b. Rapid Hardening Cement - It gains early strength quickly. as it is finer than OPC. Other properties are similar to OPC. It is used for pre-cast construction road repairs etc.

c. Sulphate Resisting cement - To resist the attacks of sulphur low content of C_3A is found to be effective. Such cement with low quantity of C_3A and C_4AF is sulphur resisting cement. It is a fine cement. It is used for foundation in sulphur rich soils and sewage construction works.

d. Coloured & White cement - It is a cement which contains / owes different colours, other than grey. This type of cement is used for various decorative purposes in construction. For manufacturing coloured cement white cement or grey OPC is used as a base.

* White cement is manufactured from chalk (pure $CaCO_3$) and fine clay (free of iron oxide) is used.
* Colouring pigments - Chromium oxide - green colour
  Cobalt - blue colour
  Iron oxide - brown / red / yellow
  Manganese oxide - black or brown.

e. High Alumina Cement - It is obtained by mixing alumina and calcareous materials in fixed proportions. It should not have alumina less than 32% by weight. It has quick strength development but has very high heat of hydration.

f. Blast Furnace Slag Cement - The waste products obtained in the manufacturing of pig iron is known as as blast furnace slag. So, this cement is made by mixing OPC clinkers, gypsum and granualated blast furnace slag in fixed proportions. It has less cost as compared to OPC. It generates less heat of hydration.

g. Low Heat Cement - This cement generates less heat of hydratio
It contains less amount of C_3A and higher C_2S. This cement evolves less heat, but, evolution of heat extends longer. This cement shows better resistance to sulphate attacks.

h. Portland Pozzolana Cement - This cement (PPC) is manufactured from pozolanic materials and clinkers of OPC. Fly ash (waste material in their thermal power station) is used as pozollanic material. It can be used at the place of OPC.
It is used for hydraulic structures (dams, wiers), and sewerage disposal works etc....

i. Oil-well cement - This cement is used for sealing the side of oil wells, so that the well can be prevented from collapsing. This cement should have rapid hardening & slow setting property. This can be attained by lowering amount of C_3A

j. Masonry Cement - This cement is used for masonry purposes. It consists of OPC clinkers, limestone & gypsum. Its compressive strength is 17.5 N/mm^2 after 28 days of curing.

k. Quick-Setting Cement - It sets very early. It has less amount of gypsum and is finer than OPC. It is used for under water construction and typical grouting operations.

Date ———
Page ———

* Aggregates - Aggregates are the inert materials which are mixed in concrete in fixed proportions to give it a body, reduce shrinkage and make it economical.
⇒ most mixed materials of the world.
⇒ comprises 70-80% part of concrete.

· Requirements of good Concrete aggregates -
a. Free from clay or other impurities.
b. They should be sufficiently hard, strong & chemically inert.
c. They should have rough surface texture.
d. Should have abrasion resisting property.

· Classification of Aggregates - Aggregates are classified in following three ways :-
a. According to geological Origin -
i. Natural aggregates - Aggregates obtained from natural deposits of sand, gravel and quarries by cutting rocks. They generally occur at river beds, quarries.
ii. Artificial / Processed aggregates - These are manufactured or processed artificially. Their most widely used form is broken bricks or air-cooled blast furnace slag. Fine aggregates may be saw dust, flyash etc... These are used in mass concrete works.

b. According to shape - Shape affect the workability & other properties of concrete.
i. Rounded aggregates - Fully shaped by attrition (sea / waterside gravels, wind blown sands etc... These have good workability. These are not suitable for high strength concrete.
ii. Irregular / Partly rounded aggregates - These are naturally

irregular. These have voids ranging 32-38%. They have less workability. They cannot be used for high strength concrete.

iii. Angular aggregates - These have well-defined edges formed at intersection of roughly planar faces. These have voids 38-40%. These are best suitable for high strength concrete.

iv. Flanky aggregates - An aggregate is termed as flankly when, its least thickness is less than 3/5 times its mean dimension. The mean dimension of the aggregate is the average of the sieve sizes through which its particles pass.

v. Elongated aggregates - more than 9/5 the mean size.

c. According to size -

i. Fine aggregates - The aggregates most of which pass from 4.75 mm sieve and retain on 75 micron (0.075 mm) sieve are fine aggregates. These include sand, silt and clay.

ii. Coarse Aggregates - Aggregates which pass through 75 mm sieve & retain on 4.75 mm sieve are coarse aggregates. These include gravels fully or partially crushed.

iii. All-in aggregates - Those aggregates which contains a mix of fine and coarse aggregates are known as all-in aggregates.

