Concrete Technology

Unit-I

Cement:- In 1984, Joseph Aspdin, a brick and mason in leeds, England, took out a potent on hydraulic cement that he called it as Portland cement because, its resembled the stone quarried on the Isle of Portland off the British Coast.

Cement is a key ingredient of concrete and the world's most widely used building material

The most common type of cement used in Ordinary Portland cement. It is manufactured by intimately mixing, in definite proportion of Argillaceous and calcareous and other silica, Alumia or Iron oxide, bearing compounds to a partial fusion at a temp of about 1400°c. As a result, a product called clinker is formed, which is cooled and then grounded to requried finess.

Types of cement

1) Ordinary Portland Cement
   (i) 33 Grade
   (ii) 43 Grade
   (iii) 53 Grade

Rapid Hardening Portland Cement

Portland slag cement

Portland Pozzolana Cement

High Alumina Cement
Hydrophobic Cement
Super-sulphate Cement
Sulphate Resisting Portland Cement

Ingredients of Portland Cement

Lime (CaO)	60% - 65%
Silica (SiO_2)	20% - 25%
Alumina (Al_2O_3)	4% - 8%
Iron Oxide (Fe_2O_3)	2% - 4%
Magnesium oxide (MgO)	1% - 3%
Sulphuretric oxide (SO_3)	1% - 2%
Alkalies	0.3% - 1%

Special Cement

1. White Portland Cement
2. Expansive Cement
3. Masonary "

Wet process (Module 1)

- Calcareous material — Argillaceous material

Lime stone → Crusher → Storage basin

Clay → Wash mills → Storage basin

Both storage basins → Wet grinding mill to make slurry

↓

Blending of slurry to correct composition

↓

Storage of corrected slurry

↓

Corrected slurry fed to kiln

↓

Slurry corrected into clinkers

↓

Clinkers are ground in ball mills

↓

Cement silos

↓

Packing plant

procedure:-

→ In wet process also cement is typically made of of material i.e calcareous, argillaceous material in wet process chalk is used it is finely broken up

→ lime stone was crushed in crusher mills into fine powder i.e in wash mills the clay (or) chalk powder is mixed with water. This 2 diff are stored in storage basins

→ Then this 2 mixtures are passed to wet grinding mills to make a paste called slurry.

→ The resultant slurry is a carry consistency liquid with 35-40 water content and small fraction of material about 2% larger than a 90 μ micron sieve size.

→ Blinding of slurry will takes place. In this sedimentation of suspended solids being prevented by budding by compressed air.

→ Temperature maintained in kiln is 1450°c At this temp the fused mass turns into balls of diameter 3 to 20 mm known as clinkers.

→ While cooling 2 to 3% of Gypsum is added is ball mill required fineness

→ Then it is taken into storage silos from when cement is

Q. Define ad-mixture and explain 5 chemical + physical ad-mixtures with effects.

A:— Admixtures:—

Admixtures are material added to the concrete before or during the mixing of concrete to improve the properties of concrete.

<u>Chemical admixtures</u>

This are the chemicals which are in liquid state and added to concrete during mixing

* Air entraining agents
* water reduces
* water- reducing retarders → i) Super plasticizers
  ii) plasticizers.
* Accelerators.

Air entraining agents

Air entraining admixtures cause small stable bubbles of air to form uniformly through a concrete mix..

→ The benefits of entraining air in the concrete include increased resistance to freeze-thaw degrada[tion]

increased cohesion

Affects :

→ flexural strength of concrete

→ It increases the workability of concrete without much increase in water - cement ratio.

water reducing agents :

water reducers are admixtures for concrete which are added in order to reduce the water content in a mixture or to slow the setting rate of the concrete while retaining the flowing properties of a concrete mixtures.

Affects :-

→ lowers the compressive strength of concrete

→ Small influence on the workability of concrete

water reducing retarders :-

water reducers are used for two dif purpose () To lower the water content in plastic concrete and increase its strength and

(ii) To obtain higher slump without adding water.

water - reducers will generally reduce the required water content of concrete mixtures for a gain slump.

- This increase strength and reduce the water content

Effects

→ Initial compressive strength reduces

→ Small influence on the workability to concrete.

→ **Accelerators :**

A cement accelerator is an admixture for the use in concrete, mortar, rendering (or) screeds. The addition of an accelerator speeds the setting time and thus cure time starts earlier. This allows concrete to be placed in winter with reduced risk of frost damage.

Mineral Admixtures

Mineral Admixtures are those admixtures which obtained from industries. Mostly mineral admixtures are residue of some industries and used to replace cement.

→ fly ash

→ blast furnace slag

→ Silica fumes

→ Rice husk ash

fly ash :-

finely divided residue resulting from the combustion of powdered coal and transported by the fuel gases and collected by electrostatic

Effects

→ Reduction of water demand for desired slump

→ with reduction of unit water content, bleeding and drying shrinkage will also be added.

Silica-fumes:

It is a product resulting from reduction of high purity quartz with coal in a electric arc furnace in the manufacture of silicon contains at least 85% SiO_2 content with mean between 0.1 and 0.2 microns.

Effects on fresh concrete:

→ fresh concrete sticky nature and hard to handle.

Effects on hardened concrete:

→ Modulus of elasticity of microsilical concrete is less

→ It causes improvement in durability of cement and resist against frost damage.

Application:

→ conserve cement

→ produce ultra high strength concrete

→ Increase early strength of fly concrete

→ Reduces unit water content

→ Reduction of bleeding

→ Reduce heat of hydration.

Explain the structure of hydration and also hydration process in cement.

Structure of hydration:-

* Anhydrous portland cement is a gray powder that consist of angular particles typically in the size range 1-5µm

* It is produced by pulverizing a clinker with a small amount of calcium the clinker being a heterogenous mixture of several minerals produced by high temperature reaction b/w calcium oxide and silica alumina and iron oxide.

* The chemical composition of the principle clinkers minerals components approximately to C_3S, C_2S, C_3A and C_4AF

Hydration process in cement:

1. Hydration process C_3S:

$$2\,3(CaO \cdot SiO_2) + 6H_2O \longrightarrow 3CaO \cdot 2SiO_2 \cdot 2H_2O + 3Ca(OH)_2$$

(or) (calcium silica hydrate)

Rice Husk Ash:

Rice husk ash is obtained by burning rice husk in a controlled manner. It greatly enhances the workability and impermeability of concrete.

It contains amorphous silica in very high proportion when burnt is controlled manner 5% carbon 2% KO_2

Effects:

→ Reducing micro cracking and impacking freeze - thaw resistance.

