A Technical Presentation

D.V .Bhavanna Rao M.Tech., F.I.E.,
PM, TPQA, NCRMP
egis-India
consulting engineering services

Important Aspects in Construction of Structures

egis International
Formerly Egis Bceom International

In Joint Venture

egis India
consulting engineers pvt. ltd.

Ingredients of Cement Concrete

- Cement
- Water
- Coarse Aggregate
- Fine Aggregate
- Admixtures

ORDINARY PORTLAND CEMENT (IS:456-2000)
BLENDED CEMENTS

Grades:33,43 and 53

GRADES of CONCRETE

i) Ordinary Concrete:M10, M15 and M20

ii) Standard Concrete:M25, M30, M35, M40, M45, M50 and M55

iii) High Strength Concrete: M60, M65, M70, M75and M80

Ordinary Portland Cement

It is composed of calcium silicates and aluminates. It is obtained by blending in predetermined proportions of lime stone and clays which are pulverised and fired at high temperatures to produce clinker. Clinker is ground with small quantities of gypsum to produce a fine powder.

Major compounds of cement			
Tri-calcium silicates		C_3S	
Di-calcium silicates		C_2S	
Tri-calcium aluminates		C_3A	
Tetra-calcium Alumino-ferrite		C_4AF	
C =CaO	S=SiO_2	A=Al_2O_3	F=Fe_2O_3
Lime stone	sand	clay	Hematite

Hydration of cement: C_3S and C_2S are the most important compounds and responsible for strength of cement paste. By selecting proper mixture of raw materials to change percentages of C_3S and C_2S and by grinding to required fineness necessary grade of cement is produced. Ratio of C_3S and C_2S is raised from 1.2 to 3 for 53 grade cement

- C_3S + water = CSH gel + $Ca(OH)_2$ (=lime 39%)
- C_2S + water = CSH gel + $Ca(OH)_2$ (=lime 18%)
- $Ca(OH)_2 + CO_2$ Humidity + $CaCO_3$ (insoluble)
- $CaCO_3 + CO_2$ Humidity = Calcium bi carbonate (soluble).

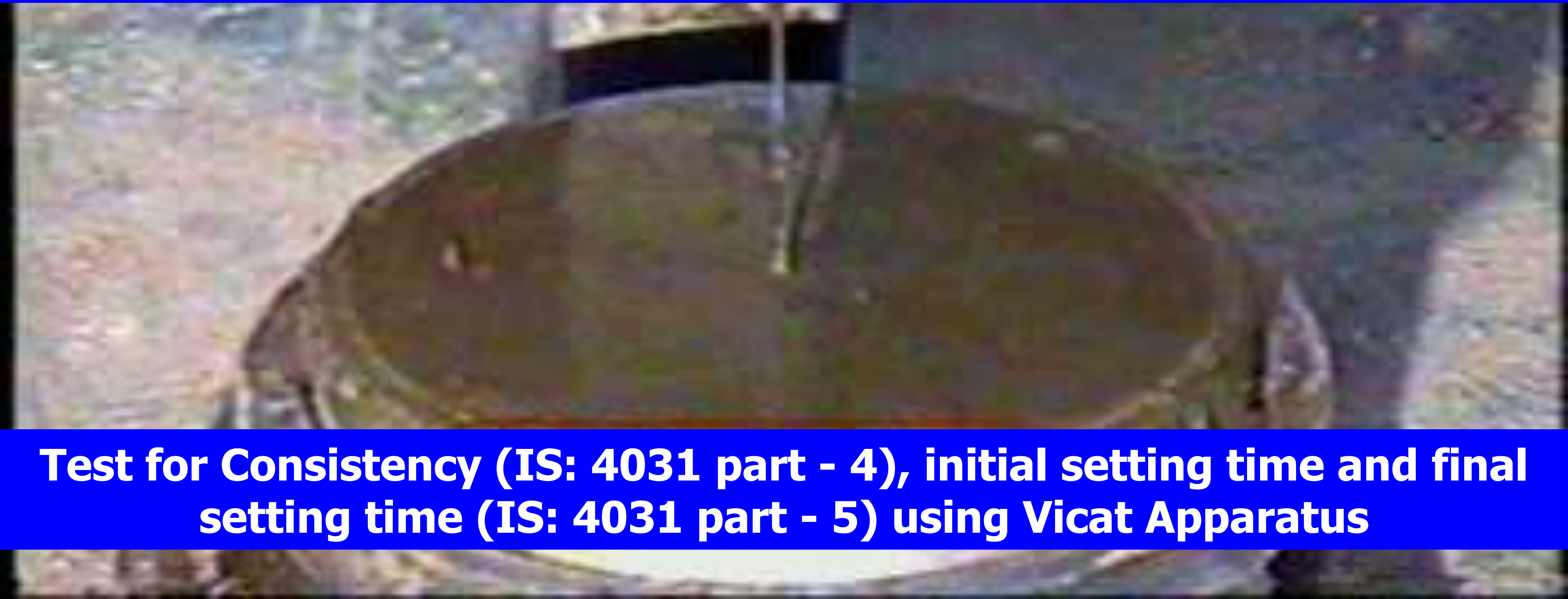
It causes lime leaching and degradation of concrete. In blended cements reactive silica reacts with $Ca(OH)_2$ and results in secondary CSH gel formation.

