Different Types Of Cement & There Advantages & Uses

Different Types Of Cement & There Advantages & Uses

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Types Of Cement :

1. Rapid Hardening Cement (RHC)
2. Portland Pozzolana Cement (PPC)
3. Portland Slag Cement (PSC)
4. White Cement
5. Ordinary Portland Cement (OPC)

1. Rapid Hardening Cement

Rapid Hardening Cement is s kind of cement which achieves strength very fast.

The strength achieved by Rapid Hardening Cement in 3 days is equivalent to the strength achieve by Ordinary Portland Cement (OPC) in 7 days.

The Hardening properties of cement are enhanced with the addition of 56% of Tricalcium Silicate.

The improved early strength is achieved by the fineness of cement.

Advantages and Uses :

It gains high strength in the early days and the formwork can be removed earlier as compared to other types of cement.

It requires a short period of curing.

Rapid hardening cement is used in areas like road pavements so that the traffic can be opened early. It is also used in manufacturing precast slabs, posts, electric poles, concreting in cold countries.

There is a reduced shrinkage during curing and hardening of cement.

Rapid hardening cement is resistant to sulphate attacks.

Rapid hardening cement is used in areas like road pavements so that the traffic can be opened early. It is also used in manufacturing precast slabs, posts, electric poles, concreting in cold countries.

AGGREGATES

CONCRETE TECHNOLOGY

- **Alternative (1) Common**: When the owner requires the concrete supplier to assume responsibility for the concrete mix proportions.
- **Alternative (2) Prescription**: When the owner assumes responsibility for the mix proportions and properties of the concrete.
- **Alternative (3) Performance**: When the owner requires the concrete supplier to assume responsibility for the concrete "as delivered".

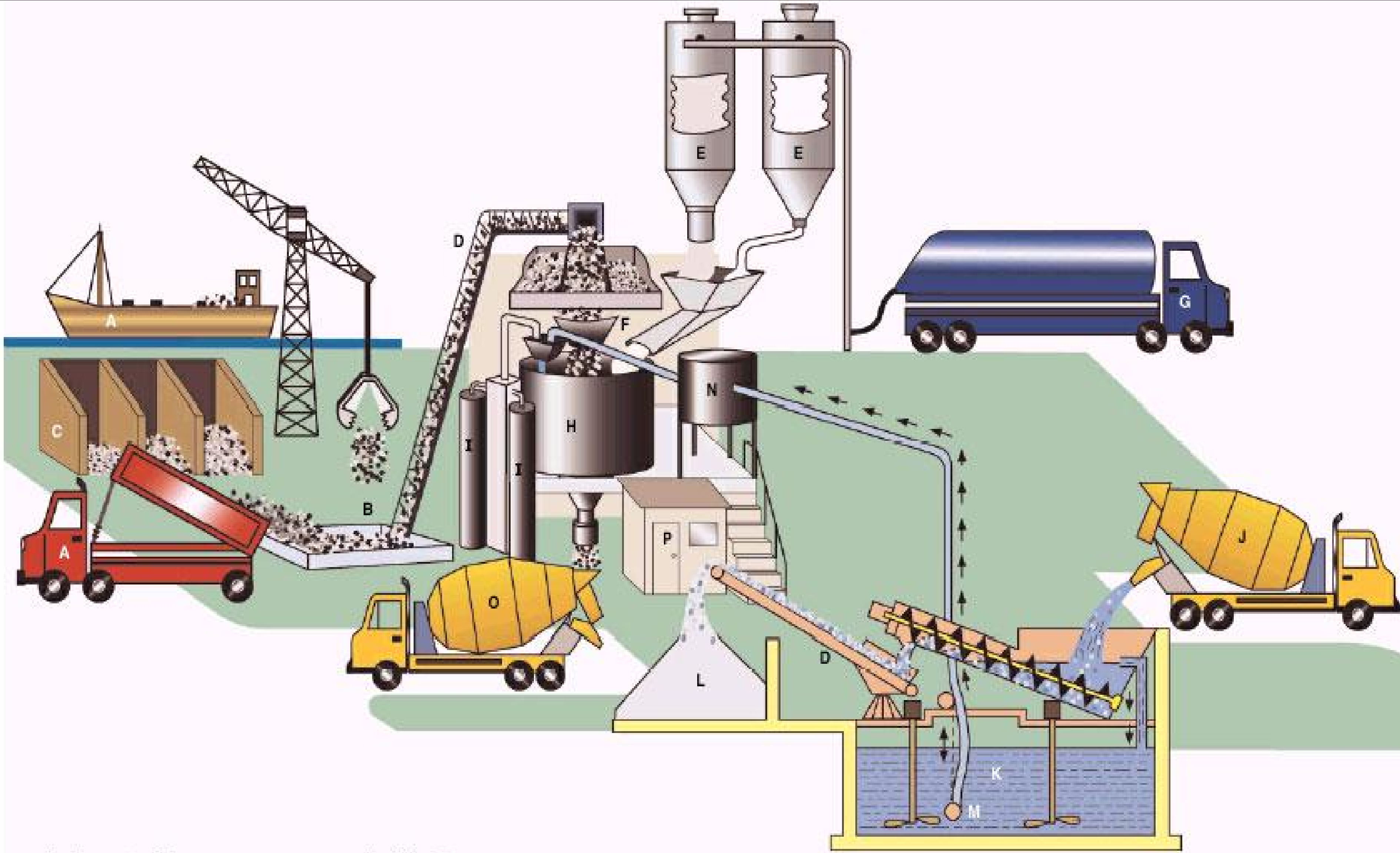
Ordering or Specifying Concrete

- The process of measuring concrete mix ingredients by either mass or volume and introducing them into the mixer.
- To produce concrete of uniform quality, the ingredients must be measured accurately for each batch.
- Most concrete today is batched and mixed by ready mixed concrete plants

Batching of Concrete

Fig. 10-2. Concrete can be mixed at the jobsite in a stationary mixer. (58642)

Fig. 10-3. Central mixing in a stationary mixer of the tilting drum type with delivery by a truck mixer operating at agitating speed. (69926)



A Aggregate delivery
B Aggregate receiving hopper
C Aggregate storage
D Conveyor belt
E Cementing material storage
F Weigh hopper
G Cement delivery
H Mixer
I Admixtures
J Ready mix truck with returned concrete
K Recycled water
L Reclaimed aggregates
M Pump
N Water storage
O Concrete loaded in ready-mix truck
P Control Room

Fig. 10-4. Schematic of a central mix ready mix plant.

Truck Agitators

Good planning and handling to avoid:

- Delays.
- Early Stiffening and drying out.
- Segregation.

Transporting Concrete

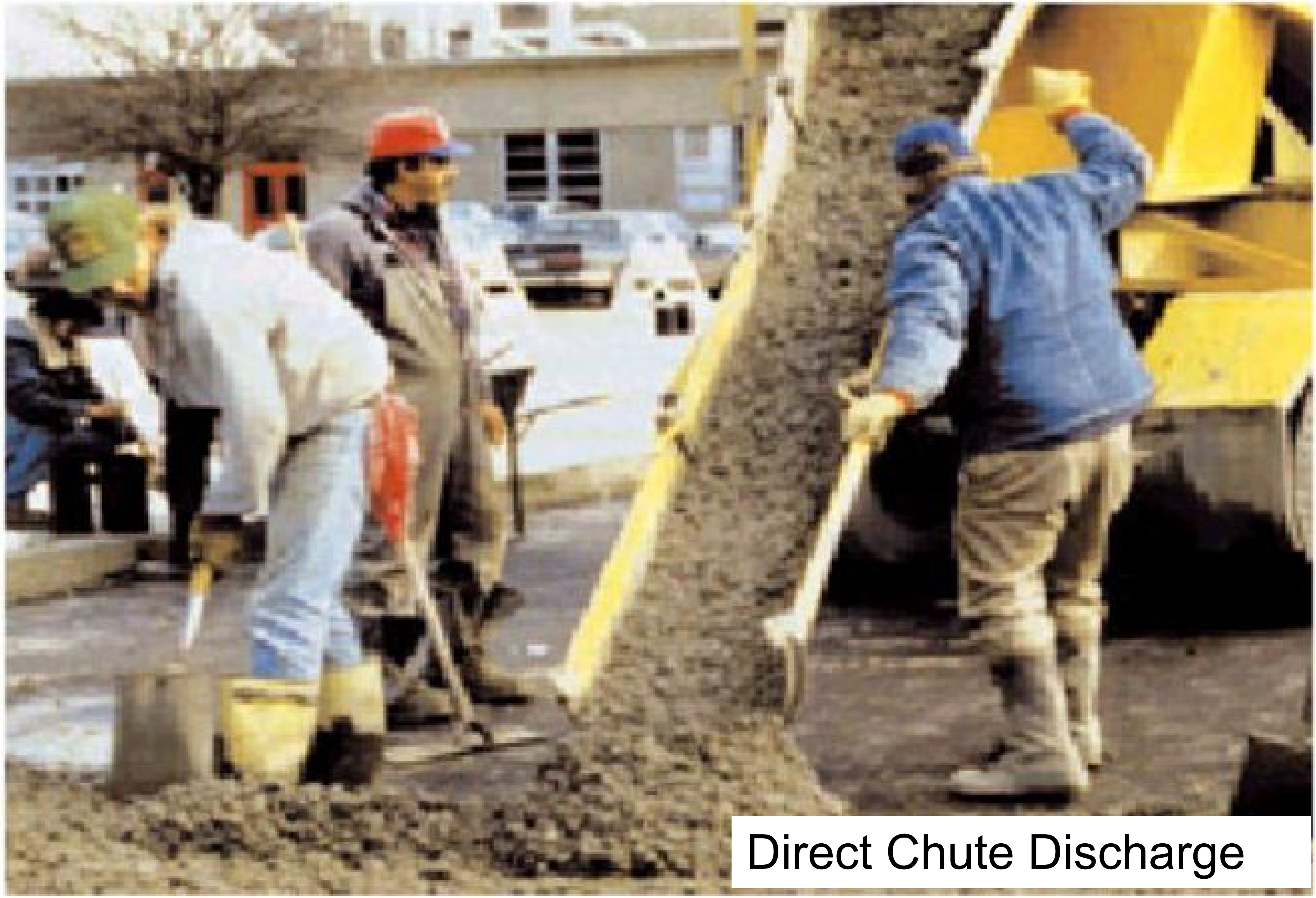


Fig. 10-9. Ready mixed concrete can often be placed in its final location by direct chute discharge from a truck mixer. (54955)

Front-discharge Truck

Fig. 10-10. In comparison to conventional rear-discharge trucks, front-discharge truck mixers provide the driver with more mobility and control for direct discharge into place. (70006)