→ Decrease the permeability of the system and impervious occure resistance to CO_2 attack improves capillary system.

Blast-furnace Slag:

→ Blasting process takes place comes from steel industries Non metalic product consisting essentially of silica and aluminium of calcium and other base. obtained by quenting molten iron slag from a blast furnace in water to produce glassy product is then dired and ground in a fine powder.

→ ... Generally

Effects:

→ Reduces unit water content

→ Reduction of bleeding

→ Reduce heat of hydration.

3. Explain the structure of hydration and also hydration process in cement.

A:— Structure of hydration:—

* Anhydrous portland cement is a gray powder that consist of angular particles typically in the size range 1-15 μm

* It is produced by pulverizing a clinker with a small amount of calcium the clinker being a heterogenous mixture of several minerals produced by high temperature reaction b/w calcium oxide and silica alumina and iron oxide.

* The chemical composition of the principle clinkers minerals components approximately to C_3S, C_2S, C_3A and C_4AF

Hydration process in cement:

1. Hydration process C_3S:

$$2\,3(CaO \cdot SiO_2) + 6H_2O \longrightarrow 3CaO \cdot 2SiO_2 \cdot 2H_2O + 3Ca(OH)_2$$

(or) (calcium silica hydrate).

$$2C_3S + 6H \longrightarrow C_3S_2H_3 + 3Ca(OH)_2$$

... 72 hours. Generally

→ fast in the beginning but is long term (decades in dams)

→ Causes heat which can be a problem if there two umum

→ Structure development in cement paste

5 process :-

Setting: Solidification of the plastic cement paste.

Initial set: Beginning of solidification - paste become unworkable - loss in consistency - not < 45 minutes

final test:

Time taken to solidify completely - not > 35 minutes

Hardening:

* Strength gain with time - after final test

* high strength.

4. Explain briefly (i) C3A ii) C3S iii) C2S iv) C4AF

A: C3A (Tricalcium aluminate:- ($3CaO\,Al_2O_3$)

Tricalcium aluminate (C3A) is mostly related to heat of hydration. It releases large amount of heat during the first few days of heating which generally results in early age cracking

cement with high content of C3A are not suitable for

* Tri-calcium Silicate hydrates rapidly and forms earlier strength of the concrete.
* C_3S produce more amount of heat during hydration process.
* cement with more content to C_2S is better cold whether concreting.

2. Hydration process - C_3A:-

$$3CaO \cdot Al_2O_3 + H_2O \longrightarrow 3CaO \cdot Al_2O_3 \cdot 6H_2O$$

(calcium Aluminate hydrates)

(or)

$$C_3A + H \longrightarrow C_3AH_6$$

→ Tri calcium Aluminate hydrates rapidly about 225°C

→ C_3A produces larger amount heat during hydration process

→ Hydrated aluminates, do not contributes heat during hydration process strength of concrete, but it will be give durability of concrete.

3. Hydration of C_3S

produces C-S-H (calcium-silicate-hydrate) makes paste strong.

→ primary chemical reduction chemical reaction that harden cement paste mass concreting and better to mixed with fly ash

In cement C_3A content is clearly important because it has good effect to protect the reinforcement from corrosion for the same amount of $CaCl_2$. Type (I) and II cement have high C_3A content and they will react with $CaCl_2$ and form insoluable component however type II. IV and V cements which have low C_3A content, the reaction above will not possible. So more corrosion will happen.

<u>C_3S</u> <u>Tricalcium Silicate</u> : ($3CaO\,SiO_2$)

Tricalcium silicate (C_3S) is the main phase of portland cement clinker. It is caused alite in clinker because it is not pure tricalcium silicate and contains a no. of impurities substituted in its crystal lattice.

This compound hydrates and harden rapidly. It largly responsible to portland cements initial set and early strength gain.

The strength developed by portland cement depends it composition.

Tricalcium silicate is used as an anticaking agen

Tolerance 2% is generally recognized as safe when used in table salt

C2S Dicalciumsilicate ($2CaOSiO_2$)

Dicalciumsilicate(C2S) hardens slowly and contributed largly to strength increases at ages beyond 7 days. There are three main crystal form of C2S (α, β) but the β-form is the only one occured in the portland cement and it react slowly with water.

→ Its reaction is slower than C3S.

→ The amount of $Ca(OH)_2$ term its hydration is less

→ Hydration of C2S take more than 4 years

→ Responsible for development of late strength C2S hydrates and hardens slowly. It is largely responsible for strength gain after one week.

→ less content in cement

→ Rapidly reacts or fast reaction.

C4AF Tetracalcium Aluminoferrite:

Tetracalcium aluminate is resposible for early setting of cement and it is also related to heat of hydration

This compound is formed with in 24 hours. Generally high quantity of this compound is avoided as its leads to cracking

5. Explain the laboratory test that are conducted on cement

(a) fineness

fineness of cement is property of cement that indicates particles size of cement and specific area and indirectly affect the heat of hydration.

finer cement reacts faster with water and the rate of development of strength and corresponding heat of hydration is heigh.

→ Increasing in fine of cement is also found to increase the drying shrinkage of concrete

→ fineness of ordinary portland cement = 10%.

→ fineness of rapid hardning cement = 5%.

→ fineness of low heat cement = 5%.

Procedure :

→ weigh 100gms of cement

→ Take it in on standard sieve no 90microns.

Continuously sieve the sample giving circular and motion for a period of 15 minutes mechanical seiving devices may also be used. weigh the residue left on the sieve. This weigh shall not exceed 10% of ordinary cement. Seive test is rarely used.

consistency test:

300g of cement is mixed with 25% of water. The paste is filled in the mould of vicat's apparatus and the surface of the filled with paste is smoothed and levelled. A square needle 10mm x 10mm attached to the plunger is then lowered gently over the cement paste. The reading on the attached scale is recorded. when the reading is 5-7mm then the bottom of the mould the amount of water added is considered to be the correct percentage of water for normal consistency.

Initial and final Setting Test

→ A Neat cement is prepared by guaging cement with 0.85 times the water required to give a paste of standard consistency

→ The stopwatch is started at instant water is added to the cement

→ The mould resting on non-porous plate, is completely filled with cement paste is levelled smooth with the top of the mould.

→ The test is conducted at room temperature of 27± 2°C

→ The mould with the cement paste is placed in vicat's apparatus and the needle is lowered gently in contact with the test block and quickly released.

→ The needle thus penetrate the test block and the reading on the vicat apparatus' graduated scale is reached.

→ The procedure is repeated until the needle fails to pierce the block by about 5mm measured from the bottom of the mould.

