - P}{P - P_1} \times 100$$

Where,P = desiredfinenessmodulusforaconcretemixoffineandcoarseaggregates.

P_1 = finenessmodulus offineaggregate

P_2 = finenessmodulusofcoarseaggregate.

MinimumVoidMethod:-

Itdoesnotgivesatisfactoryresult.

The quantity of sand used should be such that it completely fills the voids of coarseaggregate. Similarly, the quantity of cement used shown such that it fills thevoids of sand,sothatadensemixtheminimumvoidsis obtained.

In actual practice, the quantity of fine aggregate used in the mix is about 10% more than thevoids in the coarse aggregate and the quantity of cement is kept as about 15% more than thevoidsinthefineaggregate.

MaximumDensityMethod:This methodisnot veryPopular.

Itisdeterminedbytheformulaas $P = 100\left(\frac{d}{D}\right)^{1/2}$

Where,D = maximumsizeofaggregate(i.e.coarseaggregate)

P =percentageofmaterialfinerthandiameterd(byweight)d = maximumsizeoffineaggregate.

Aboxisfilledwithvaryingproportionsoffineandcoarseaggregates.Theproportionwhichgivesheaviestweightisthenadopted.

Water – CementRatioMethodofProportioningConcrete:-

According to the water – cement ratio lawgiven by Abram as a result of many experiments,thestrengthofwellcompactedconcretewith good workabilityisdependentonlyontheratio.

- The lowerwatercontentproducesstiffpaste having greaterbinding property andhence the lowering the water-cement ratio within certain limits results in theincreased strength.
- Similarly, the higherwatercontentincreasesthe workability, butlowerthe strengthof concrete.
- Theoptimumwatercementratiofortheconcreteofrequiredcompressivestrengthisdecidedfrom graphs andexpressionsdevelopedfrom variousexperiments.
- Amountofwaterlessthantheoptimumwaterdecreasesthestrengthandabout10%less may be insufficient to ensure complete setting of cement. An increase of 10%above the optimum may decrease the strength approximately by 15% while anincreasein50%maydecreasethestrengthtoone-half.
- According toAbram'sLawwater-cementlaw, lesser thewater-cementratio in aworkablemixgreaterwillbethestrength.
- Ifwatercementratioislessthan0.4to0.5,completehydrationwillnotbesecured. Somepractical values ofwater cementratiofor structurereinforcedconcrete

- 0.45for 1:1:2concrete
- 0.5for 1:1.5:3concrete
- 0.5to0.6for 1:2:4concrete.

Concretevibratedbyefficientmechanicalvibratorsrequirelesswatercementratio,andhencehave morestrength.

ThumbRules for decidingthequantityofwaterinconcrete:

(i) Weightofwater = 28%oftheweightofcement + 4%oftheweightof totalaggregate

(ii) (ii)Weightofwater = 30%oftheweightofcement + 5%oftheweightoftotalaggregate.

BIS METHODOFMIXDESIGN:-

The process of selecting suitable ingredients of concrete and determining their relativeamountswiththeobjectiveofproducingaconcreteoftherequired,strength, durability,andworkabilityas economicallyas possible,istermedtheconcretemixdesign. Procedurefor concretemixdesignrequires followingstepbystepprocess:

1. Calculationoftargetstrengthofconcrete
2. Selectionof water-cementratio
3. Determinationofaggregateaircontent

4. Selectionofwatercontent forconcrete
5. Selectionofcement content forconcrete
6. Calculationofaggregateratio
7. Calculationof aggregatecontentforconcrete
8. Trialmixesfortestingconcretemixdesignstrength

Step1:CalculationofTargetStrengthofConcrete:-

Targetstrengthisdenotedby$f_t$whichis obtainedbycharacteristiccompressivestrengthofconcreteat28days (f_{ck}) andvalue ofstandarddeviation (s)