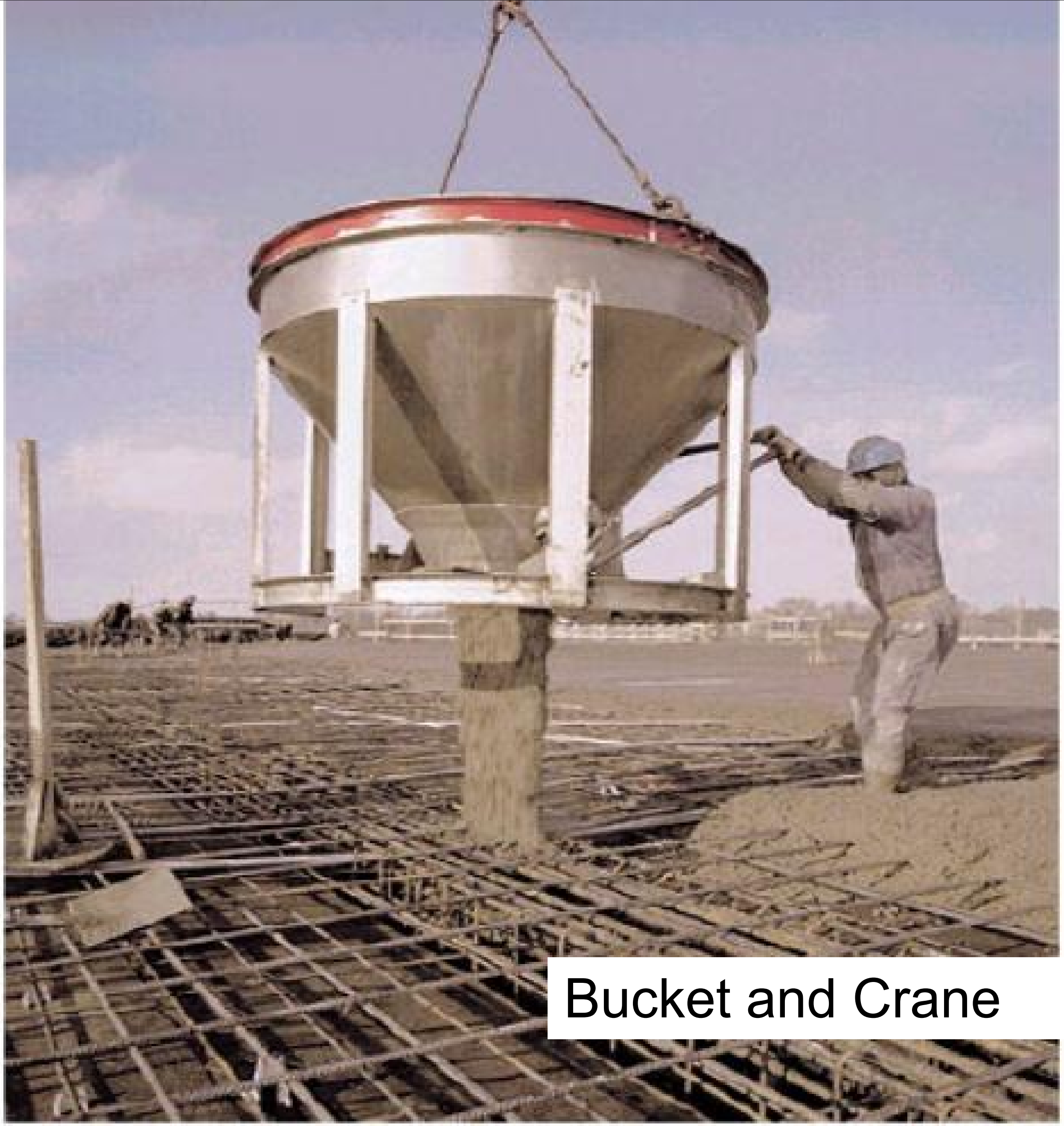


Fig. 10-11. Concrete is easily lifted to its final location by bucket and crane. (69687)

Fig. 10-12. The tower crane and bucket can easily handle concrete for tall-building construction. (69969)

Fig. 10-13. The conveyor belt is an efficient, portable method of handling concrete. A dropchute prevents concrete from segregating as it leaves the belt; a scraper prevents loss of mortar. Conveyor belts can be operated in series and on extendable booms of hydraulic cranes. (69896)

Truck-mounted Pump and Boom

Discharging from Flexible Hose

Fig. 10-16. The screw spreader quickly spreads concrete over a wide area to a uniform depth. Screw spreaders are used primarily in pavement construction. (69895)

Placing and Finishing Lecture 16

Preparation prior to placing concrete includes the following:

- Compacting, trimming, and moistening the subgrade (see Figs. **11-1**, **11-2**, and **11-3**);
- Erecting the forms;
- Setting the reinforcing steel and other embedded items securely in place.

Preparation Before Placing

Fig. 11-2. Water trucks with spray-bars are used to moisten subgrades and base course layers to achieve adequate compaction and to reduce the amount of water drawn out of concrete as it's placed. (69931)

Fig. 11-3. (top) Adequate compaction of a base course foundation for concrete pavement can be achieved by using a vibratory roller. (bottom) Vibratory plate compactors are also used to prepare subgrades under slabs. (69934, 69930)

- Concrete should be deposited continuously as near as possible to its final position without objectionable segregation.
- concrete should be placed in walls, thick slabs, or foundations in horizontal layers of uniform thickness; each layer should be thoroughly consolidated before the next is placed.
- To avoid segregation, concrete should not be moved horizontally over too long a distance.

Depositing the Concrete

Fig. 11-4. Wheelbarrows are used to place concrete in areas that are not easily accessed by other placement methods. (69929)

Fig. 11-5. The swing arm on a conveyor belt allows fresh concrete to be placed fairly evenly across a deck. (70002)

- the process of compacting fresh concrete; to mold it within the forms and around embedded items and reinforcement; and to eliminate stone pockets, honey-comb, and entrapped air.

Consolidating Concrete

Fig. 11-9. Honeycomb and rock pockets are the results of inadequate consolidation. (50207)

- hand rodding, that is, thrusting a tamping rod or other suitable tool repeatedly into the concrete.
- or by mechanical methods.

Consolidation is accomplished by

- The most widely used method for consolidating concrete.
  - Internal or immersion-type vibrators.
  - External vibrators.

Vibration

Fig. 11-11. Internal vibrators are commonly used to consolidate concrete in walls, columns, beams, and slabs. (69970)

Fig. 11-12. Vibratory screeds such as this truss-type unit reduce the work of strikeoff while consolidating the concrete. (55801)

- (1) honeycomb: spaces between coarse aggregate particles do not become filled with mortar
- (2) excessive amount of entrapped air voids;
- (3) cold joints: discontinuity resulting from a delay in placement that allowed one layer to harden before the adjacent concrete was placed.

Consequences of Undervibration

- (4) placement lines: dark lines between adjacent placements of concrete batches
- (5) subsidence cracking: as concrete settles over reinforcing steel in relatively deep elements

Consequences of Undervibration

- (1) segregation as vibration and gravity causes heavier aggregates to settle while lighter aggregates rise;
- (2) loss of entrained air in air-entrained concrete;
- (3) excessive form deflections or form damage;
- (4) form failure caused by excessive pressure from vibrating the same location too long.

Defects from overvibration include

- **Screeding (Strikeoff)**

Screeding or strike off is the process of cutting off excess concrete to bring the top surface of a slab to proper grade

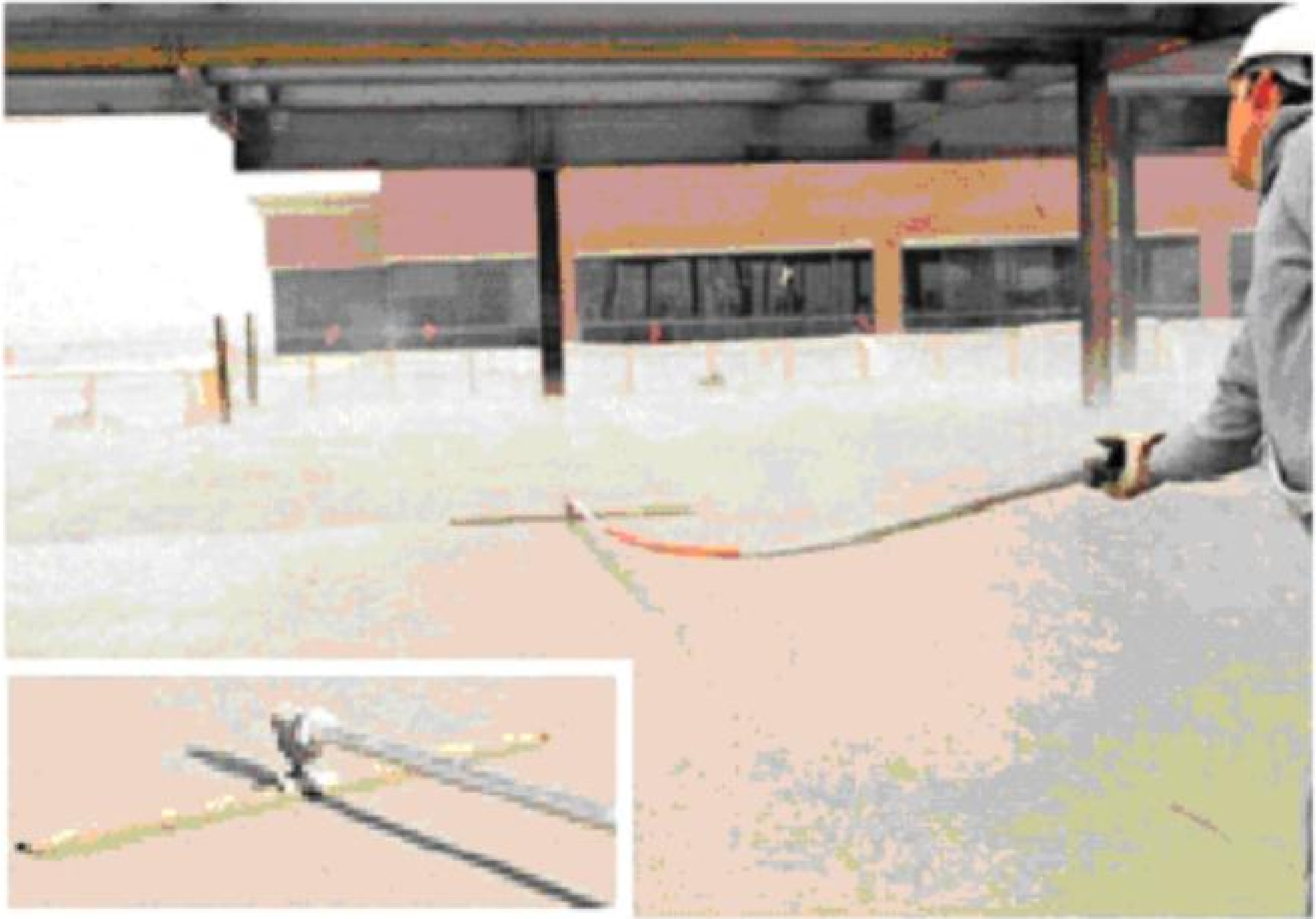
Concrete Finishing

Fig. 11-12. Vibratory screeds such as this truss-type unit reduce the work of strikeoff while consolidating the concrete. (55801)

- **Bullfloating or Darbying**

To eliminate high and low spots and to embed large aggregate particles, a bullfloat or darby should be used immediately after strikeoff.

Concrete Finishing



- **Brooming Finish**

Brooming should be performed before the concrete has thoroughly hardened, but it should be sufficiently hard to retain the scoring impression to produce a slip-resistant surface

Concrete Finishing

Fig. 11-20. Brooming provides a slip-resistant surface mainly used on exterior concrete. (69943)

Fig. 11-19. Hand floating (right hand) the surface with a hand float held flat on the concrete surface and moved in a sweeping arc with a slight sawing motion. Troweling (left hand) with blade tilted is performed before moving the knee-boards. (69933)

- Highway pavements are textured by "tining" the surface with stiff wires; this improves traction and provides vehicles with a surface that significantly reduces the chance of hydroplaning.

Concrete Finishing

Fig. 11-21. (top) This machine is tining the surface of fresh concrete. (bottom) Tining of pavements improves tire traction and reduces the risk of hydroplaning. (69944, 69945)

- A newly placed and finished concrete should be cured and protected from drying, extreme changes in temperature, and damage.
- The curing should begin immediately after finishing.

Curing and Protection

Role of Aggregates in Concrete:

- Concrete is basically a mixture of two components
- Paste (**Portland cement, water, and air**)
- Aggregate (**sand, gravel, crushed stone**)
- The aggregate occupies 70-75% of the volume of concrete, so its quality is of great importance.

- Aggregates may affect the following properties of concrete:
  - Strength
  - Durability
  - Structural Performance
  - Economy

Aggregates have 3 main functions in concrete:

1) To provide a mass of particles which are suitable to resist the action of applied loads & show better durability then cement paste alone.
2) To provide a relatively cheap filler for the cementing material.
3) To reduce volume changes resulting from setting & hardening process & from moisture changes during drying.

The properties of concrete are affected by the properties of aggregate:

1. The mineral character of aggregate affects the strength, durability, elasticity of concrete.
2. The surface characteristics of aggregate affects the workability of fresh mass & the bond between the aggregate & cement paste in hardened concrete. If it is rough, workability decreases & bond increases.
3. The grading of aggregate affects the workability, density & economy.

Aggregates:

- Aggregates are inert materials mixed with a binding material like cement or lime in the preparation of mortar or concrete.
- Granular material of mineral composition such as sand, gravel, shale, slag or crushed stone.

Uses of Aggregates:

- Filler material
- Dimensional Stability
  - shrinkage,
  - thermal changes
- Strength and Stiffness
- Economy
- To make the concrete denser

Classification of Aggregates: Natural Aggregates

- All natural aggregates particles originally formed a part of a larger parent mass.
- many properties of the aggregates depend entirely on the properties of the parent rock. E.g. chemical and mineral composition, petrological character, specific gravity etc.
- some properties are possessed by the aggregates but absent in the parent rock: particle shape and size, surface texture, and absorption.

Artificial Aggregates

- They are obtained either as a by-product or by a special manufacturing process such as heating. (blast furnace slag, expanded perlite).

Classification of Aggregates According to Petrological Characteristics:

1. Igneous rocks: are formed by solidification of molten lava. (granite)
2. Sedimentary rocks: are obtained by deposition of weathered & transported pre-existing rocks or solutions. (limestone)
3. Metamorphic rocks: are formed under high heat & pressure alteration of either igneous & sedimentary rocks (marble).