→ The stop watch is pushed off and the time is recorded which gives initial setting time.

→ when the needle gently applying at some time it fails to mark or mark or impression on concrete block. That time give the final setting time.

Soundness test: To detect presence of uncombined lime in cement

→ Mould is placed on glass plate and filled with cement paste.

→ It is covered at top by another glass plate and a small weight is placed at top and the whole assemble is submerged in water for 24hrs

→ The temperature of water should be between 24°c - 35°c

→ Then remove the assemble from water after 24hrs

→ The mould is again placed in water and applied heat in such a way that boiling point of water is to be reached in 30 min.

→ The boiling of water continued for 1 hr

→ The difference between 2 reading ($L_2 - L_1$) indecates expansion of cement and it should not exceed 10mm.

iv) Specific gravity test on cement:

→ weigh the empty flask of weight as w_1

Aggregats

Introduction :- Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy

- Earlier aggregate were considered as chemically inert material but now it has been recognised that some of the aggregate are chemically active and also that certain aggregate. exhibit chemically bond at the interface of Aggregate and paste

- The fact that the aggregate occupy of 70-80% of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtely considerable

- To know more about the concrete it is very essential that one should know more about the aggregate which constitute major volume in concrete

Classification :- Agg can be classified as

(i) Normal Weight Aggregates

→ Natural Agg:- Sand, Gravel, crushed rock such as Granite, Quartzite, Basalt

→ Aritifical Agg:- Broken Bricks, Air cooled slag, sinterred fly Ash

(ii) Light weight Agg :- Bloated clay.

(iii) Heavy Weight Aggregate

Aggregate can also be classified on the basis of the size of the aggregate as coarse Aggregate and fine Aggregate.

Size : The largest max size of Aggregate Practicable to handle under a given set of condition should be used. 80mm size is max size that could be conveniently used for concrete making.

for heavily Reinforced concrete member the nominal max size of Aggregate should usually be restricted to 5mm less than the min. clear distance between the main bars 5mm less than min cover to the reinforcement, which even is smaller.

- But from various other practical consideration for Reinforced concrete work, Aggregate having a maxm size of 20mm are generally considered satisfactory.

- Aggregate are divided into two category

1. Coarse Aggregate
2. fine Aggregate

The size of Aggregate bigger than 4.75mm considered as coarse Aggregate and aggregate whose size is 4.75mm & less is considered as fine Aggregate

The angular aggregate exhibit are superior to rounded aggregate from the following two points of view

(a) Angular Aggregate exhibit a better interlocking effect in concrete, which propert makes it superior in concrete used for roads and pavement

(b) The total surface area of rough textured Angular aggregate is more than smooth Rounded Aggregate for the given vol By having greater surface area, the Angular Aggregate may show higher bond strength than rounded Aggregate

Texture

Surface texture is the property, the measure of which depends upon the relative degree to which particle surfaces are polished or dull, smooth or rough

- surface texture depends upon hardness, grain size, pore structure, structure of the rock and the degree to which forces acting on the particle surface have smoothed or roughed it

- As surface smoothness increase contact area decrease, hence a highly polished particle will have less bonding area with the matrix than a rough particles of the same volume.

Shape:- The shape of Aggregate is an important characteristic since it affects the workability of concrete

The shape of the aggregate is very much influenced by the type of crusher and the reduction ratio i.e the ratio of size of material fed into crusher to the size of the finished product.

classification of Praticles on the Basis of shape of the aggregate as shown follows

classification	Description	Example
① Rounded	Fully water worn or completely shaped by Atrition	River/Seash desert, Seas and wind b and sands
② Irregular (or) Portly rounded	Naturally Irregular or portly shaped by Atrition having rounded edges	Pitsands & Gravels, lan or dug pin cuboid
③ Angular	Possesing well-defined edges formed at the intersection of roughly planar faces	Crushed Roc of All type tales, scre
④ Flaky	Material usually, Angular of which the thickness is small relative to the width and/or length	Laminate Rock

Surface characteristics of Aggregate

Group	Surface texture	Example
1	Glassy	Black flint
2	Smooth	chert, slate, Marble
3	Granular	Sand stone, oolite
4	Crystalline	fine :- Basalt, trachyte Medium :- Dolerite, Granophyre, Granite Coarse :- Gabbro, Gneiss, Granite, Syenite
5	Honey Combed & porous	Scoria, pumice.

It has been also shown by experiments that rough textured aggregate develops higher bond strength in tension than smooth textured aggregate

Strength

we donot imply the strength of the parent rock form which the aggregates are produced because the strength of the rock does not exactly represent the strength of the agg in concrete

- Concrete is an assemblage of individual pieces of agg bound together by cemeting material its properties are based primarily on the quality of the cement paste

The strength is dependant on the bond b/w cement paste & Aggregate

- If the strength of paste b/w bond is low, prous are formed in the concrete and it result to low Quality of concrete and viceversa

The test for strength of aggregate is required to be made in the following concrete

(i) for producing high strength & ultra strength concrete

(ii) when use the weatherating rocks.

(iii) Aggregate that are manufactured by industrial process

Mechanical Properties of Aggregate :-

1. Test for determination of aggreagate crushing value
2. Test for determination of fineness value.
3. Test for determination of Impact value.
4. Test for determination of Abrasion value.

Crushing Value

The aggregate crushing value give a relative measure of the resistance of an aggregate to crushing value under a gradually Applied Compressive load.

- with Aggregate of Aggregate crushing value 30 or higher, the result may be anamolous

MODULE-2

AGGREGATES

Aggregates:-
A material obtained from a mass of fragments (or) particles loosely compacted together and used as filler in concrete.

classification of aggregates:-
Aggregates classified as
(i) Normal weight aggregates
(ii) light "
(iii) Heavy "

Normal weight aggregates:
It is ~~classifed as~~ classified as 2 types.
1) Natural aggregates Ex:- sand, gravel, sandstone.
2) Artifical " Ex:- broken brick, air pulled slag fly ash.

Source:-
Their are three types of rocks:
(1) Igneous rocks
(2) Sedimentary rocks
(3) Metamorphic "

Igneous rocks:-
These rocks obtained by cooling of magma (or) lava at the surface of crest (or) deep beneath.

Ex:- Granite, basalt, dolerite.

Sedimentary rocks:

These rocks are formed below sea-bed and lifted up.

Ex: sandstone, shale, limestone, siltstone.

Metamorphic rocks:

These rocks are originally either igneous or sedimentary ~~wit~~ which are subject to metamorphism due to heat and pressure.

Ex:- marble, slate.

* Size:-

Aggregates are divided into 2 categories.