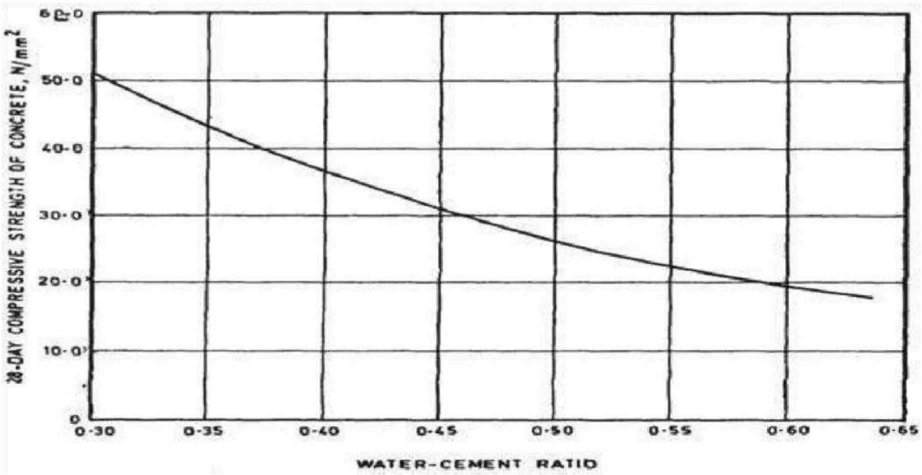
$$f_t = f_{ck} + 1.65s$$

Standarddeviationcanbetakenfrombelowtable

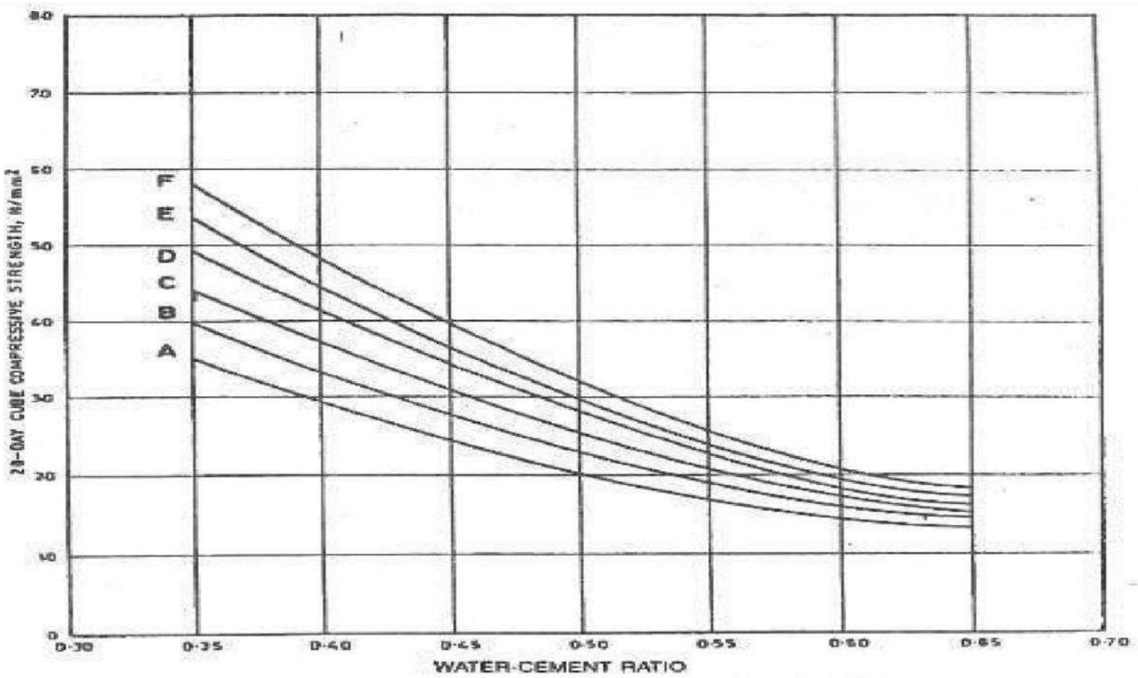
Gradeofconcrete	Standarddeviation(N/mm^2)
M10	3.5
M15	3.5
M20	4.0
M25	4.0
M30	5.0
M35	5.0
M40	5.0
M45	5.0
M50	5.0

Step2:Selectionof Water-CementRatio:-

Ratio of the weight of water to weight of cement in the concrete mix is water-cement ratio.Itistheimportant considerationinconcretemixdesigntomaketheconcreteworkable.Watercementratioisselectedfr omthebelowcurvefor28dayscharacteristiccompressivestrengthofconcrete.