Fine Aggregates (d ≤ 5 mm)

- Particles of fine aggregates pass through 4.75mm(No.4) sieve .Most commonly used fine aggregates are sand, crushed stone, ash or cinder and surkhi.

Coarse Aggregates (d > 5 mm)

- Coarse aggregates are retained on 4.75mm sieve.
- Aggregates the size of whose particle is bigger than 4.75 mm but smaller than 37.5 mm are known as coarse aggregates.
- It specially includes gravel and crushed stones.

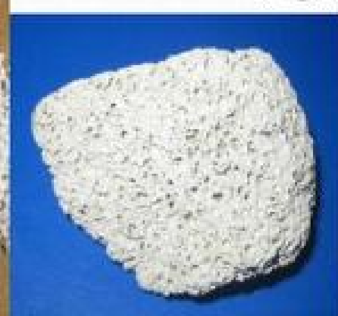
Classification of Aggregates According to Unit Weight:

1. Heavy weight agg.: Hematite, Magnetite Specific Gravity, $G_s > 2.8$
2. Normal weight agg.:Gravel, sand, crushed stone $2.8 < G_s < 2.4$
3. Light weight agg.:Expanded perlite, burned clay $G_s < 2.4$

Weight	Examples of Aggregates Used	Uses for the Concrete
ultra-lightweight	vermiculite, ceramic, diatomite, pumice, scoria, perlite,	can be sawed or nailed, also used for its insulating properties **(250 to 1450 kg/m3).**
lightweight	expanded clay, shale or slate, crushed brick	used primarily for making lightweight concrete for structures, also used for its insulating properties **(1350 to 1850 kg/m3).**
normal weight	crushed limestone, sand, river gravel, crushed recycled concrete	used for normal concrete projects
heavyweight	barlite, magnetite , steel or iron shot; steel or iron pellets	used for making high density concrete for shielding against nuclear radiation

Ultra-lightweight Aggregates

Vermiculite



Perlite Pumice Scoria Diatomite

Lightweight Aggregates

Expanded clay (left)

Expanded shale (right)

Crushed Brick

Normal weight Aggregates

River gravel

Crushed Limestone

Crushed Concrete

Heavyweight Aggregates

Magnetite (left)

Magnetite-sand (right)

Constituents in naturally occurring Aggregates:

- Naturally occurring concrete aggregates are a mixture of rocks and minerals
  - Minerals
    - Silica (ex. Quartz)
    - Silicates (ex. Clay)
    - Carbonate (ex. Calcite, dolomite)
  - Igneous rocks
    - Granite
    - Basalt
  - Sedimentary rocks
    - Sandstone
    - Limestone
    - Shale
  - Metamorphic rocks
    - Marble
    - slate

PARTICLE SHAPE & SURFACE TEXTURE:

- In addition to petrological character, the external characteristics, i.e. The shape & surface texture of aggregates are of importance.

Particle Shape

- Rounded: Completely water worn & fully shaped by attrition. (River Gravel)

- Irregular: Partly shaped by attrition so it contains some rounded edges. (Land Gravel)

- Angular: Has sharp corners, show little evidence of wear. (Crushed Stone)

- Flaky: Thickness is relatively small with respect to two other dimensions. (Laminated Rocks)

- Elongated: Have lengths considerably larger than two other dimensions.

FLAT

ELONGATED

ANGULAR

ROUND

- Rounded aggregates are suitable to use in concrete because flaky & elongated particles reduce workability, increase water demand & reduce strength.

- In the case of angular particles, the bond between agg. Particles is higher due to interlocking but due to higher surface area, angular particles increase water demand & therefore reduce workability. As a result, for the same cement content & same workability rounded agg. Give higher strength.

Grading of Aggregates:

- Grading is the particle-size distribution of an aggregate as determined by a sieve analysis using wire mesh sieves with square openings.

According to ASTM

Fine aggregate - 7 standard sieves with openings from 150 µm to 9.5 mm

Coarse aggregate - 13 sieves with openings from 1.18 mm to 100 mm

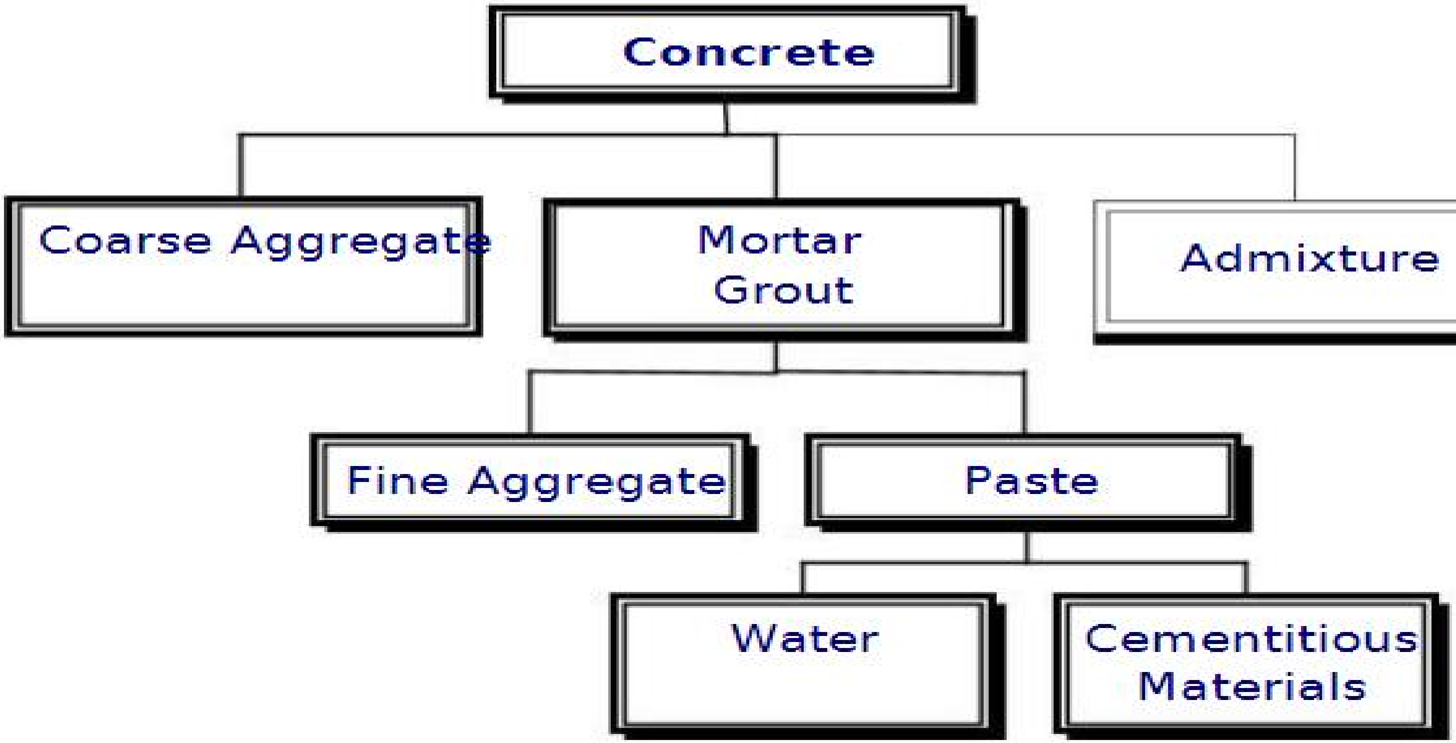
	IS Sieves
	125 mm
	90 mm
Sieves for Fine	63 mm
Aggregates	31.5 mm
	16 mm
	8 mm
	4 mm
	2 mm
	1 mm
	0.5 mm
	0.25 mm

	IS Sieves
	125 mm
	100 mm
	90 mm
	75 mm
Sieves for	63 mm
Coarse	50 mm
Aggregates	37.5 mm
	25 mm
	12.5 mm
	9.5 mm
	4.75 mm
	2.38 mm
	1.19 mm
	0.595 mm
	0.297 mm
	0.149 mm

CHAPTER-4
CONCRETE

What is Concrete?

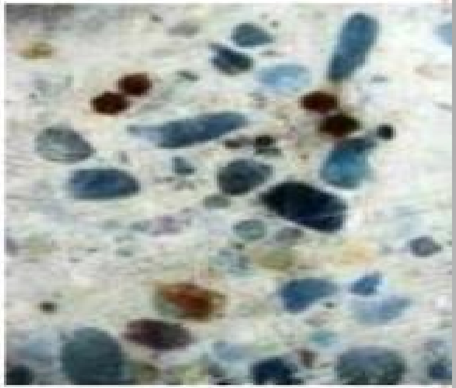
- ✓ Concrete is one of the most commonly used building materials.
- ✓ Concrete is a composite material made from several readily available constituents (aggregates, sand, cement, water and aamixture (if required).
- ✓ Concrete is a versatile material that can easily be mixed to meet a variety of special needs and formed to virtually any shape

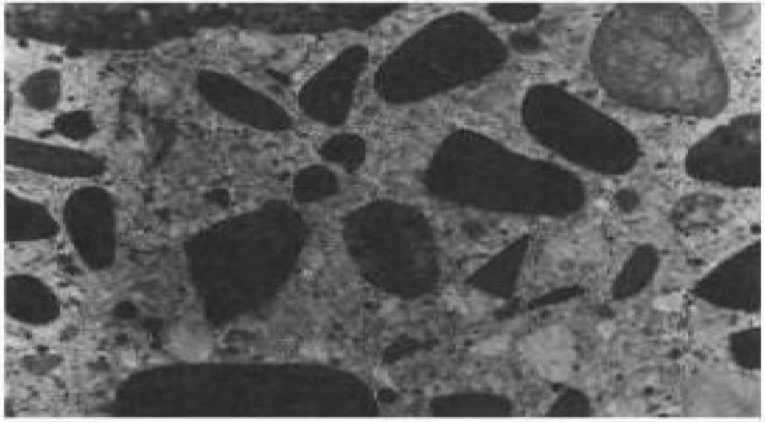


Concrete
Coarse Aggregate
Mortar
Grout
Admixture
Fine Aggregate
Paste
Water
Cementitious
Materials

Concrete Constituents

- Cement
- Fine Aggregate (sand)
- Coarse Aggregate
- Water
- Admixtures (If necessary)





Voids (2 – 8 %)
Cement paste (25 - 40 %)
Aggregates (60 - 75 %)

ADMIXTURES

What?

 Admixture is a material added to plastic (fresh) concrete or mortar before or during mixing.

Why?

 To change one or more properties of fresh or hardened concrete.

When to use admixture?

 When the desired modification of properties of fresh or hardened concrete cannot be achieved by changing the composition of the mix proportion or by using different types of cement.

Types of admixtures

 Chemical admixtures:

 Mineral/Pozzolanic admixtures

Types of Admixture Effects

- Accelerating admixture: Accelerate setting time and rate of hydration, early strength development
- Retarding admixture: Delay setting time and rate of hydration
- Water reducer: Reduce water content; increase strength
- Air entraining admixture: Protect against freeze thaw cycles

Application

- Used in cold-weather condition, rapid removal of formwork or urgent repair work.
- When early strength is required.

Compressive strength at 3 days at least 25 % higher than normal concrete.

Cement + Coarse Aggregate + Fine aggregate + Water + Admixtures

Hydration of cement paste

↓

Fresh concrete → Plastic state

(can be placed and compacted)

↓

Hardened concrete

(retains shape, develops strength)

Use of concrete

- For building construction
- For road construction especially in bridge and rigid pavement(Portland Cement Concrete Pavement)
- For construction of reinforced concrete dam
- As a bedding material of different substructures

Concrete Quality

- Achieve the required strength / grade
- Workable
- Enough time for placing before setting
- Free from defects after formwork is removed (Uniform appearance of hardened concrete)
- Durable

The quality of concrete is governed

- Chemical composition of Portland cement Hydration
- Aggregate characteristics
- Amount of water
- Admixtures

- The raw materials must be properly proportioned to ensure a quality concrete.