(1) coarse aggregate

(2) Fine aggregates

Coarse aggregates ~~are not passi~~ particles not passing through 4.75mm sieve

Ex:- gravel, crushed stone.

Fine aggregate particles are passing through 4.75mm sieve.

Ex:- sand, silt, clay.

* Shape:

classification	Description	Examples
(1) rounded	Fully water worn (or) completely shaped by attrition.	river (or) seashore gravel.

(2) Irregular	Naturally irregular or partly shaped by attrition	pit sands (or) gravels.
(3) Angular	possessing well defined edges formed at intersection of roughly planar faces	Crushed rocks
(4) flaky	Material, usually of granular of which the thickness is small relative to the width (or) length	laminated rock.
(5) ~~Texture~~	~~textu~~	

*TEXTURE:-

Texture depends on hardness, grain size, pore structure of rock.

Types	examples
(1) Glassy	Black flint
(2) Smooth	Slate and marble.
(3) Granular	Sandstone.
(4) Crystalline	Basalt, dolerite, granite.
(5) Honeycombed and porous	pumice, trass.

* Calculate the finess modulus of fine aggregate.

I.S Sieve Size	wt retained (gms)	cum wt retained	% retained	% cum retained	% cum passing
4.75	10	10	$\frac{10}{500} \times 100 = 2$	$\frac{10}{500} \times 100 = 2$	98
2.36	50	60	$\frac{50}{500} \times 100 = 10$	$\frac{60}{500} \times 100 = 12$	88
1.18	50	110	10	22	78
600	95	205	19	41	59
300	175	380	35	76	24
150	85	465	17	93	7
less than 150	35	500	7	100	0
	500 gms			Σ 246	354

$$F.M = \frac{\Sigma \text{ \% cum retained}}{100}$$ (upto 150 micron only F.A)

$$= \frac{246}{100}$$

$$= 2.46 = 2.46$$

* Fineness modulus :-

→ It is an empirical factor obtained from adding the cumulative %age of aggregates retained on different standards sieves ranging from 80mm to 150mm and dividing the sum by 100.

Fine sand = 2.2 - 2.6

medium " = 2.6 - 2.9

coarse " = 2.9 - 3.2

→ different types of aggregates based on grading:-

(1) poorly graded (or) uniform graded
(2) Gap graded aggregates
(3) well graded aggregates

poorly	Gap	well
→ It contains the large %age of aggregates having approximately equal size.	→ one or more intermediate size aggregates are omitted.	→ It means sizes within the entire range are appr. equal amounts.
→ Friction at few points of contact.	→ Friction at many points of contact.	→ Friction at many pts of contact.
→ poor interlocking/bonding	→ Good interlocking	→ Excellent interlocking.
→ higher % of voids	→ few voids	→ very few voids will require min paste to fill.
→	→ very economical preparation	

* **Maximum aggregate size:**

The smallest sieve opening through the entire amount of aggregate is required to pass/ to 100% pass is called maximum size agg.

For Ex:-

Sieve size (mm)	% passing
37.5	100 → max size agg.
25	95-100
12.5	25-60
4.75	0-10
2.36	0-5

* **Grading:**

Plot the graph b/w the sieve size and % cummilative passing.

→ Grading requirements for fine aggregates

* " " " coarse "

→ because of workability grading is required.

* **Deleterious substance in Agg:-**

(a) **Organic impurities:-**

It contains the products of decay of ~~in~~ Vegetable matter. The organic impurities may effect the hydration of cement. So, It effects the rate of gaining the strength.

(b) clay and other fine materials:-

→ It effects the bonding b/w agg and cement paste.

→ It effects the strength and durability of the concrete.

* Ex:- silt and dust

→ BSEN 12620:- aggregates for concrete ~~units~~ limits, the content of fine materials (clay & silt) not more than the follows.

1) 15% by the wt in the crushed sand.
2) 3% by the wt in the natural gravel.
3) 1% by the wt in the coarse agg.

~~(c)~~
* contamination (c) salt contamination

~~(a)~~ Agg contains the salt should be wash ~~b~~ with the water.

Effects:-

(1) It will absorb the ~~co~~moisture from the air and causes the Efflorescence (salt coating on agg)

(2) corrossion of reinforcement.

(d) alkalinity of agg:-

The reaction takes place b/w Siliceous materials in the agg. and alkaline materials (minerals) from the cement.

→ It causes the cracking of concrete.

Scanned with CamScanner

* Alkali agg reaction:-

→ The aggregates contain the reactive silica react with alkalies present in the cement. i.e sodium oxide (Na_2O) and pottassium oxide (K_2O).

→ water (H_2O) + alkali in cement + Sti silica in agg = alkali agg reaction.

*In America it is found that many failures of concrete structures because of alkali agg reaction.

Factors effecting the alkali agg reaction:

1) Reactive type of agg.
2) High alkali content in cement.
3) availability of moisture.
4) Temperature conditions.

→ reactive

Mo: (1) Reactive type of agg:-

motar bar expansion test derived by Stanton for accessing the reactivity.

A sample of 25mm x 25mm x 250mm length is caste, cure and stored in standard manner.

Measure the length of the sample periodically 1, 2, 3, 6, 9, 12. If the expand more than 0.05% after 3 months (or) 0.1% after 6 months It is harmful.

(2) High alkali content in cement :-

Agg should not contains the 0.6% of alkali content. ($Na_2O + 0.658 K_2O$)

(3) availability of moisture :-

The alkali agg reaction will not occur in the interior part of the cement. It will be occured on surface of the concrete. To reduce the alkali agg reaction. Water proofing agents will be coated on the surface of the concrete.

(4) Temperature conditions :-

The ideal temp for promotion of alkali agg reaction is in the range of 10-38 °c

*Moisture content in agg :-

Module - II

fresh concrete: fresh concrete is that stage of Concrete in which concrete can be moulded and it is in plastic state. The potential strength and durability of Concrete of a given mix proportion is very dependent on the degree of its compaction.

Workability tests on concrete setting times of fresh Concrete:

workability of concrete is defined as the ease and homogeneity with which a freshly mixed concrete or mortar can be mixed, placed, compacted and finished.

factors affecting workability:

1. **water content:** the increase in water content helps to increase the workability of concrete. But water/cement ratio remains the same.
2. **Size of aggregates:** Concrete having large sized aggregate is more workable.
3. **Mix proportions:** If aggregate / cement ratio is higher, Concrete becomes leaner and provides better workability.
4. **Shape of aggregates:** Angular & flaky aggregates make Concrete very harsh.
5. **Use of admixtures:** The use of plasticizers and super-plasticizers increase the workability of Concrete.
6. **Time and temperature:** fresh concrete gets stiffened as the time flows. The temperature increases, the workability of mix reduces.