Similarly,wecan determinethewater-cementrationfromthe7-dayconcretestrength,thecurves are divided on the basis of strength from water cement ratio is decided. Which isobservedfromthebelowgraph.



7 - Day Strength of Cement, Tested According to IS : 4031-1968
A = 21.6 - 25.0 N/mm²
B = 25.0 - 29.8 N/mm²
C = 29.8 - 35.0 N/mm²
D = 35.0 - 41.5 N/mm²
E = 41.5 - 48.0 N/mm²
F = 48.0 - 53.4 N/mm²

Step3:DeterminationofAggregateAircontent:-

Nominalmaximumsizeofaggregate	Aircontent (% ofvolume ofconcrete)

10mm	5%
20mm	2%
40mm	1%

Air content in the concrete mix is determined by the nominal maximum size of aggregateused.Belowtable willgivetheentrappedaircontentinpercentageofvolumeofconcrete.

Step 4:SelectionofWaterContentforConcrete:-

Selectthe watercontentwhich isusefulto getrequired workabilitywith thehelpofnominalmaximum size of aggregate as given in below table. The table given below is used whenonly angular shaped aggregates are used in concrete as well as the slump should be 25 to50mm.

Nominalmaximumsizeofaggregate	Maximumwatercontent
10mm	208
20mm	186
40mm	165

Iftheshapeofaggregateorslumpvalueisdifferingfromabove,thensomeadjustmentsarerequiredas follows.

MODULEV
SPECIALCONCRETE

LIGHTWEIGHTCONCRETE:-

Lightweightconcretecanbedefinedasatypeofconcretewhichincludesanexpandingagentinthatitincreases the volume of the mixture while giving additional qualities such as liability and lessened thedeadweight.Itislighterthantheconventionalconcrete

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The material unit cost of lightweight concrete is typically higher than that of normal-weight concrete,but the unit cost usually is more than offset by the overall reduction in concrete volume and steeltonnageforthestructuralsystem.

Thebenefitsofusinglightweightaggregateconcreteinclude:

- • Reductionindeadloadsmakingsavingsinfoundationsandreinforcement.
- • Improvedthermalproperties.
- • Improved fireresistance.
- • Savings intransportingandhandlingprecastunitsonsite.
- • Reductioninformworkandpropping.

Disadvantages:-

- • Itisverysensitivewithwater contentinthemixture.
- • It isdifficulttoplaceandfinis becauseoftheporosityandangularityoftheaggregate.
- • Mixingtimeislongerthanconventionalconcretetoassurepropermixing.

Lightweightaggregateconcrete:-

Light weight aggregate is a type of coarse aggregate that is used in the production of lightweightconcreteproductssuchasconcreteblock,structuralconcrete, andpavement.Theexpandedmaterialhas properties similar to natural aggregate, but is less dense and therefore yields a lighter concreteproduct.

Foam concrete, also known as Lightweight Cellular Concrete (LCC) or Low Density Cellular Concrete(LDCC) is defined as a cement-based slurry, with a minimum of 20% (per volume) foam entrained intothe plasticmortar.

The concrete has a minimum 28-day compressive strength of 2500 psi (17 M Pa), an equilibriumdensitybetween70and 120lb/ft³ (1120 and1920kg/m³),and consistsentirelyoflightweightaggregateoracombinationoflightweightandnormal-densityaggregate.

CELLULAR CONCRETE:- Cellular concrete is a lightweight cement-based material, containingmanygasbubblesevenlydistributedinthevolume,producedbyblending andmaturingofamixtureofcement, filler, water, agent generating cells. By the method ofgenerating the air or gas cells there existfoamconcreteandgas concrete.