The quality of concrete will also be affected by

- Methods of mixing
- Transporting
- Placing
- Compaction
- Curing

During constructior

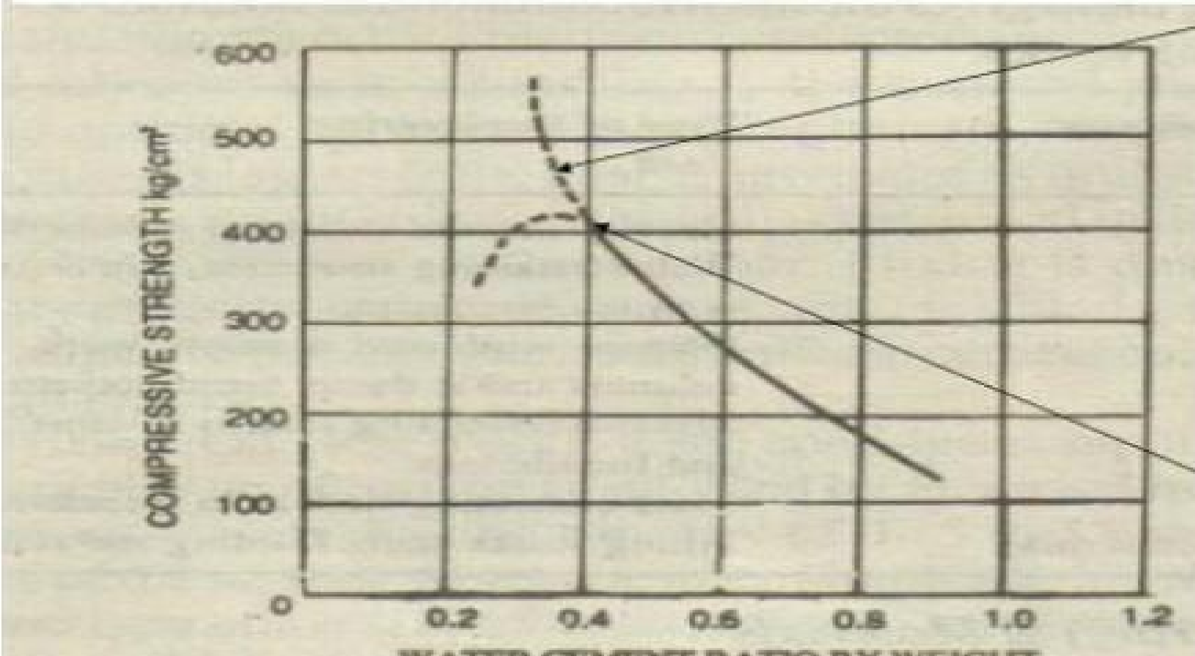
Properties of Concrete

- **Water Cement ratio (w/c ratio)**

$$= \frac{\text{weight of water in the mix}}{\text{weight of cement in the mix}}$$

- Water-cement ratio affects
  - strength and durability of concrete
  - workability of concrete
- Water-cement ratio for
  (a) Normal strength concrete – 0.45 to 0.6
  (b) High strength concrete – < 0.45

Variation of Strength with W/C ratio (Cube strength at 28 days)



Variation of Strength with W/c Ratios
(Cube strength at 28 days)

Achieved under goo compactio by mechanica vibration

Below 0.4 strength decrease because concrete i not workable

Presentation on

Principles of Concrete &
Concrete Mix Design- IS 10262

Concr ete

- Concrete is an intimate mixture of:

  Cement,

  Sand (Fine

  Aggregate), Coarse

  Aggregate, Water.

- New Generation Concrete needs use of Special Materials in addition to above i.e. “ADMIXTURES”
- Admixtures may be Mineral or Chemical Admixtures.

Concrete

Versatility of making concrete with locally available materials, ease in moulding it into any shape and size and economy in its making has made concrete the 2nd largest consumed material on earth!!

Concr
ete

Structures of such dimensions possible today due to developments in Concrete.

Requirements of Good Concrete

A good concrete should:

- meet the strength requirements as measured by compressive strength,
- fulfill durability requirements to resist the environment in which the structure is expected to serve,
- be mixed, transported and compacted as efficiently as possible and
- will be as economical as possible.

Concrete Durability

- “Durability of concrete is the ability of concrete to withstand the harmful effects of environment to which it will be subjected to, during its service life, without undergoing into deterioration beyond acceptable limits”.

- Durability can be assured keeping in view the environment exposure of structure, certain minimum cement binder content, max limit on w/c ratio and a certain minimum grade of concrete for that particular exposure.

Making Durable Concrete

- Lowering the porosity and permeability of concrete is only way to reduce environmental attacks on concrete,

- Dense and compact concrete that prevents the ingress of harmful elements is the key to "*DURABLE CONCRETE*".

Making Good Concrete

Making good concrete involves:

- Good quality raw materials,
- Proportioning of materials,
- Mixing,
- Transporting,
- Placing,
- Compacting,
- Curing.


CEMENT

Cement

- Cement is a fine powder, which when mixed with water and allowed to set and harden can join different components or members together to give a mechanically strong structure.
- Although the percentage of cement in concrete is around 15%, the role of cement is very important in the strength and durability of concrete.

Selection of good quality cement is therefore essential.

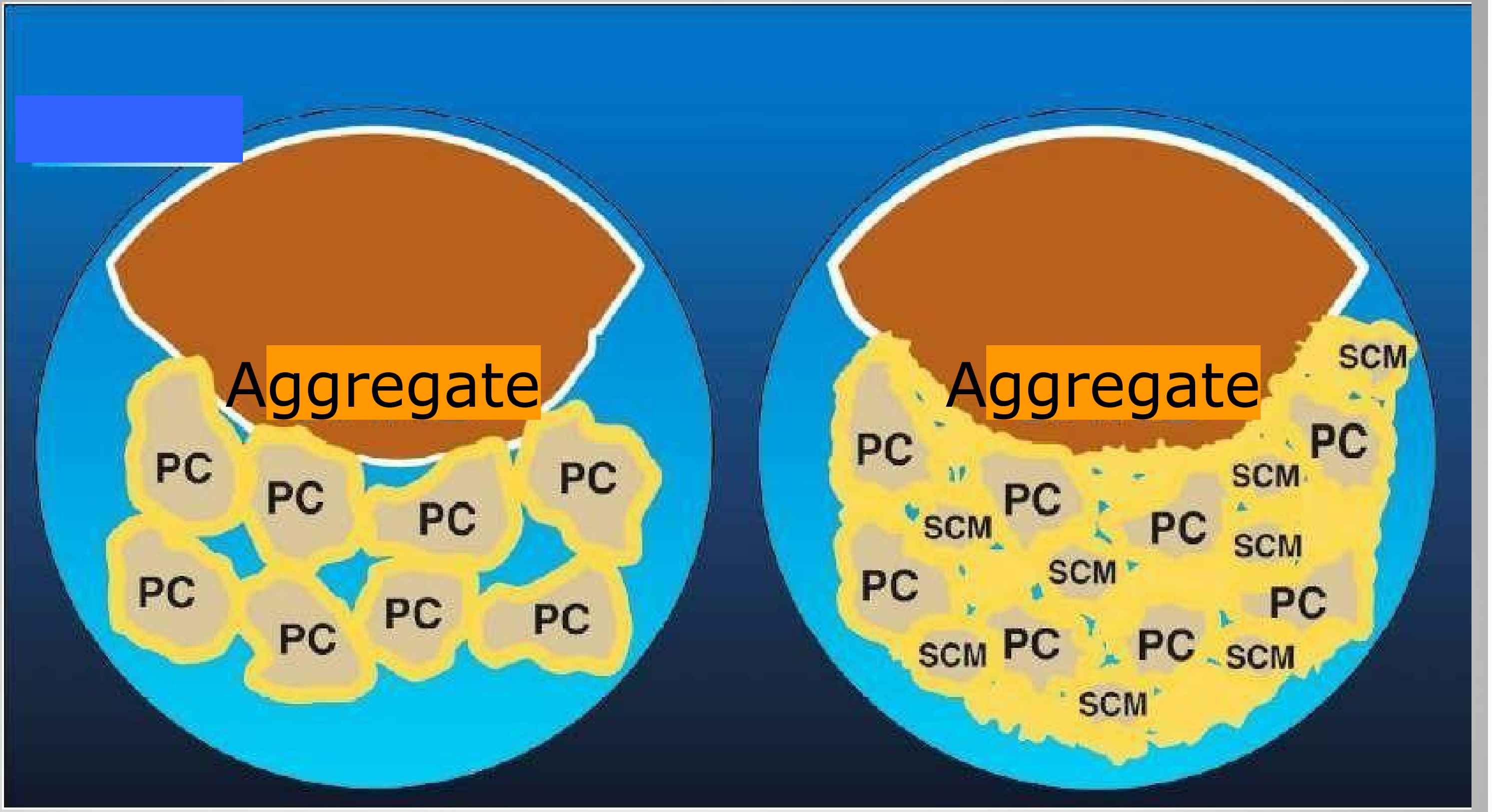
Types of Cement

Although around 18 types of cements are recognized by BIS, more commonly used ones are:

- Ordinary Portland Cement 33, 43, & 53 grade OPC,
- Blended Cements (PPC and PSC).
- Sulphate Resisting Cement
- (SRC),
- Low Heat Portland Cement (LHPC),
- Hydrophobic Portland Cement,

Coloured Cement (White Cement).

Advantages of Blended Cements



Ideal Applications of PPC/ PSC

Structures within/ along the Sea Coast

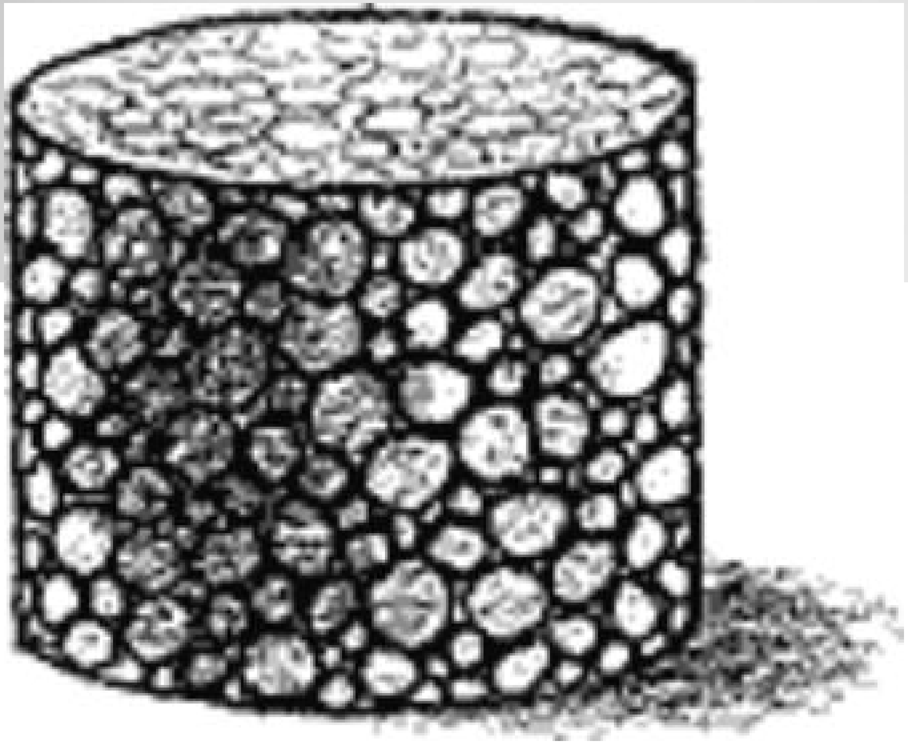
Mass Concrete structures, huge foundations