Workability Tests:

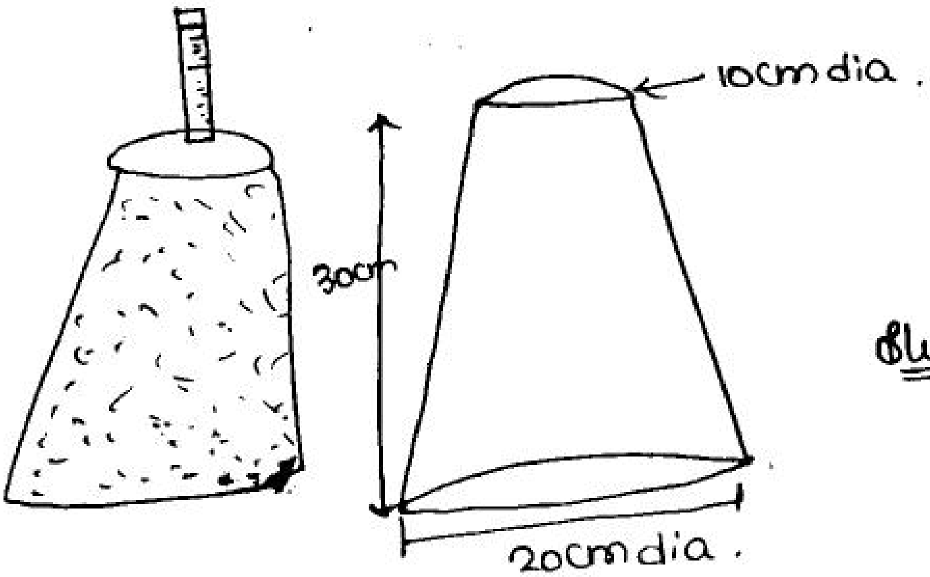
1) slump test: The tools needed are:

1. slump cone and tamping rod
2. water proof base
3. Trowel
4. Measuring tape.
5. concrete.

The workability of concrete is affected by the amount of water in the mix. A Slump test is carried out on site Before the concrete is poured in place. A Sample is taken from the lorry when it arrives on site.

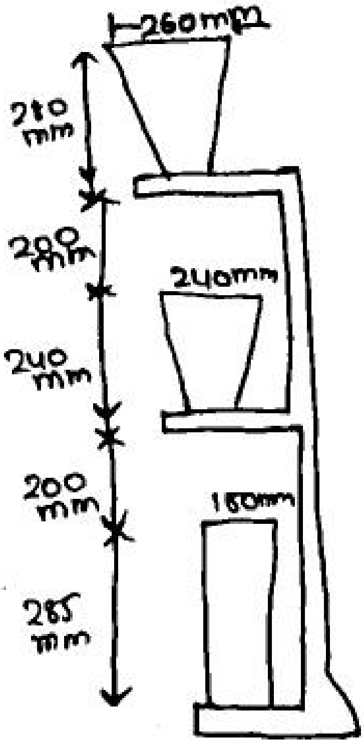
procedure:

1. place a cone on a level waterproof base and pour 75mm of concrete in cone and tamp 25times. Repeat this 3 more times.
2. Gently lift cone from the concrete.
3. Area cone beside concrete and put tamping rod across the top of cone.
4. Measure down from bottom of tamping rod to top of concrete. This is slump of concrete.



Slump test.

2. **Compaction factor test:** It is more precise and sensitive than slump test and used for concrete mix of low workability. It requires balance, compaction factor apparatus with allied tools.



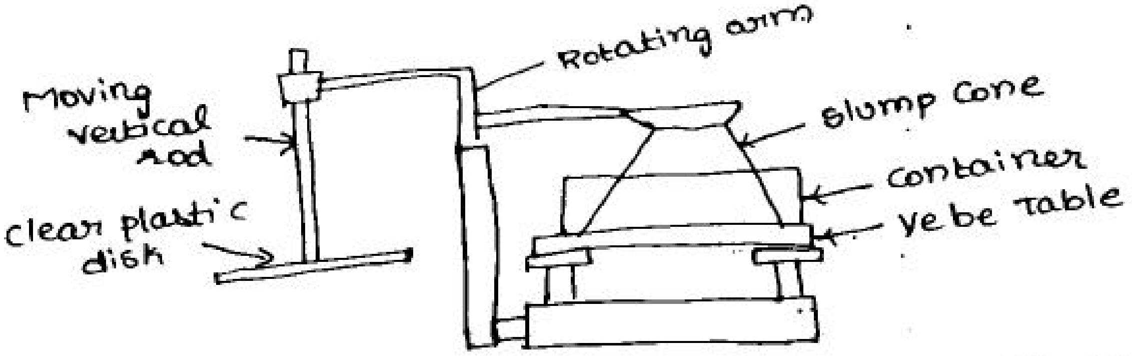
procedure:

1. weigh the bottom cylinder & gently fill the upper hopper with sampled concrete to level of rim.
2. open the trap door of upper hoppor and allow it to fall into middle hopper, and open middle hopper to fall in bottom cylinder.
3. Remove the surplus concrete and weigh the concrete which is fully compacted. This weight is fully compacted concrete (w_2). weight of empty cylinder (w_1). weight of partially compacted concrete (w_1).

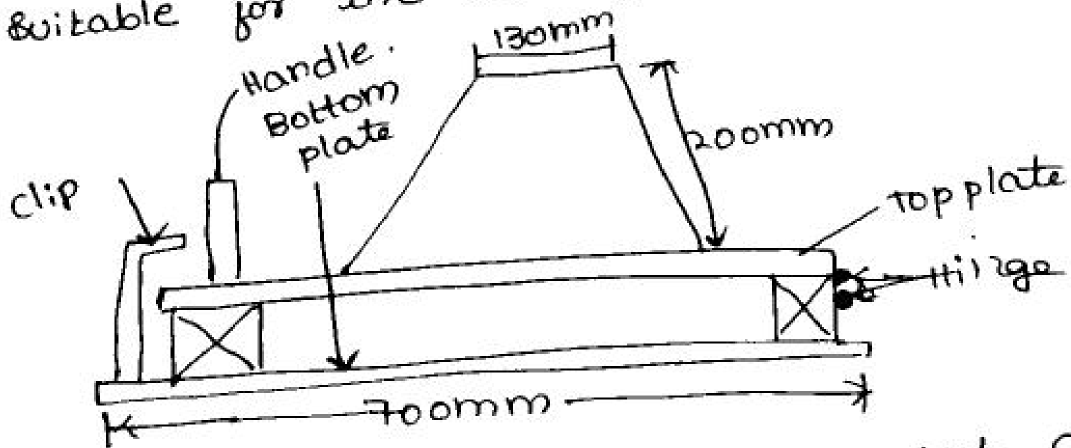
$$\text{Compaction factor value} = \left(\frac{w_1 - w}{w_2 - w}\right)$$

Ranges from 0.7 to 0.95.