cellularconcrete is used in building and construction applications such as roof decks and floor decks,and geotechnical applications such as annular space filling in slip lining and void fill abandonment.Cellular concrete can also be found in architectural and precast applications. cellular concrete is used inbuildingandconstructionapplicationssuchasroof decksandfloordecks,andgeotechnicalapplicationssuchasannularspacefillinginslipliningandvoidfillabando

nment. Cellularconcretecanalsobefoundinarchitecturalandprecastapplications.
MaterialUsedinCellularConcrete:-
Thematerialsusedincellularconcrete whichreducethedensityofconcreteare :
1. Cement
Cellularlightweightconcreteisahomogeneouscombinationof Portlandcement,cementsilica,cementp ozzolana, lime-pozzolana; lime-silica pastes having identical cell structure obtained using gas-formingchemicalsoffoamingagents atmeasuredlevels. 2. FlyAsh
Asflyashisaby-productanditsdisposalisveryexpensive.Itisusedinthepreparationofcellularlight-weight concrete. It is one of the key ingredients which resolve the issue of disposal and at thesametime,it'sveryeconomicalmakingitenvironmentallyfriendly.
3. Foam
Themainconstituentoftherawmaterialoffoamthatisusedintheproductionofcellularconcreteis Genfiland its organic substance. The size of the bubbles differs from around 0.1 to 1.5 mm indiameter.Thefoamgeneratorisemployed to produce stablefoambyusinganappropriate agent.ReferenceCodesonCellular Concrete

1. ASTM C 869 – "Standard Specification for Foaming Agents Used in Making Preformed FoamforCellularConcrete"
2. ASTMC796 – "StandardTestMethodforFoamingAgentsforuseinProducingCellularConcreteusingPreformedFoam"
3. ASTM C 495 – "Standard Test Method for Compressive Strength of Lightweight Insulating

Concrete"
TypesofCellularConcretebased onDensity Cellular concreteisdifferentiatedinto3typesbasedontherangeofdensity,whichisproducedfordifferentpurpose.
1. HighDensityCellularConcrete
This is a structural grade concrete having the density ranging from 1200kg/m3 to 1800 kg/m3. It isused in the construction of load-bearing walls, partition walls and in the production of pre-cast blocksforload-bearingbrickwork.
2. MediumDensityCellularConcrete
Thedensityrangeofthiscellularconcreteis800-1000 kg/m3.Themajoruseofthistypeofcellularconcreteisfoundinthemanufacturing pre-castblocksfornonloadbearingbrickwork.
3. LightDensityCellularConcrete
Light density cellular concrete has a density in the range of 400 –600 kg/m3. LDCC is ideal for thermalandsoundinsulations.Theyactasaresistanceagainstfireaccidents,termiteandmoistureabsorbent. Theyhavealsoprovedtobeabettersubstitutethanglasswool,woodwooland thermocol.**AdvantagesofCellularConcrete:**
1. Lightweight
Thelowweightpropertyofcellular concretehasagreatadvantageonbuildingdeadloadsandcraningworks.
2. FireResistance
Theair pocketsformedactsasabarrierfor fire.Thestructuremadeofcellular concreteisnon-combustible andcanendurefirebreakoutforhours.
3. ThermalInsulation
Cellularconcreteactsaperfectthermalinsulator.
4. AcousticalInsulation
Thelowdensityincreasesacousticalinsulation.
5. EnvironmentalFriendly
Fly-ashbasedcellularlightweightconcreteissuitableforsurroundingbecausefly-ashisoneoftheby-productsofindustrialwaste.6.Cost-Efficient

Costofthematerialusedisconcreteisreducedasthefoamisintroduced intotheconcrete.Secondly,the use of industrial waste such as fly-ash saves a considerable amount of investment on cementproducts.
7.Other Advantages
Cellularlight-weightconcreteisalsotermite-proofandresistanttowardsfreezing issues.

NON-FINESCONCRETE:-

HIGHDENSITYCONCRETE:-

Highdensityconcreteisa concretehavingadensityin therange of6000to6400kg/cum.

High density concrete is also known as Heavy weight concrete. High density concrete is mainly usedfor the purpose of radiation shielding,forcounterweights and otheruses where high density isrequired.

The high density concrete has a better shielding property, so that it can protect harmful radiations likeXrays,gammarays,andneutrons.

High density aggregatesare used toachieveheavy weightconcrete.Some of thehigh densityaggregatesarebarite,ferrophosphorus,limonite,hematite,limonite,magnetite,goethite,steelpunching, and steel shots. The point to rememberis thatin order to achieve this type of concrete,highfixedwatercontentisrequired.