Sewage and Water Treatment Plants

Port Facility/ Jetty

Gradation of Aggregates

Densely packed Graded Aggregates, less voids



Gradation of Aggregates

Single Size Aggregates with more voids

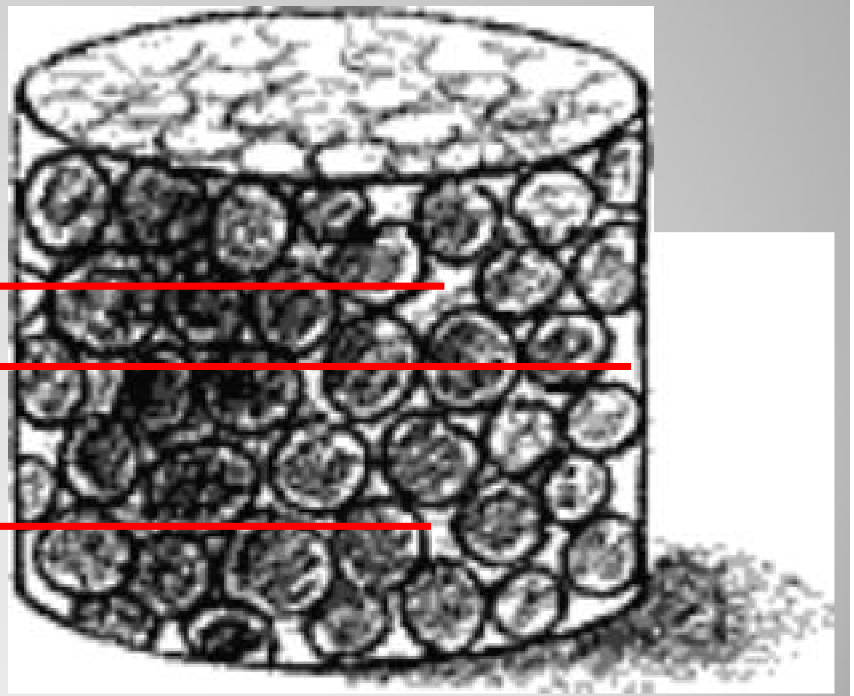
VOIDS

&

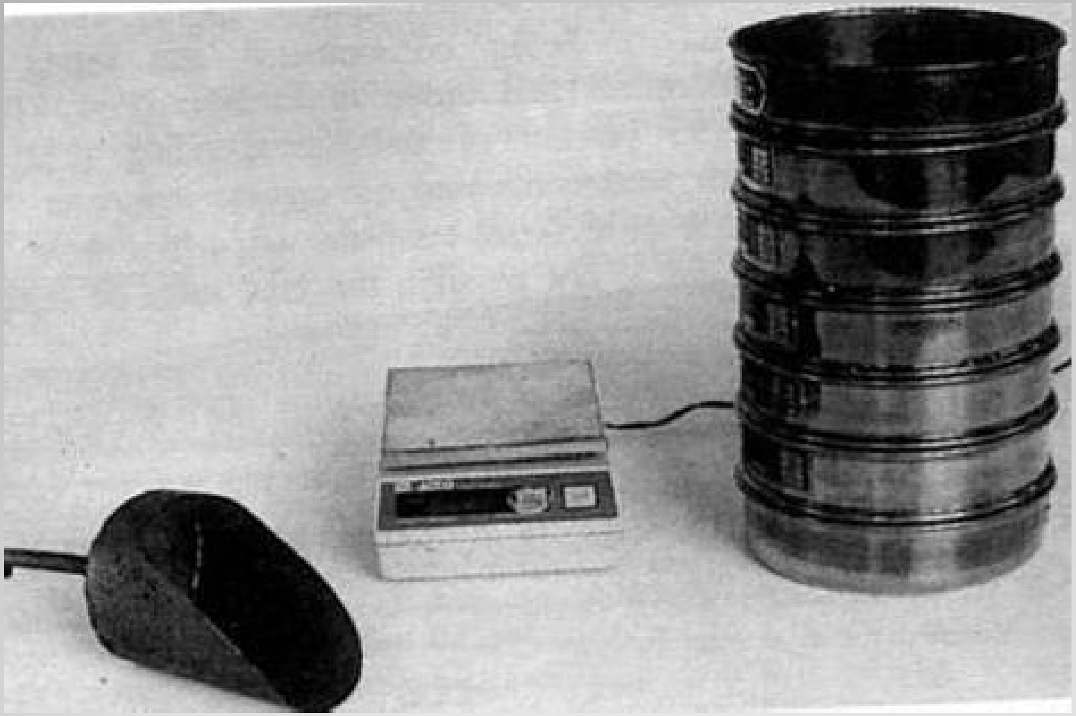
EMPT

Y

SPACES



Sieve Analysis



Equipments for Sieve Analysis Test on Aggregates

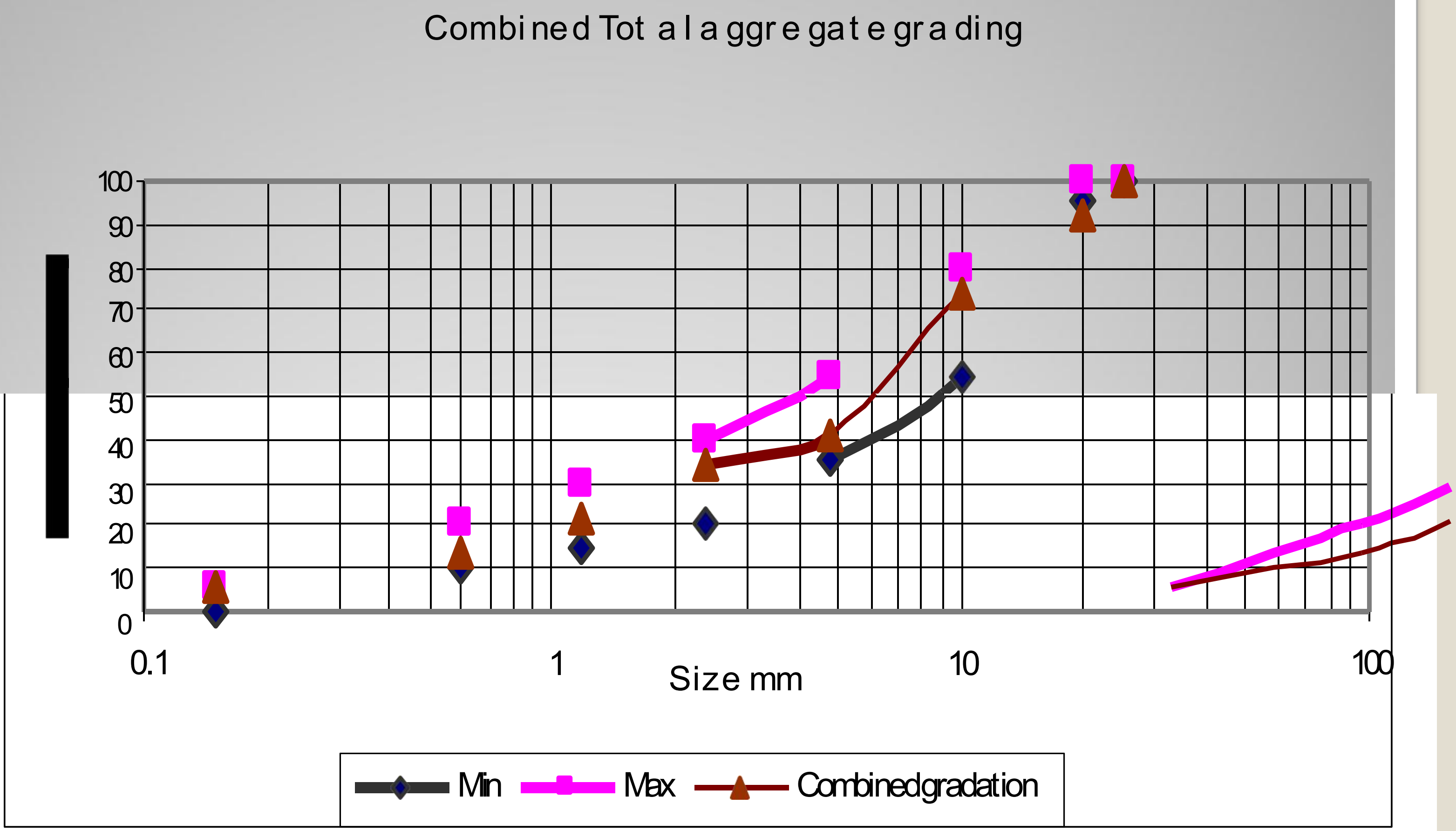
Gradation Limits as per IS 383

IS sieve	Zone I	Zone II	Zone III	Zone IV
4.75 mm	90- 100	90- 100	90- 100	90- 100
2.36 mm	60- 95	75- 100	85- 100	95- 100
1.18 mm	36- 70	55- 90	75- 100	90- 100
600 micron	15- 34	35- 59	60- 79	80- 100
300 micron	5- 20	8- 30	12- 40	15- 50
150 micron	0- 10	0- 10	0- 10	0- 15
Remarks	V. Coarse	Coarse	Medium	Fine

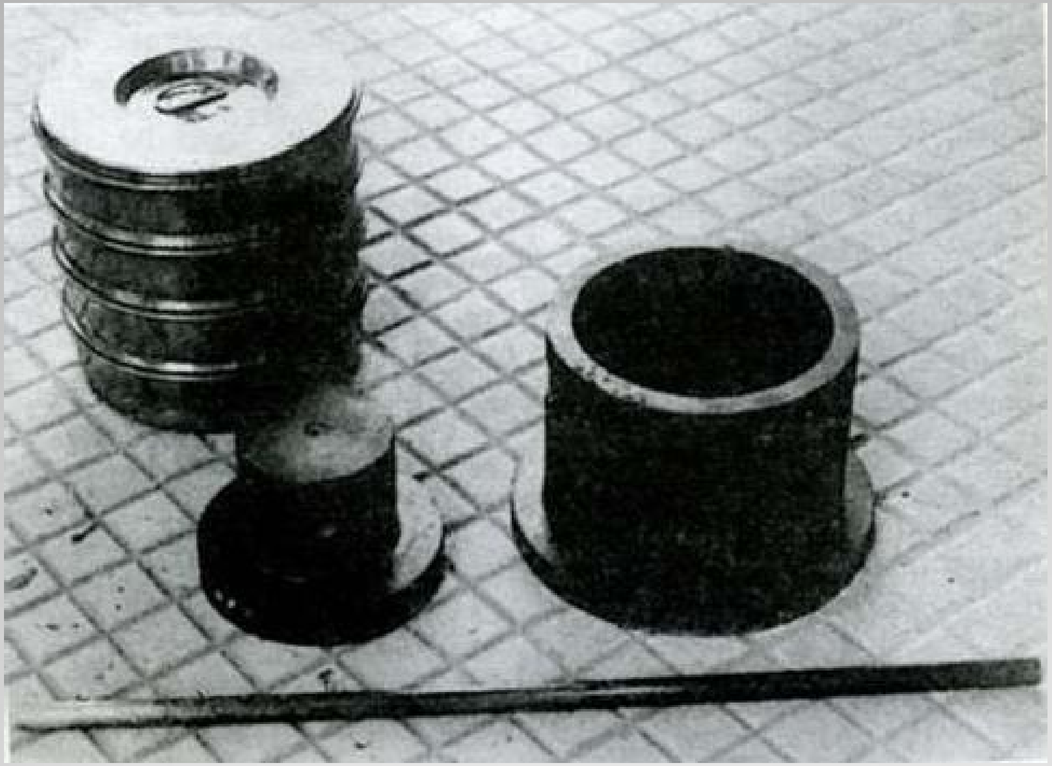
IS Limits for Graded Coarse Aggregates

IS sieve size	40 mm MAS % passing	20 mm MAS % passing	10 mm MAS % passing
40 mm	95- 100	100	100
20 mm	30- 70	95- 100	100
10 mm	10- 35	25- 55	40- 85
4.75 mm	0- 5	0- 10	0- 10

Combined Grading of CA & FA



Aggregate Crushing Value



Equipments for Crushing Value Test on Aggregates

Important mechanical properties of Aggregates

Properties	Limiting values, percent	
	For wearing surfaces	Other than wearing surfaces
Crushing Value	30	45
Impact Value	30	45
Abrasion Value (Los Angeles)	30	50

Properties of Aggregates

Specific Gravity	Indicates density & crushing strength,
Surface Texture	Rough texture for bond,
Particle Shape	Should be cubical and not flaky and elongated,
Porosity	Should have very low water absorption,
Stability	Be chemically inert,
Impurities	Free from organic/ mineral impurity,
Compactness	Should be graded, for reducing voids.