3. **Vee-Bee test**: To use a vee-bee consistometer, slump test is performed. Slump cone is placed inside part of a Vee-Bee. when the mixture is poured, the glass arm turns, this triggers an electric vibrator. vibration continues till the conical shape of concrete disappears. when the mixture assumes a complete cylindrical shape, this time is recorded to understand the consistency of mixture.



4. **flow test**: this is a laboratory tests. It gives an indication of the quality of concrete with respect to consistency, cohesiveness. The spread of the flow of the concrete is measured and this is related to workability. Best suitable for the use of superplasticizing admixtures



5. **Kelly Ball test**: This is a simple test consisting of determination of indentation made by 15cm dia metal by 15cm diameter metal hemisphere when fresh placed on fresh concrete. B It is easy & faster but it requires large amount of concrete to be performed.

Setting times of fresh concrete:

1. **Initial setting time:** The time elapsed between the moment that the water is added to the cement, to the time that the paste starts losing its plasticity.

→ Normally a minimum of 30min has maintained for fixing and handling operations.

→ It should not be less than 30min.

Theoretically, Initial setting time of concrete is the time period between addition of water to cement till the time at 1mm square section needle fails to penetrate the cement paste, placed in vicat's mould 5mm to 7mm from the bottom of the mould.

Initial setting time duration is required to delay the process of hydration or hardening.

Test:

1. Take 400g of cement and prepare a neat cement paste with 0.85P of water. fill the vicat mould, resting on a glass plate.
2. place the test block under road bearing needle.
3. lower needle gently and note down the readings, take readings every 5 min untill the value is b/w 2to4mm.

2. **final setting time:** final setting time is the time period between the time water is added to cement and the time at which 1mm needle makes an impression on the paste in the mould but 5mm doesnot make any impression.

ar Test:

1. for final setting time, replace the needle of the Vicat's apparatus.

2. The cement is considered finally set when upon applying final setting needle on test block. Record the values and time.

Segregation in Concrete: Segregation in concrete is commonly thought as separation of some size groups of aggregates from cement mortar in isolated locations with corresponding deficiencies of these materials in other location.

→ segregation depends on much vibration, improper transportation, placement or adverse weather conditions.

→ The effect of aggregate segregation on the mechanical and transport behavior of concrete.

Bleeding in Concrete:

→ Bleeding is one form of segregation, where water comes out to the surface of the concrete, being lowe[st] specific gravity among all the ingredients of concrete.

→ Bleeding can be easily identified in the field by the appearance of a thin layer of water on the top surface of freshly mixed concrete.

Hardened concrete:

→ Concrete that is in a solid state and has developed a certain strength.

Reaction continues with time and produced hard, strong and durable solid material.

Abram's law:

→ strength of fully compacted concrete is inversely proportional to water cement ratio.

→ As the water content increases the strength of concrete decreases.

Abram's law is a special case of a general rule formulated emperically by feret:

$$S = \frac{A}{B^{w/c}}$$

where S is strength of concrete

A and B are constants

w/c is water-cement ratio, which varies from 0.3 to 1.2

Gel space ratio: It is the ratio of solid products of ~~hydrogb~~ hydration to space available for these hydration products.

→ power's experiment showed that the strength of concrete bears a specific relationship with gel/space ratio.

→ calculation of gel/space ratio for complete hydration

$$\text{Gel/Space ratio} = \frac{\text{volume of gel}}{\text{Space available}} = \frac{0.657C}{0.319C + W_0}$$

→ Calculation of gel/space ratio for partial hydration

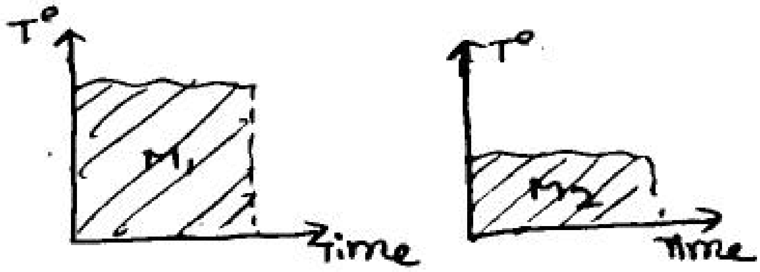
$$\text{Gel/space ratio} = \frac{\text{Volume of gel}}{\text{Space available}} = \frac{0.657C\alpha}{0.319C\alpha + W_0}$$

Maturity concept:

Concrete maturity indicates how far curing has progressed. Maturity is the relationship between concrete temperature, time and strength gain. It is represented by an index value that can be measured in real time in the field. It is an accurate way to determine real-time strength values of curing concrete.

Relation between maturity index and concrete strength for each concrete mixture should be established.

If $M_1 = M_2$ then $f_1 = f_2$



Stress behaviour in concrete:

The shape of ascending part of the stress-strain curve is more linear & steeper for high-strength concrete & strain at the maximum stress is slightly higher for HPC.

→ High performance concrete exhibits less internal micro cracking than lower-strength concrete for a given imposed axial strain.

Creep of Concrete: creep is time dependent deformations of concrete under permanent loads and permanent displacement.

→ When concrete is subjected to compressive loading it deforms instantaneously.

→ This time-dependent strain is termed as creep.

factors affecting creep:

→ concrete mix proportion

→ Aggregate properties

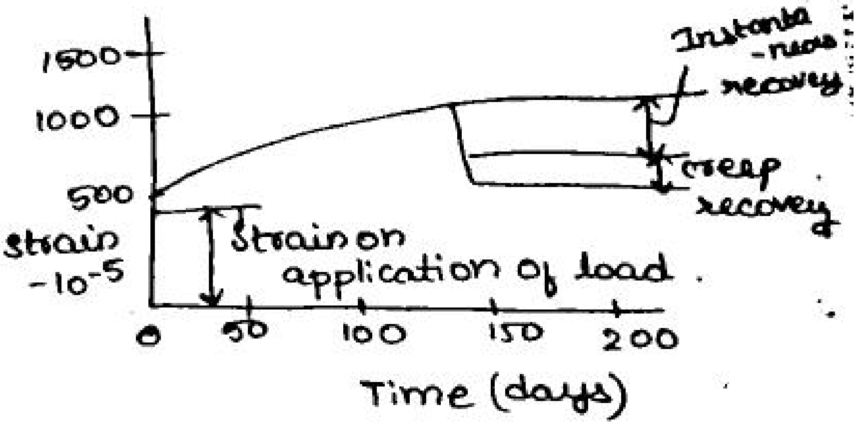
→ Age at loading

→ curing conditions

→ cement properties

→ Temperature

→ Stress level.