The selection ofthe abovementionedaggregatesmainly depend upon the physical propertieslikebulkdensity,specificgravity,availabilityofmaterials,anditsexpenses.Inordertoachievework ability, high density the aggregates should be free from dirt, oil or grease stains and other foreignmatter. Or else, it will retard the hydration process and the effective bonding of particles. Some of theboron additions like colemanite, borocalcite are used in the preparation of concrete to improve theshielding properties. These additions may affect the setting time of concrete so, trial mixes should bemade andtesteddependinguponthesuitability.

FIBRE REINFORCEDCONCRETE:-

FibreReinforced Concrete can be defined as a composite material consisting of mixtures of cement,mortarorconcreteanddiscontinuous,discrete,uniformlydispersed suitablefibres.

Fibre is a small piece of reinforcing material possessing certain characteristics properties. They can becircular or flat. The fibreis often described by a convenientparameter called “aspectratio”. Theaspect ratio of the fibre is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to150.

Fibre-reinforcement is mainly used in shotcrete, but can also be used in normal concrete. Fibre-reinforced normal concrete are mostly used for on-ground floors and pavements, but can beconsideredforawiderangeofconstructionparts(beams, pliers, foundationsetc)eitheraloneorwithhandtiedrebars.

NECESSITYOFFIBERREINFORCEDCONCRETE:-

- Itincreasesthe tensile strengthoftheconcrete.
- Itreducestheairvoidsandwatervoidstheinherentporosityofgel.
- Itincreases thedurabilityoftheconcrete.
- Fibressuch as graphite and glass have excellent resistance to creep, while the same is not trueformostresins.Therefore,theorientationand volumeoffibreshaveasignificantinfluenceonthe creepperformanceofrebars/tendons.
- Reinforced concrete itself is a composite material, where the reinforcement acts as thestrengthening fibreandtheconcreteasthematrix.Itisthereforeimperativethatthebehaviourunder thermal stresses for the two materials be similar so that the differential deformations ofconcrete andthe reinforcementareminimized.
- It has been recognized that the addition of small, closely spaced and uniformly dispersedfibres to concrete would act as crack arrester and would substantially improve its staticanddynamicproperties.

Polymerconcretes

Polymer concretes are a type of concrete that use polymers to replace lime-type cements as a binder.In some cases the polymer is used in addition to Portland cement to form Polymer Cement Concrete (PCC)orPolymerModifiedConcrete (PMC).

COMPOSITION:-

In polymer concrete, thermoplastic polymers are used, but more typically thermosetting resins areusedastheprincipalpolymercomponentdueto theirhighthermalstabilityand resistanceto awidevarietyofchemicals.Polymerconcreteis alsocomposed of aggregates that include silica, quartz, granite, limestone, and other high quality material. Theaggregate must be of good quality, free of dust and other debris, and dry. Failure to fulfil these criteriacanreducethebondstrengthbetweenthe polymerbinderandthe aggregate.**USES:-**

- Polymer concrete may be used for new construction or repairing of old concrete. Theadhesiveproperties of polymer concrete allow repair of both polymer and conventional cementbasedconcretes.
- The corrosion resistance and low permeability of polymer concrete allows it to be used inswimming pools, sewer structure applications, drainage channels, electrolytic cells for basemetalrecovery,andotherstructuresthatcontainliquidsorcorrosivechemicals.
- It is especially suited to the construction and rehabilitation of manholes due to their ability towithstand toxic and corrosive sewer gases and bacteria commonly found in sewer systems.Unlike traditional concrete structures, polymer concrete requires no coating or welding ofPVCprotectedseams.