Typical limits for solids in water

Solids	Permissible limits, max, mg/ l
Organic	200
Inorganic	3000
Sulphates (as SO_3)	400
Chlorides (as Cl)	
▪ For plain concrete	2000
▪ For reinforced concrete	500
Suspended matter	2000

Limits of Chloride content of Concrete

Type or use of concrete	Maximum total acid soluble chloride content expressed as kg/m^3 of concrete
Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
Reinforced concrete or plain concrete containing embedded metal	0.6
Concrete not containing embedded metal or any material requiring protection from chloride	3.0

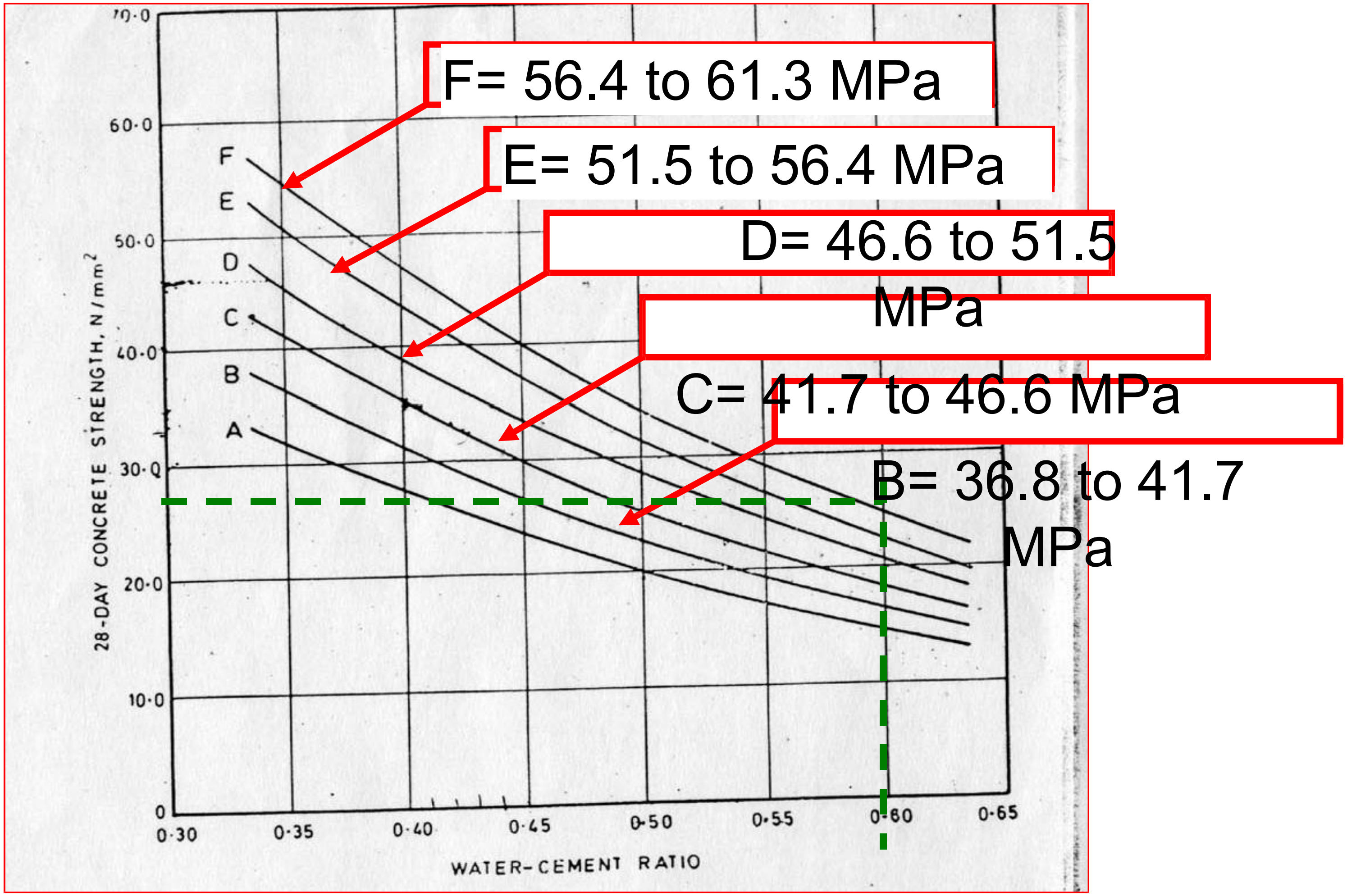
Durability Criteria as per IS 456- 2000

Exposure	Plain Concrete			Reinforced Concrete		
	Min. Cement	Max w/c	Min grade	Min. Cement	Max w/c	Min grade
Mild	220 kg/m3	0.60	--	300 kg/m3	0.55	M 20
Moderate	240 kg/m3	0.60	M 15	300 kg/m3	0.50	M 25
Severe	250 kg/m3	0.50	M 20	320 kg/m3	0.45	M 30
V. Severe	260 kg/m3	0.45	M 20	340 kg/m3	0.45	M 35
Extreme	280 kg/m3	0.40	M 25	360 kg/m3	0.40	M 40

Durability Criteria as per IS 456- 2000

Adjustments to minimum cement content for aggregates other than 20 mm nominal max. size aggregates as per IS 456: 2000.

10 mm	+ 40 kg/cum
20 mm	0
40 mm	- 30 kg/cum



F= 56.4 to 61.3 MPa
E= 51.5 to 56.4 MPa
D= 46.6 to 51.5 MPa
C= 41.7 to 46.6 MPa
B= 36.8 to 41.7 MPa
70·0
60·0
50·0
40·0
30·0
20·0
10·0
0
F
E
D
C
B
A
28-DAY CONCRETE STRENGTH, N/mm²
0·30
0·35
0·40
0·45
0·50
0·55
0·60
0·65
WATER-CEMENT RATIO

Workability of Concrete

Placing condition	Degree	Slump (mm)	Compaction factor
Mass concrete, lightly reinforced sections in beams, walls, columns and floors	LOW	25 to 75	0.8 to 0.85
Heavily reinforced sections in slabs, beams, walls, columns and footings	MEDIUM	50 to 100	0.9 to 0.92
Slip formwork, pumped concrete, in- situ piling	HIGH	100 to 150	0.95 to 0.96

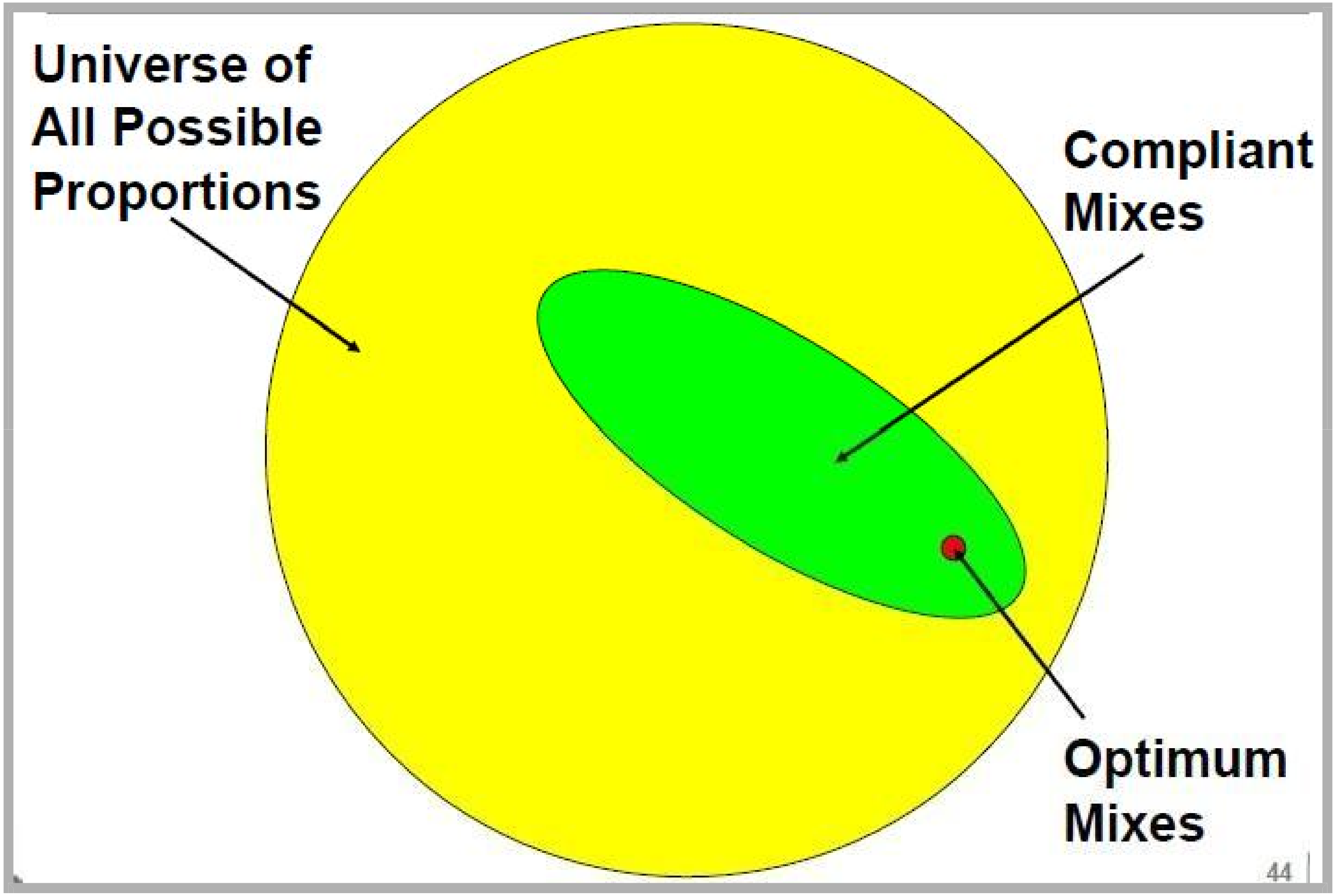
Concrete Mix Design - Definition

- Concrete mix design is defined as the appropriate selection and proportioning of constituents to produce a concrete with pre-defined characteristics in the fresh and hardened states.

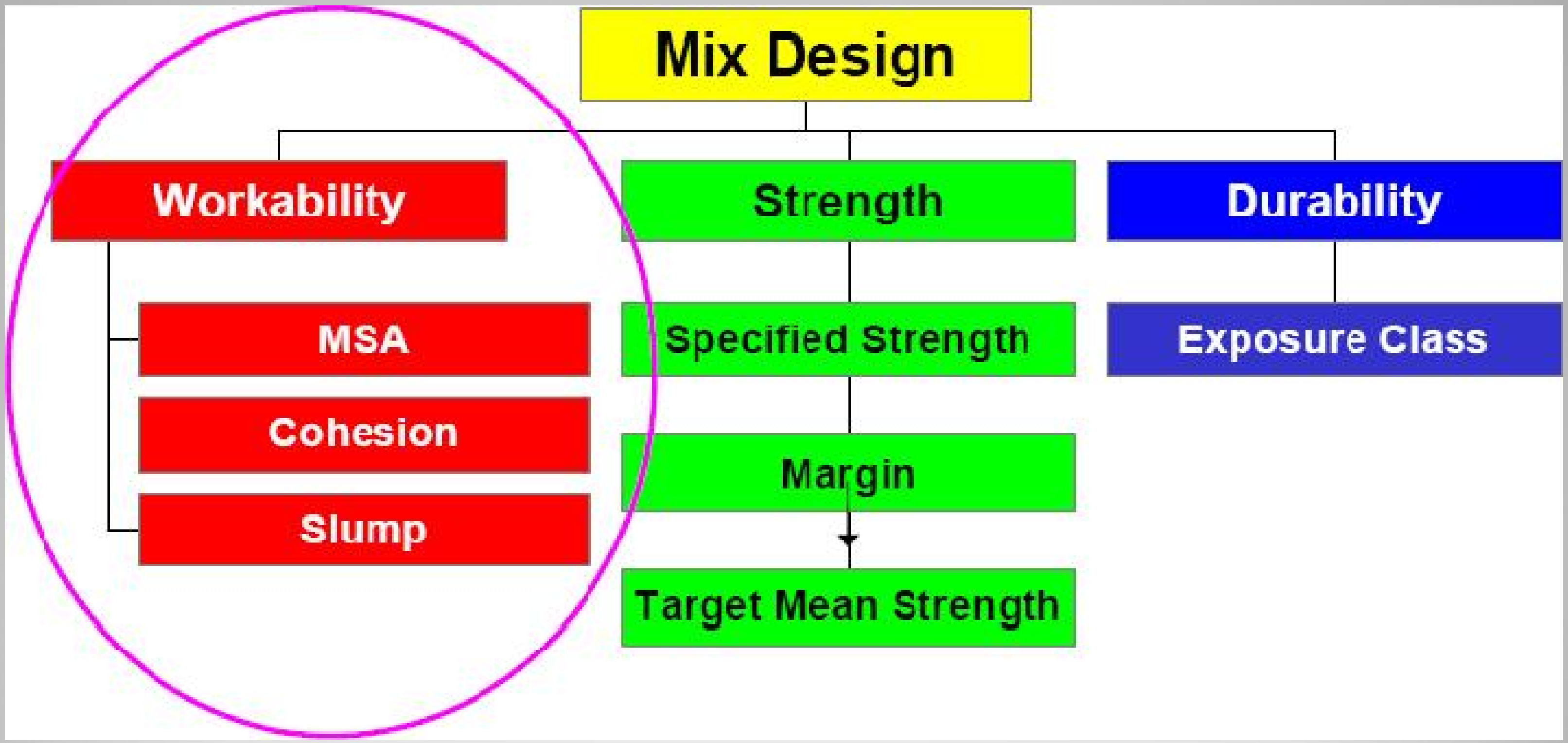
- In general, concrete mixes are designed in order to achieve a defined workability, strength and durability .