Shrinkage of concrete:

→ Shrinkage is Shortening of concrete due to drying & is independent of applied loads.

→ Shrinkage of concrete is the time-dependent strain measured in an unloaded and unrestrained specimen at constant temperature.

factors affecting Shrinkage:

→ Drying conditions

→ Time

→ water cement ratio

Durability Tests on Concrete:

A durable Concrete is one that performs satisfactorily in the working environment during the anticipated exposure conditions during service.

The general tests conducted are:

1. frost damage test.
2. Sulphate attack test
3. Alkali-aggregate reaction
4. Chloride penetration Test

1. **frost damage test:** The procedure allows us to measure the amount of scaling per unit surface area due to a number of well defined freezing & thawing cycles in the presence of deicing salt.

→ the test results showed that the freeze-thaw resistance is influenced directly by the compressive strength property of concrete.

2. **Sulphate attack test on concrete:**

→ Sulfate attack comprises a series of chemical react between sulfate ions & the components of hardened concrete.

→ As these reactions may lead to cracking, spall or strength loss of concrete structures, appropiate t methods are needed to determine the resistance c concrete under sulfate exposure.

3. Alkali aggregation reaction: It is a term mainly referring to a reaction which occurs over time in a concrete between the highly alkaline cement paste and non-crystalline silicon dioxide, which is found in many common aggregates.

4. Chloride penetration test: Reinforced concrete structures are exposed to harsh environments. It is a slow process the determination of diffusion values in a reasonable time.

Non-destructive tests on Concrete:

1) N. It is a process of inspecting, testing or evaluating materials, components without destroying the parts of the system.

1) Rebound hammer test:

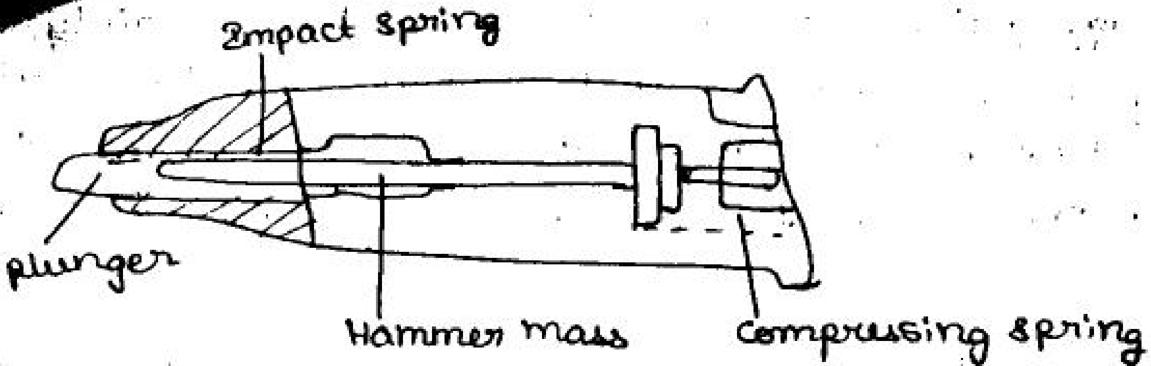
→ It is one of the non-destructive test used to find out the compressive strength of concrete.

→ The rebound of an elastic mass depends on the hardness of the surface against which its mass strikes.

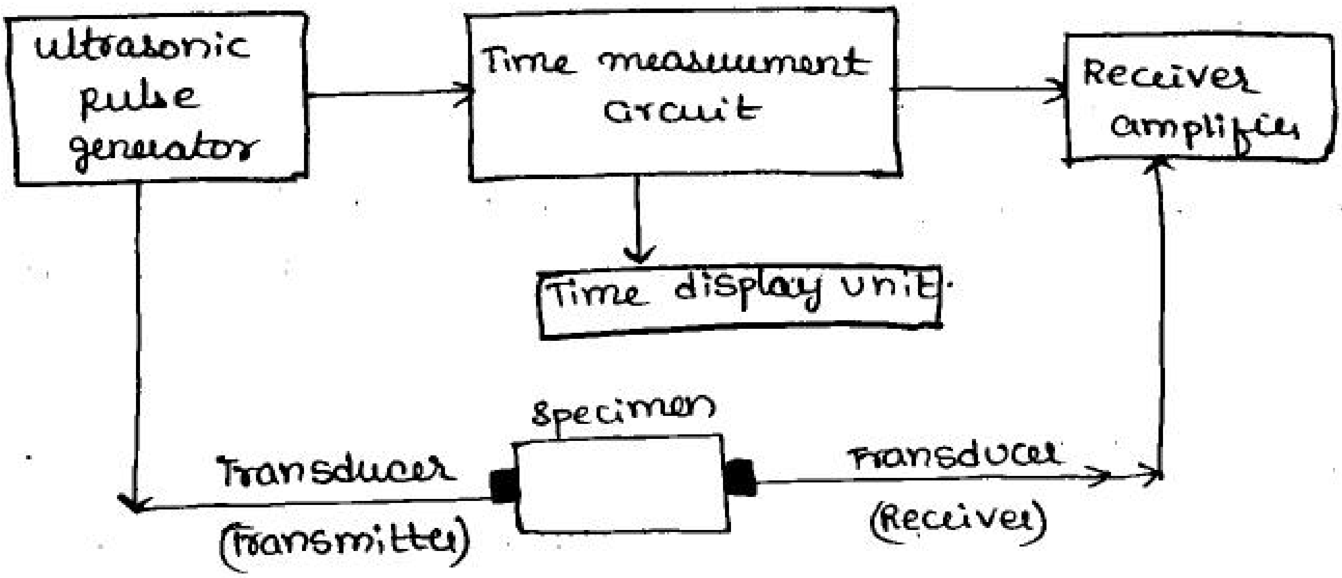
→ Simple to use. No special equipment is needed.

→ The concrete should be 14 to 56 yrs old.

→ The surface of concrete must be smooth, dry & free of honeycombing. The rubbing stone provided can be used to grind the surface smooth, if necessary



2) ultrasonic pulse velocity test:



→ The method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested.

→ Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogenity etc.

pulse velocity

3. alkali aggregation reaction: It is a term mainly referring to a reaction which occurs over time in a concrete between the highly alkaline cement paste and non-crystalline silicon dioxide, which is found in many common aggregates.

4. Chloride penetration test: Reinforced concrete structures are exposed to harsh environments. It is a slow process the determination of diffusion values in a reasonable time.

Non-destructive tests on concrete:

1) ~~N~~ It is a process of inspecting, testing or evaluating materials, components without destroying the parts of the system.

1) Rebound hammer test:

→ It is one of the non-destructive test used to find out the compressive strength of concrete.

→ the rebound of an elastic mass depends on the hardness of the surface against which its mass strikes.

→ Simple to use. No special equipment is needed.

→ the concrete should be 14 to 56yrs old.

→ The surface of concrete must be smooth, dry & free of honeycombing. The rubbing stone provided can be used to grind the surface smooth, if necessary

pulse velocity (km/sec)	concrete quality
Above 4.5	Excellent
3.5 to 4.5	Good
3 to 3.5	Medium
Below 3	Doubtful

3. Half cell potential:

→ To evaluate potential of concrete in promotin corrosion activity of reinforcement by Half cell poten test.

→ To evaluate reinforcing steel in concrete tha arbonated to the level of the embedded steel.

Interpretation of Test results.

potential over an area	most likely o
more positive than -0.2V CSE	90% probabilit no reinforcin is corroded
-0.2 to -0.35V CSE	Corrosion activi reinforcing s
more negative than -0.35V CSE	90% probabilit reinforcing ste

[illegible]

Q. Importance of Quality Control in Design.

A. Quality control: for the building structure to be durable, more strength and also for aesthetic, accomplishing a quality. Concrete is of supreme importance. Low strength and low durable concrete structure have damaged millions of lives and properties in past decades. So in order to achieve a quality and a durable building structure maintaining the quality and standard of concrete is paramount.

Quality Control application in Concrete Construction:

- Mechanical properties of the reinforcement to be used.
- location of pre-stressing ducts.
- properties of the concrete mix designed of use in the

Mixing of the Concrete.
Dump of the Concrete.
pouring of the Concrete
- Control of water addition
- Preparation of areas where different Concrete pours are done
- Control of Compression test Sample
- control of form work removal.

Q. Design a Concrete mix for targeted 28 days Cube strength of 45 MPa from the following data.

1. Max. Size of crushed aggregate to be used = 20mm
2. low workability, Slump = 10-30 mm
3. Specific gravity of aggregate = 2.65
4. The aggregate percentage passing 600 micron = 50%
5. Exposure to Concrete is moderate.
6. the Cover to the reinforcement to be provided is 25 mm.

Design :

Step 1: Determine the target strength from the relation.

target strength = Specified characteristic strength + Standard deviation X Risk factor In this Case the target strength is directly given as 45 MPa at 28 days.

Step 2: Find out the water / cement ratio for targeted strength

45 MPa.

(a) for find out the w/c ratio, refer to table from this for ordinary port-land cement and uncrushed 20mm agg the 28 days strength is 42 MPa.

(b) find the point of inter section of 42 MPa at 0.5 water/cement ratio through this point draw a dotted line curve parallel to the neighboring curve. Now draw a strength line from the desired strength on y-axis, where this line cuts the curve, draw a perpendicular on x-axis which will give w/c ratio for the targeted strength ie 45 MPa

from this curve for 45 MPa strength the water/cement ratio comes out 0.54

for uncrushed aggregate of 20 mm max. size aggregate approximate water content from table 20.47, is 160 kg/m3.

for moderate exposure and 25mm cover maximum w/c ratio from durability consideration is permitted as 0.5. Actually the lower value of the two should be adopted. Hence adopt w/c ratio as 0.5 water content for 10 to 30 mm slump from table 20.47 is 160 kg/m3

Cement Content:

from w/c ratio 0.5 and water content 160 kg, 160

Cement Content = 160/0.5 = 320 kg

from durability consideration, the quantity of cement should be used as 350 kg/m3, thus adopt greater cement content as

...tion of density of fresh concrete:
...er content of 160 kg/m3, 20mm uncrushed, the wet ...ity of concrete = 2490 kg/m3.

...ermination of total weight aggregate.

Total weight of aggregate = total weight of concrete − weight of water − weight of cement.

= 2490 − 160 − 350

= 2490 − 540 = 2180 kg/m3

fine aggregate for slump 10-30 aggregate passing through 600 microns as 50% for w/c ratio 0.5

f.A = 27%

∴ weight of fine aggregate = (2180 × 27) × 100 = 588.6 = 589 kg/m3

weight of coarse aggregate = 2180 − 588.6 = 1591.4 kg/m3

Estimated quantities in kg/m3 are:

(a) Cement = 350 kg/m3

(b) f.A = 588.6 kg/m3

(c) C.A = 1591.4 kg/m3

(d) water = 160 kg/m3

(e) wet density = 2490 kg/m3.

from these quantities the trial made is prepared, samples cast and tested at 28 days to judge the suitability of concrete for the desired work. If need arises, adjustment in quantities be ma...

Q Distinguish high strength Concrete and high performance Concrete.

	High strength Concrete	High performance Concrete
1.	It defined purely on the basis of its Compressive strength at 28 days.	It is Concrete mixture p[…] high workability, high dur[…] and high ultimate strength[…]
2.	High strength Concrete are Concretes with the strengths.	High performance Concrete (HPC) are Concrete with properties (or) attributes which satisfy the performance Criteria.
3.	To achieve this high strengths the w/c ratio must be as low as possible.	It cannot always be achieved routinely by using only Conventional materials and normal mixing, placing and curing
4.	More Compaction is required while placing this type of Concrete to avoid segregation and honey Combs.	the strength has been the major Concern in a Concrete mix.
	High strength Concrete is used to avoid the segregation and honey combs.	the HPC has to overcome less durability, weaker transition zone, low resistance to chemical attack.

	[illegible] of super [illegible] can also be implied [illegible] the workability to [illegible] the derived workability.	the super plasticizers will enables the production of self consolidating Concrete and high performance concrete.
	Mineral admixture like fly ash and silica fume are also used in HSC to increase the Compressive strength.	Minerals admixtures like silica fume, granulated blast, slag are used in higher Concentration.
8.	uses in the Construction of high rise buildings, bridges with long spans, high load Carrying buildings built on weak soil.	uses in the Construction of high rise buildings, tunnels, nuclear structures, Constructions at sever exposure Conditions.