PROPERTIES:-

Theexactpropertiesdependonthemixture,polymer,aggregateusedetc.etc.butgenerallyspeakingwithmixturesused:

Thebinderismoreexpensivethancement

SignificantlygreatertensilestrengththanunreinforcedPortlandconcrete(sinceplastic is'stickier'thancement andhasreasonabletensilestrength)

SimilarorgreatercompressivestrengthtoPortlandconcrete

Much fastercuring

Good adhesion to most surfaces, including to reinforcements Goodlong-termdurabilitywithrespecttofreezeandthawcycles

Low permeabilityto waterand aggressivesolutions Goodchemicalresistance

Goodresistanceagainstcorrosion

Lighter weight (slightly less dense than traditional concrete, depending on the resincontent ofthemix)

Maybevibratedtofillvoidsinforms

Allowsuseofregular form-releaseagents(insomeapplications)

Dielectric

Product hard to manipulate with conventional tools suchas drills and presses due to itsdensity.Recommendgettingpre-modifiedproductfromthemanufacturer

Smallboxesaremorecostlywhencomparedtoitsprecastcounterparthoweverprecastconcretes inductionofstackingorsteelcoversquicklybridgethegap.

Polymers are added to the concrete mixes either in the form of an aqueous emulsion or in a dispersedform.Thisistoimprove thefollowingproperties ofconcrete:

1. Theextensibilityand thetensilestrengthoftheconcretestructure
2. Theimpactresistance
3. TheAbrasionresistance
4. Thedurabilityandtheresistancetotheaggressivefluids
5. Thebondbetweentheoldand thenewconcrete

The polymer modified cement concrete is a composite that is obtained by the incorporation of apolymeric material into the concrete. This is carried out during the mixing stage. The polymers thatareincorporatedatthisstageshouldinnowayinterfere withthe hydrationprocess.

TypesofPolymerModifiedConcrete(PMC)

Basedonthetypeofthemodifierused, polymermodifiedconcretecanbeclassifiedintothefollowingtypes:

1. Latex-ModifiedCementConcrete
2. Pre-PolymerModifiedCementConcrete

Latex-ModifiedCementConcrete

Thelatticesarewhitemilklikesuspensionsthatconsistofverysmallsizedpolymerparticles,thataresuspended in water with the help of emulsifiers and stabilizing agents. It contains about 50% ofpolymersolidbymass.

Both elastomeric and glassy polymers have been employed in the lattices for modifying cementconcrete.Theseimparthighmodulusofelasticity,higherstrengthandlowrateofcorrosionofthere inforcement.

Thelatexadmixturescanbestoredinanadequateexposurethathelpsthemixturetobeprotectedagainstthefree zingandtemperatureexposures.

Ifthemixturestoreddrumisexposedtosunlight,ithastobeproperlycoveredwithasuitableinsulatingblanket.T heenclosed temperaturetobemaintainedmustbelessthan85F.

Thenaturalrubberlatex,acrylonitrile-butadiene,neopreneandrubberlatexaresomeofthecommonly used elastomeric latex. The glass polymers have a greater modulus of elasticity, strengthandtheyundergoabrittle typeoffailure.

The common examples of the same are polyvinylidene chloride, acrylic polymers, polyvinyl acetateand styrene butadiene copolymer latex. The polyvinylidene copolymer is used in unreinforcedconcrete applications due to the presence of residual chlorine that causes the corrosion ofreinforcement.

Moist curing of composite for a period of one to seven days forms the optimum curing temperature.This is later followed by a dry curing. At the 28 days of curing, the latex modified concrete wouldhave gaineditsfinalstrength.

Prepolymers-ModifiedCementConcrete

The polyester -styrene based system, epoxy system and the furan system etc. are used for this. Thestrengthimprovementofthis type ofPMCisoftheorderof50-100%overthe conventionalconcrete.

Its adhesion property is good and has the improved durability properties. The tensile strength and themodulus of rupture are more than twice those of the conventional concrete. The formation of themicro-crackingislessinthe case ofpre-polymer-modifiedcementconcrete.

There is lower water cement ratio and the filling of pores within the pre polymer modified concretewhichwill helpinimproving thedurabilityoftheconcretecompared withtheconventionalconcrete.Butthecostofthepolymerisnotaccountedinthestrengthgainofthepolymerm odified concrete.