- The selection and proportioning of materials depend on:
  - the structural requirements of the concrete
  - the environment to which the structure will be exposed
  - the job site conditions, especially the methods of concrete production, transport, placement, compaction and finishing
  - the characteristics of the available raw materials

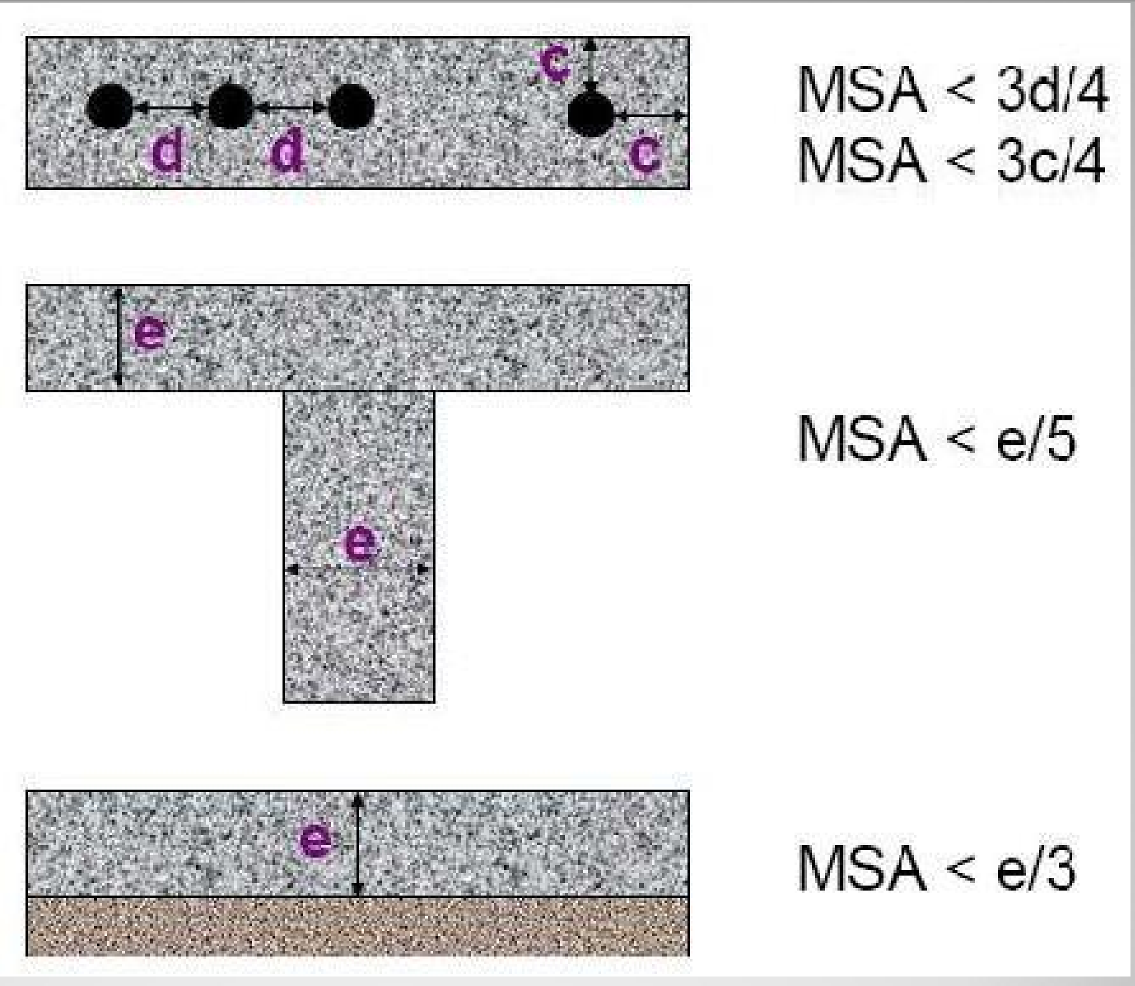
Mix Design (Technically Compliant Mixes) vs. Mix Optimization (Lowest Cost Compliant Mixes)



Main Aspects to be considered in Mix Design



Limits to MSA



Factors Influencing Consistency (Slump)

- The consistency of fresh concrete depends on many factors, the main ones being:
  - Water Content (kg/m3)
  - W/c Ratio
  - Fineness Modulus of the Aggregate
  - Use of Water Reducers (Plasticizers / Super plasticizers)
  - Type and shape of Aggregate
  - Entrained Air Content

- There are other secondary factors too, such as:
  - Mix temperature, aggregates’ dust, cement type, additions (silica fume, fly-ash, slag, fibers), etc.

Durability Constraints

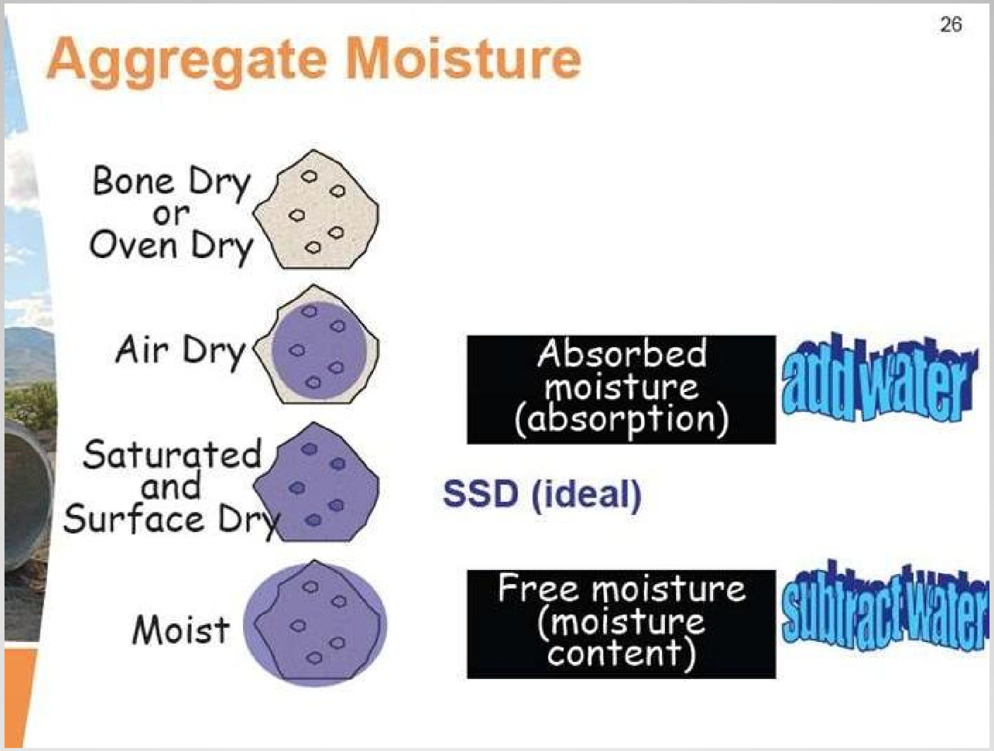
- Usually, durability requirements end in some constraints to the maximum W/C ratio and/or to the minimum cement content of the mix.

- Very often these requirements are more stringent than those demanded by the strength requirements, which usually ends in concretes which are overdesigned in strength.

Factors affecting Strength

- The strength of hardened concrete depends on many factors, the main ones being:
  - W/C Ratio
  - Strength of the Cement
  - Type and shape of Aggregate
  - Entrained Air Content
- There are other secondary factors too, such as:
  - Mix temperature, etc.

Aggregate Moisture



Concrete Mix Design steps by IS: 10262 First Revision - 2009

Determine Target mean strength of concrete as:

$$f_t = f_{ck} + k.\ s$$

where, f_t = target mean compressive strength at 28 days,

f_{ck} = Characteristic compressive strength of concrete at 28 days,

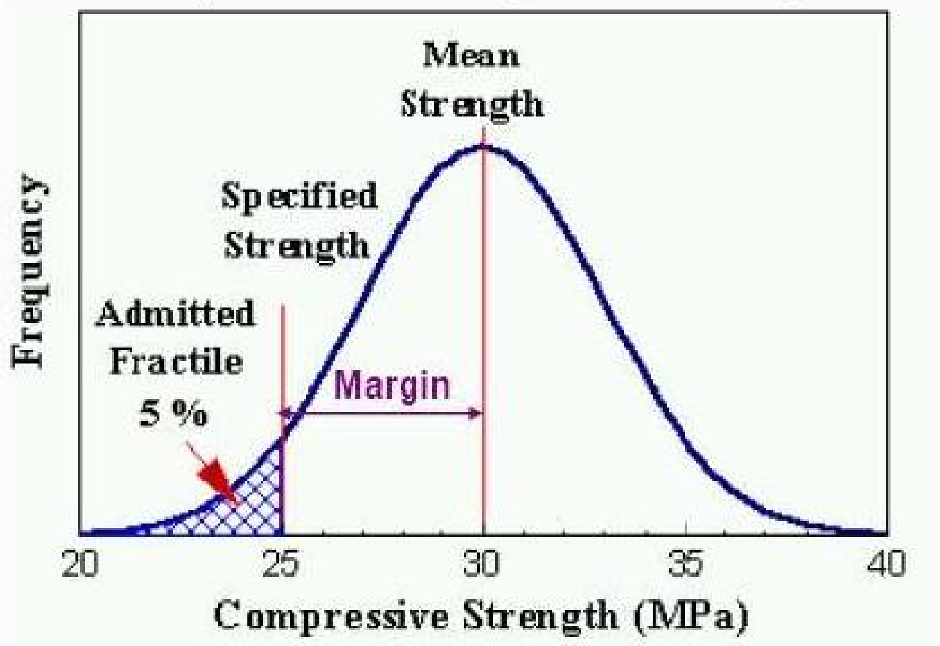
Step 1

k = usually 1.65 as per is 456-2000

s = standard deviation.

Specified and Target Mean Strength

- The specified strength, is a statistical minimum value of strength. It is a value of strength such that only a given % (the Admitted Fractile or „defectives“) of results is expected to show lower strengths.
- The graph illustrates the meaning of the Specified Strength, the Admitted Fractile (5% in this case) and the Target Mean Strength.

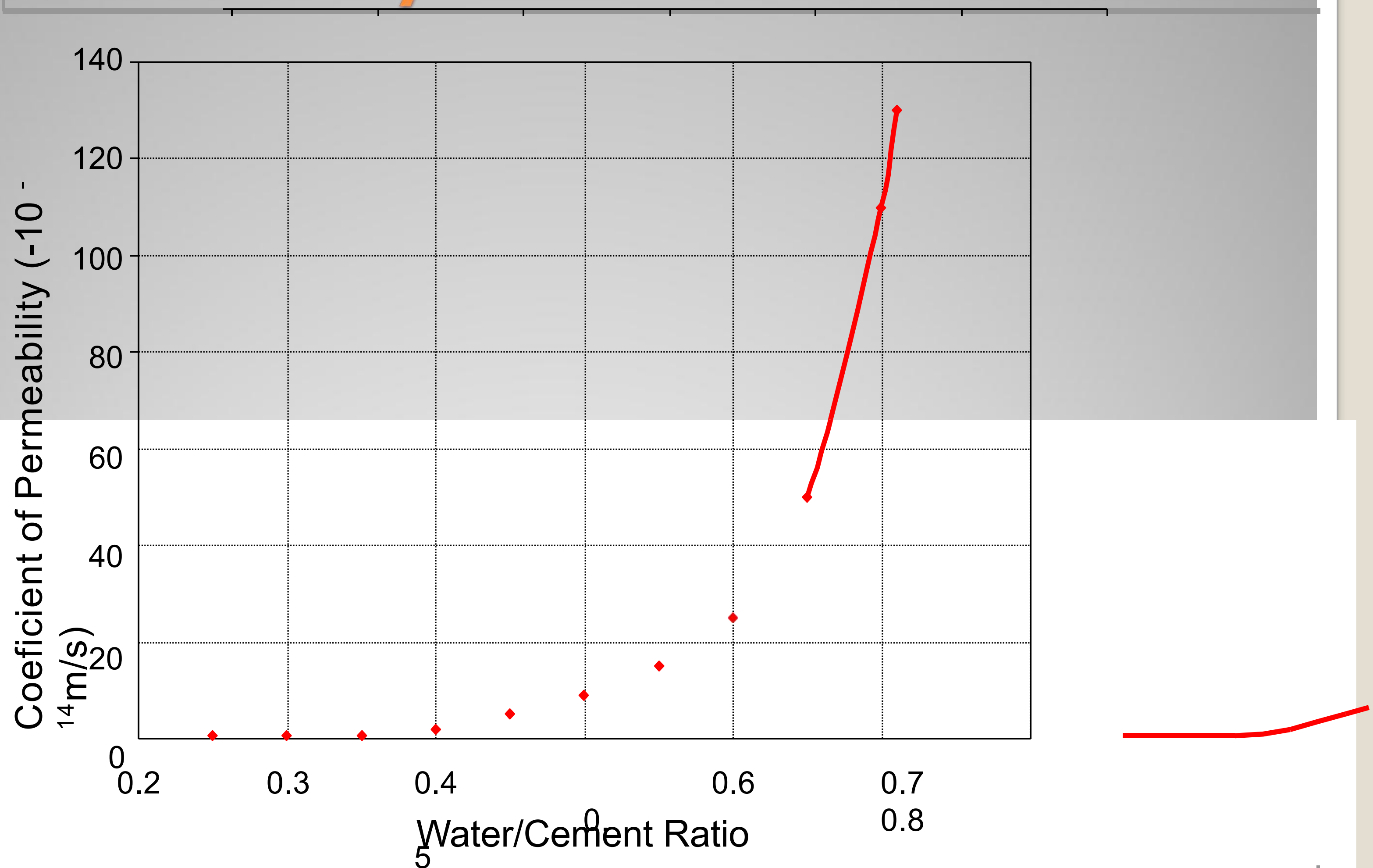


Grade of concrete	Assumed Standard Deviation
M 10	3.50 N/ mm^2
M 15	
M 20	4.00 N/ mm^2
M 25	
M 30	5.00 N/ mm^2
M 35	
M 40	
M 45	
M 50	