Choice of Aggregates.

S No.	Factors	Influencing Property
1	Specific gravity / porosity	Strength / absorption
2	Chemical stability	Durability
3	Surface texture	Bond grip
4	Shape	Water demand - strength
5	Gradation - particle size	Strength, cohesion, bleeding
6	Maximum size	water demand
7	Deleterious materials	bond, cohesion, durability

* Characteristics of Aggregates-

a. Particle size - It governs the quantity of cement required, water required of the concrete.

b. Shape of aggregates - Shape of aggregates decide the amount of cement paste required, strength and bonding of the concrete.

c. Surface Texture - It influences the bond between cement and aggregates. Aggregates with rough texture develop a strong bond and vice-versa. But rough texture decreases workability.

d. Specific gravity - Specific gravity of aggregates indicate its quality. Low specific gravity indicates - high porosity, less durability and low strength.

For aggregates, it ranges from 2.4 - 2.9.

g. Bulk Density - The bulk density / unit weight of of an aggregate is defined as mass of the material in a given volume. It is expressed in kg/l.

h. Surface moisture, Absorption & Porosity - These properties are important for determining cement - water ratio. Like, if porosity is more, concrete will lose its workability at much faster rate.

1. Moist aggregates - Desired water - water available at surface.
2. Saturated but surface dry - Desired water.
3. Air Dry - Desired water + water absorbed in 10-15 mins.
4. Oven Dry - Desired water + water absorbed in 24 hours.

i. Bulking of Aggregate (sand) - Bulking / swelling takes place more in fine aggregates than coarse aggregates. When sand is damp, the water coating on each sand particle causes the seperation of particles from one another. Thus the sand is bulked. This sand occupies more volume and hence its hence its batching is done by volume and then correction of bulking volume is applied.

*** Impt→ If bulking correction is not done the concrete will be certainly defecit in sand (aggregates) and will have a tendency to segregate, also concrete yield will be less.

• When moisture is 5% bulking is maximum and after that it reduces, as the film around it gets broken and it starts to come to its original volume.

j. Deleterious material in aggregates – The materials which adversely or may affect the properties of concrete in fresh and hardened stage. These affect – strength, workability, durability etc. These may be like –

i. Organic impurities – Can affect hydration of concrete.
Ex – Decayed vegetable material

ii. Unsound particles – clay lumps, shale etc...

iii. Silt & clay – Prevents proper bonding in concrete.

k. Soundness – Aggregates should not go excessive change in volume, when exposed to environmental conditions.

l. Strength – Strength of aggregate is determined by crushing strength test and aggregate impact value test.

* Sieve Analysis – It involves dividing of aggregate sample into various fractions of different sizes. It is termed as grading.

Sieve Designation (in mm)	Aggregates
10, 4.75, 2.36, 1.18, 0.6, 0.3, 0.15	Fine aggregates
80, 63, 40, 20, 16, 12.5, 10	coarse aggregates

* Grading of aggregates - The particle distribution of aggregates, as determined by sieve analysis is termed as grading. It plays a vital role in determining the properties of concrete.

* Types of Grading -

a. Well-graded - It contains the aggregates of all sizes, large and small hence leaving minimum voids. It leads to a compact, dense and best concrete mix.

b. Gap-graded - When particles of certain size lack in concrete is gap-graded. It do not affect compressive or tensile strength, but proper bonding is not sure.

c. Poorly graded - In this, proportions of certain intermediate particles are defecit or in excess amount.

d. Continously graded - Aggregates are continously graded when it contains particles of every size. Such gradings are coarser or finer depending on higher proportions of coarse or fine aggregates.

* Effects of Grading - Grading of aggregate has following effects :-

i. Density - Well graded aggregates have lesser voids & more density. This requires less cement to fill the voids - hence economical.

ii. Segregation - Prevents segregation and bleeding of concrete. It also increases its strength.

* Fineness Modulus - It is a numerical index number which gives an idea of coarseness and fineness of aggregates. It also gives an idea about mean size of aggregates.

· Larger the value of modulus, coarser is the aggregate.