PropertiesofPolymerModifiedConcrete

ThepropertiesofPolymermodifiedconcreteareexplainedbelow:

- The addition of polymers makes the concrete mix to become more workable. This can hencereduce theamountofwaterthatisaddedtothe concretemix.
- Thecrushingstrengthoftheconcreteisincreasedusingthepolymerinconcrete.This isbecause the polymer reduces the water cement ratio which in turn increase the crushingstrength.
- Thebondbetweentheaggregateandthematrixisimproved.
- Thepolymermodificationincreasestheflexuralstrengthoftheconcrete.
- The polymer modified concrete consist of at least 3 % more amount of entrained air than theplain concrete. This additional amount of entrained air will reduce the modulus of elasticity ofthe concrete(PMC).
- Thepolymer additionincreasesthesettingtimeofconcrete.
- Theresistanceoftheconcreteagainstabrasion isincreasedusingthepolymer.
- Freezingandthawingresistanceoftheconcretestructureisimprovedbypolymermodification.
- Thepenetrationofchlorineionsandotherdeleteriousmaterialsisrestricted.ThePMCgainhigherr esistance againstsuchundesirableeffects.
- ThePMCgainssuperiorshearbondstrength.
- Theductilitypropertyofthepolymermodifiedconcreteismorecomparedwiththeconventionalco ncrete.
- Thesegainasuperiortensileandflexuralstrengthcomparedtotheconventionalconcrete.

ApplicationsofPolymerModifiedConcrete:-

- Thepolymermodifiedconcretecanbeusedintherepairandtherehabilitationofolddamagedconcr ete.
- Thefloorconstructioninfrozen – foodfactoriesgainsgreatapplication.Thisisbecause ofthehigherfreezeandthaw resistanceofPMCs.
- For floor construction of factories were chances of the splitting of chemicals andoilsmore pronetohappen.
- Forthepreparationofsteelbridgeand shipdecks surfaces.
- Fortheconcretestructurethatismoresubjectedto largedosesofde-icingsalts.

HIGHPERFORMANCECONCRETE:-

- Highperformanceconcreteisaconcretemixture,whichpossesshighdurabilityandhighstrength whencomparedtoconventionalconcrete.
- Thisconcretecontainsoneormoreofcementiousmaterialssuchasflyash,Silicafumeorground granulatedblastfurnace slagandusuallya superplasticizer.
- Theterm'highperformance'issomewhatpretentiousbecausetheessentialfeatureofthisconcrete isthatit'singredientsand proportionsarespecificallychosensoasto

have particularly appropriate properties for the expected use of the structure such as highstrengthandlowpermeability.

- Hence High performance concrete is not a special type of concrete. It comprises of the samematerials as thatof theconventional cementconcrete. Theuseofsomemineral andchemical admixtures like Silicafume and Super plasticizer enhance the strength, durabilityandworkabilityqualities toa veryhighextent.

- High Performance concrete works out to be economical, even though it's initial cost is higherthanthatofconventionalconcretebecausetheuseofHighPerformanceconcreteinconstruc tion enhances the service life of the structure and the structure suffers less damagewhichwouldreduceoverallcosts.
- Concreteisadurableandversatileconstructionmaterial.Itisnotonly
- Strong, economical and takes the shape of the form in which it is placed, butit is alsoaestheticallysatisfying.Howeverexperiencehasshownthatconcreteisvulnerabletodeterior ation, unless precautionary measures are taken during the design and production. Forthis we need to understand the influence of components on the behaviour of concrete and toproduce aconcretemixwithincloselycontrolledtolerances

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TheconventionalPortlandcementconcreteis founddeficientinrespectof:

- Durabilityinsevereenvirons(shorterservice lifeandfrequentmaintenance)
- Timeofconstruction(slowergainofstrength)
- Energyabsorptioncapacity(forearthquakeresistantstructures)▪Repairandretrofittingjobs.

Hence it has been increasingly realized that besides strength, there are other equally important criteriasuch as durability, workability and toughness. And hence we talk about 'High performance concrete'where performance requirements can be different than high strength and can vary from application toapplication.

SELFCOMPACTING CONCRETE(SCC):-

Selfcompactingconcrete(SCC)canbedefinedasfreshconcretethatflowsunderitsownweightanddoes not require external vibration to undergo compaction. It is used in the construction where it ishardtousevibratorsforconsolidationofconcrete.

MaterialsUsedforSelfCompactingConcrete

Themainingredientsusedindesignofselfcompactingconcreteare:

1. Cement

OrdinaryPortlandcementeither43or53gradecementcanbeused.