Chosen the Right w/c Ratio

- Studies show that capillary porous start to be connected when w/c is higher than 0.40
- When w/c is higher than 0.70, all capillary porous are connected
- Based on this:
  - Standards tend to establish 0.70 as the maximum value for w/c ratio
  - Higher is the aggressiveness of the environment lower should be the w/c ratio
  - For concrete exposed to a very aggressive environment the w/c should be lower that 0.40

Relationship Between W/C and Permeability



After Neville (1995) Properties of Concrete

Step 2 (Selection of Water-Cement Ratio)

Choose w.c.ratio against max w.c.ratio for the requirement of durability. (Table 5, IS:456-2000)

Make a more precise estimate of the preliminary w/c ratio corresponding to the target average strength.

Durability Criteria as per IS 456- 2000

Exposure	Plain Concrete			Reinforced Concrete		
	Min. Cement	Max w/c	Min grade	Min. Cement	Max w/c	Min grade
Mild	220 kg/m^3	0.60	--	300 kg/m^3	0.55	M 20
Moderate	240 kg/m^3	0.60	M 15	300 kg/m^3	0.50	M 25
Severe	250 kg/m^3	0.50	M 20	320 kg/m^3	0.45	M 30
V. Severe	260 kg/m^3	0.45	M 20	340 kg/m^3	0.45	M 35
Extreme	280 kg/m^3	0.40	M 25	360 kg/m^3	0.40	M 40

Durability Criteria as per IS 456- 2000

Adjustments to minimum cement content for aggregates other than 20 mm nominal max. size aggregates as per IS 456: 2000.

10 mm	+ 40 kg/cum
20 mm	0
40 mm	- 30 kg/cum

Estimate the air content for maximum size of aggregate used

Approximate Entrapped Air Content

Max. size of Aggregate (mm)	Entrapped air as % of concrete
10	3.0
20	2.0
40	1.0

Step 3

Step 3 – Selection of Water Content

- Water Content is Influenced By:
  - Aggregate size
  - Aggregate shape and texture
  - Workability required
  - Water cement ratio
  - Cementations material content
  - Environmental exposure condition

Nominal Max aggregate size	Water content per cum of concrete (kg)
10	208
20	186
40	165

- For angular coarse aggregates – SSD condition

- Slump 25 – 50 mm

For Other Conditions

Condition	Correction
Sub-Angular Aggregates	- 10 Kg
Gravel + Crushed Particles	- 20 Kg
Rounded Gravel	- 25 Kg
For every slump increase of 25 mm	+ 3 %
Use of Water Reducing Admixture	- 5 to 10 %
Use of Superplasticzing Admixtures	- 20 %

Step 4 – Calculation of Cementations Material

Calculate the cement content from W/C ratio and final water content arrived after adjustment.

Check the cement content so calculated against the min. cement content from the requirement of durability. Adopt greater of the two values.

Step 5 – Estimation of Coarse Aggregate Proportion

- For W/C ration of 0.5 use following Table

(T

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate

(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

Correction in Coarse Aggregate values

The table specified for W/C ratio of 0.5

1. For Every +0.05 change in W/C ratio: -0.01
2. For Every -0.05 change in W/C ratio: +0.01
3. For Pumpable Mix : -10 %

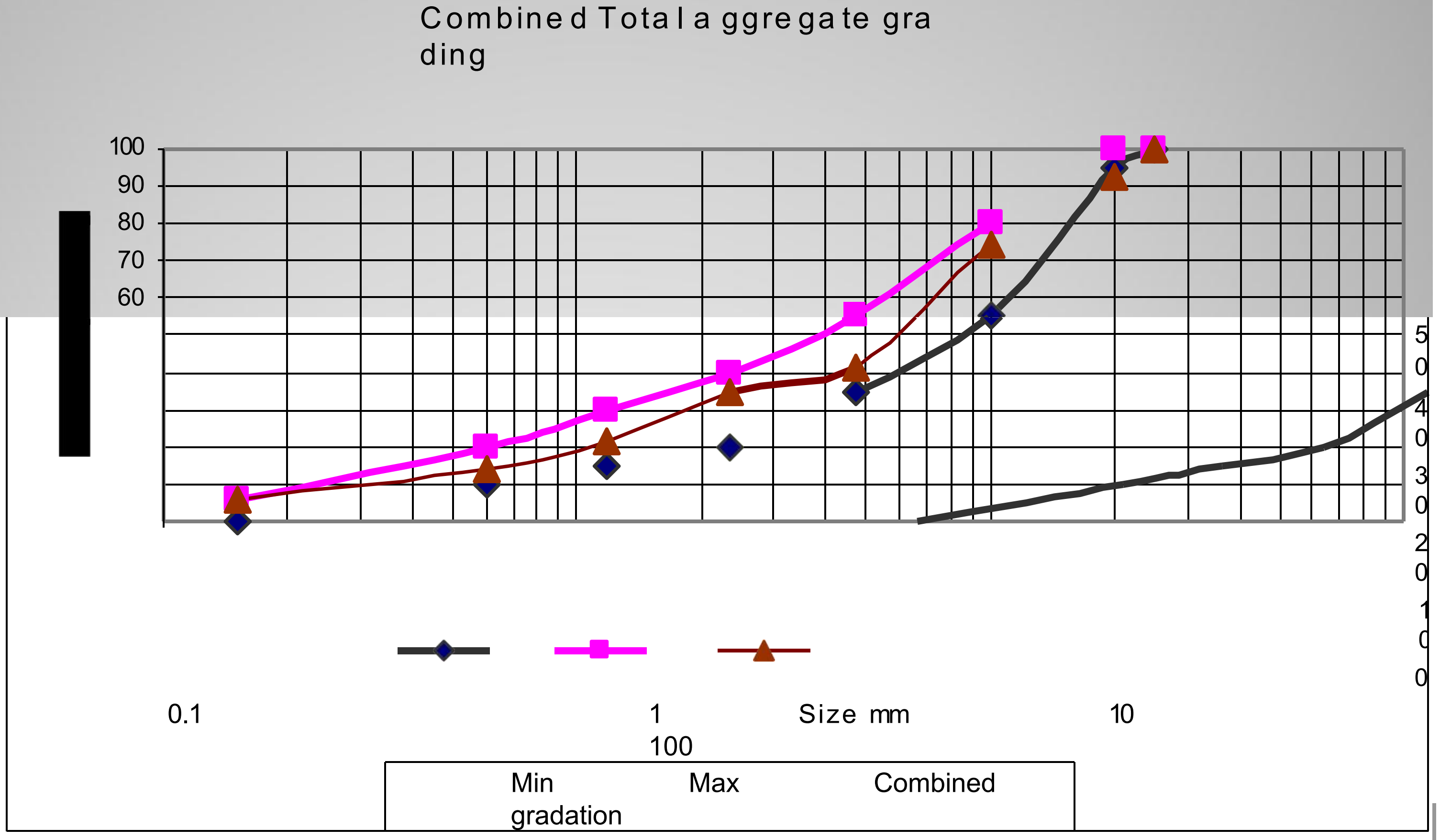
Step 6 – Combination of Different Coarse Aggregate Fraction

- It can be done based on IS 383

IS Sieve designation (mm)	Percentage passing for Graded aggregates of nominal size (by Weight)			
	40 mm	20 mm	16 mm	12.5 mm
80	100			
63				
40	95- 100	100		
20	30- 70	95- 100	100	100
16			90- 100	
12.5				90- 100
10	10- 35	25- 55	30- 70	40- 85
4.75	0- 5	0- 10	0- 10	0- 10
2.36				

IS Sieve designation	Percentage passing by weights for all in aggregates of	
	40 mm nominal size	20 mm nominal size
80 mm	100	--
40 mm	95- 100	100
20 mm	45- 75	95- 100
4.75 mm	25- 45	30- 50
600 micron	8- 30	10- 35
300 micron	0- 6	0- 6

Combined Grading of CA & FA



Step 7 – Estimation of Fine Aggregate Proportion

a Volume of Concrete = 1 m3

b Volume of Cement = (Mass of Cement / SG of Cement) * 1/1000

c Volume of Water = (Mass of Water / SG of Water) * 1/1000

d Volume of Chemical Admixture

(2 % of Mass of cementations material)

= (Mass of Admixt. / SG of Admixt) * 1/1000

e Volume of All in Aggregates = [a - (b + c + d)]

f Mass of Coarse aggregate = e * Volume of coarse aggregate * SG of coarse aggregate * 1000

g Mass of fine aggregate = e * Volume of fine aggregate * SG of fine aggregate * 1000

Major Changes

S.N.	Old Edition	Revised 2009 Edition
1	Title - " Recommanded guidelines for Concrete mix Design"	Title - "Concrete mix Proportioning - Guidelines"
2	Applicability was not specified for any specific Concrete Grades	Specified for Ordinary (M 10 - M 20) and Standard (M25 - M 55) Concrete Grades only.
3	Based on IS 456 : 1982	Modification in line with IS 456 : 2000
4	W / C ratio was based on Concrete grade and 28 days compressive strength of Concrete and the durability criteria	W/C ratio is based on Durability criteria and the Experience and Practical trials
5	Water Content could be modified taking into account the compaction factor value (Laboratory based test for Workability) and the shape of aggregates.	Water content can be modified Based on Slump vale (Field test of Workability) and Shape of Aggreagtes, and use of Admixtures.
6	Entrapped Air cotent considered according to Nominal Maximum size of Aggregates	No Entrapped Air content taken into account
7	Not much Consideration for Trial Mixes	Trial Mixes concept is mentioned
8	Concrete Mix Design with Fly ash is not mentioned	An illustrative example of Concrete Mix Prportioning using Fly ash has been added

Nominal Mixes for Concrete

Proportions for Nominal Mix Concrete

Grade of Concrete	Total qty of dry aggregate (CA + FA) per 50 kg cement	Proportion of FA to CA by volume	Water per 50 kg cement (max) lit
M 5	800	1: 2 (Zone II) subject to upper limit of 1: 1.5 (Zone I) & lower limit of 1 : 2.5	60
M 7.5	625		45
M 10	480		34
M 15	330		32
M 20	250		30

Example for Nominal Mixes

- Grade of Concrete: M 20
- Total Aggregate (CA + FA) per 50 kg cement: 250 kg, FA of Zone II (say)
- Water content: 30 lit per 50 kg cement
- w/c ratio= 30/50= 0.60
- Considering FA: CA= 1: 2,
  - Sand= (250 X 1)/ 3= 83 kg
  - Coarse Aggregate= (250 X 2)/ 3= 167 kg

Cement	FA	CA	Water
50 kg (35 Lit)	83 kg	167 kg	30 lit

Cement	FA	CA	Water
50 kg	83 kg	167 kg	30 lit
(by weight) 1	1.66	3.32	0.6
1.43 kg/ lit	1.52 kg/ lit	1.60 kg/ lit	
35 lit	54.6 lit	104.4 lit	30 lit
(by volume) 1	1.56	2.98	

M 20 Grade Concrete (by Volume) is 1: 1 ½ : 3

Thank You