2. Aggregates

Thesizeoftheaggregatesusedfor SCCdesignis limitedto20mm. Ifthereinforcementemployedforthe structure is congested, the aggregate size used can be in the range 10 to 12mm. Well gradedaggregateseitherroundorcubicalshapeare abestchoice.

The fine aggregates used in SCC can be either natural aggregates or manufactured aggregates (M- Sand) with a uniform grade. The fine aggregates with particle size less than 0.125mm are generallyemployed.

3.Water

Thequalityofwaterusedissamethatfollowedforreinforcedconcreteandprestressedconcreteconstruction.

4.MineralAdmixtures

Themineraladmixturesusedcanvarybasedonthemixdesignandpropertiesrequired. Mentionedbelow are the different mineral admixtures that can be used and their respective properties theyprovide.

Ground Granulated Blast Furnace Slag (GGBS): The use ofGGBS helps to improvetherheologicalproperties ofthe selfcompacting concrete.

Flyash: Thefineflyashparticleshelptoimprovethefillingoftheinternalconcretematrixwithfewerpores.This improves the qualityanddurabilityoftheSCC structures.

SilicaFumes: Theuseofsilicafumeshelpstoincreasethemechanicalpropertiesoftheselfcompactingconcret estructure.

StonePowder: Theuseofstonepowder inSCCisusedto improvethepowdercontentofthemix.**5.ChemicalAdmixtures**

Newgenerationsuper plasticizersarecommonlyusedinSCCmixdesign. Inordertoimprovethefreeze and thaw resistance of the concrete structure, air entraining agents are used. To control thesettingtime,retarders areemployed.

TestsandPropertiesofSelfCompactingConcrete

Therequirementsoftheselfcompacting concreteareachievedbythepropertiesin itsfreshstate.Thethree mainproperties ofSCC are:

FillingAbilityTests	PassingAbilityTests	SegregationResistanceTests
Slumpflowtest	L-BoxTest	V- funneltestat T5minutes
T50cm Slump Flow	J- ring test	GTM screen stability Tests
Orimet	U- BoxTest	
V-funnelTest	Fill – BoxTest	

1. **FillingAbility:**Thispropertyoftheconcreteistheabilitytoflowunderitsownweightwithoutanyvibra tionprovidedintentionally.
2. **PassingAbility:**Thispropertyistheabilityof theconcretetomaintainitshomogeneity.
3. **Segregationresistance:**This istheresistanceoftheconcretenottoundergosegregationwhenitflowsduringtheselfcompactionproc ess.

Different tests are conducted to determine the above mentioned properties of Self compactingconcrete.ThetestsconductedforSelfcompactingconcretecanbecategorizedintothreecategorie s:

1. FillingAbilityTests
2. PassingAbilityTests
3. SegregationResistanceTest

AdvantagesofSelfCompactingConcrete

Themain advantagesofselfcompacting concreteare:

1. Thepermeabilityoftheconcretestructureisdecreased
2. SCCenablesfreedomindesigningconcretestructures
3. TheSCCconstruction is faster
4. Theproblemsassociatedwithvibrationiseliminated
5. Theconcreteisplacedwithease,whichresultsinlargecostsaving
6. Thequalityoftheconstructionisincrease
7. The durability and reliability of the concrete structure is high compared to normal concretestructures
8. Noisefromvibrationisreduced. Thisalsoreducethehandarmvibrationsyndromeissues

DisadvantagesofSelf CompactingConcreteSCCconstructionfacethe followinglimitations:

1. There isnogloballyacceptedteststandardtoundergoSCCmixdesign
2. Thecostofconstructioniscostlier thantheconventionalconcreteconstruction3.Theuseofdesignedmixwillrequiremor etrialbatchesandlabtests
4. Themeasurementandmonitoringmustbemoreprecise.
5. The materialselectionforSCCismorestringent

ApplicationsofSelfCompactingConcrete

Themajorapplicationsofselfcompactingconcreteare:

1. Constructionofstructureswithcomplicatedreinforcement
2. SCC isusedforrepairs,restorationandrenewalconstruction

3. Highlystable anddurableretainingwallsareconstructedwiththe helpofSCC
4. SCC isemployedintheconstructionofraftandpilefoundations