- 53 grade OPC give about 25% surplus lime
- 43 grade OPC give about 18% surplus lime

Physical characteristic requirement of cement

Characteristic	Requirements		
	33 grade IS: 269-1989	43 grade IS: 8112-1989	53 grade Is: 12269-1987
Minimum compressive strength in N/mm^2			
3 days	16	23	27
7 days	22	33	37
28 days	33	43	53
Fineness (minimum) (M^2/Kg)	225	225	225
Setting time (minute)			
Initial – (minimum)	30	30	30
Final – (maximum)	600	600	600
Soundness, expansion			
Le Chatleier– (maximum) mm	10	10	10
Autoclave test–(maximum) %	0.80	0.80	0.80

Plunger for consistency: If penetration is 5 to 7 mm from bottom of mould (40mm), water added is of correct quantity for standard consistency (25 to 32%). **1 mm square needle for IST:** Initial setting time is time between addition of water to cement and when the needle ceases to penetrate completely (about 5 ± 0.5 mm from bottom of mould). **Needle with annular collar:** Final setting time after water is added to cement and when needle makes an impression but not the collar on cement mould.



Test for Consistency (IS: 4031 part - 4), initial setting time and final setting time (IS: 4031 part - 5) using Vicat Apparatus

As per IS: 4032 part – 6
Mortar cube compressive Strength test on 70.6mm 1:3 cement mortar cubes to determine the grade of cement
sand shall be as per IS:650

Grade number is 28 days' compressive strength in MPa or N/mm^2
$1MPa=10.21\ Kg/cm^2$

Compressive Strength of cubes as per IS: 516

3 specimens of 150mm cubes from the same concrete are to be tested for compressive strength

Average value of 3 specimens represent a sample result. If the results of 3 specimens show more than 15% variation with average value, it be ignored

Cube after failure

Water for mixing and curing

Potable water is generally considered satisfactory for both mixing and curing.

In case of doubt, 28 days average compressive strength of at least three 150mm cubes prepared with water proposed to be used shall not be less than 90% of the average strength of 3 similar cubes prepared with distilled water.

Initial setting time of test block made with water proposed to be used shall not be less than 30 minutes and shall not differ by ± 30 minutes from the initial setting time of test block prepared with distilled water.

Permissible limits for solids in Water

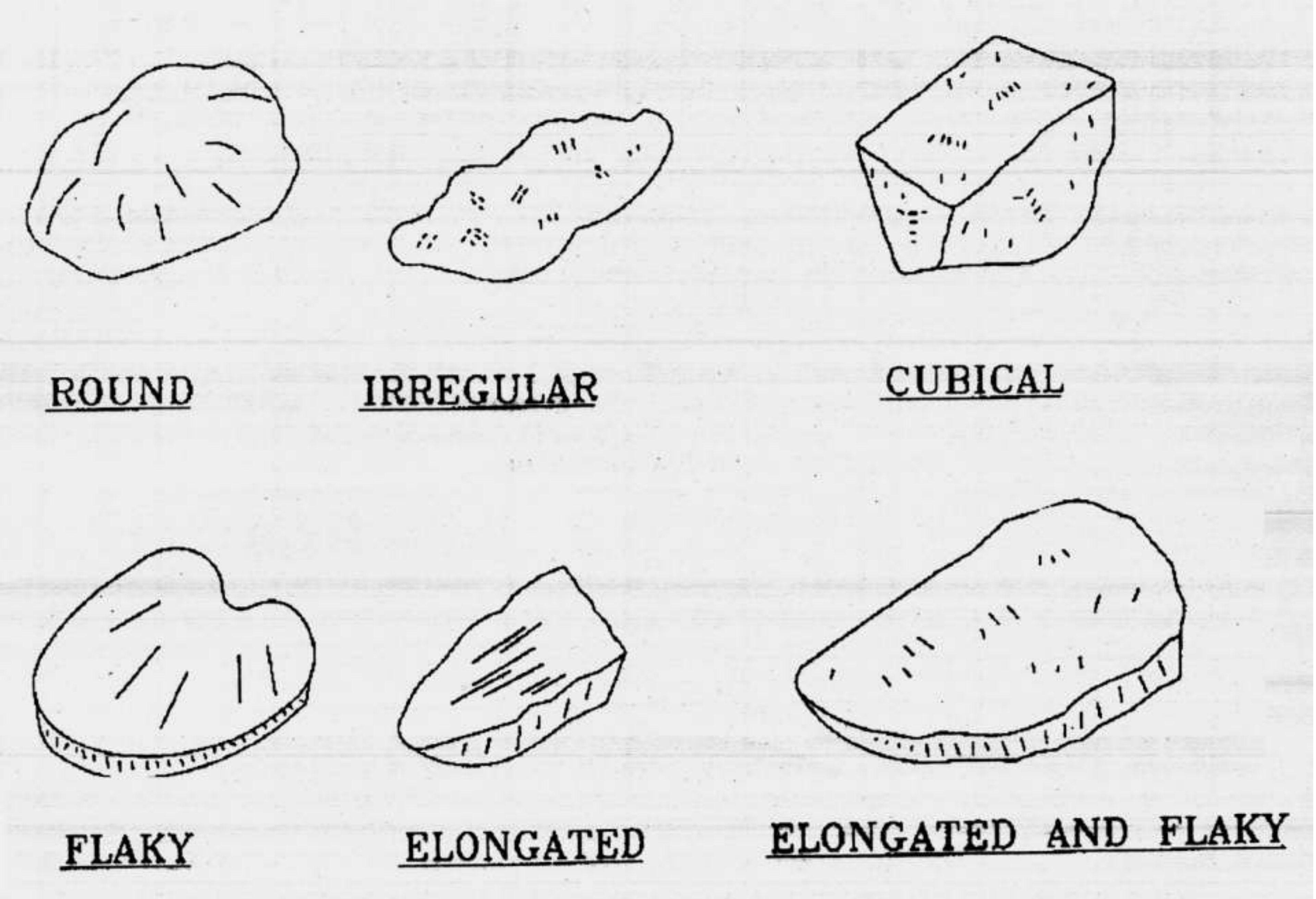
Cl. 5.4 of IS: 456-2000

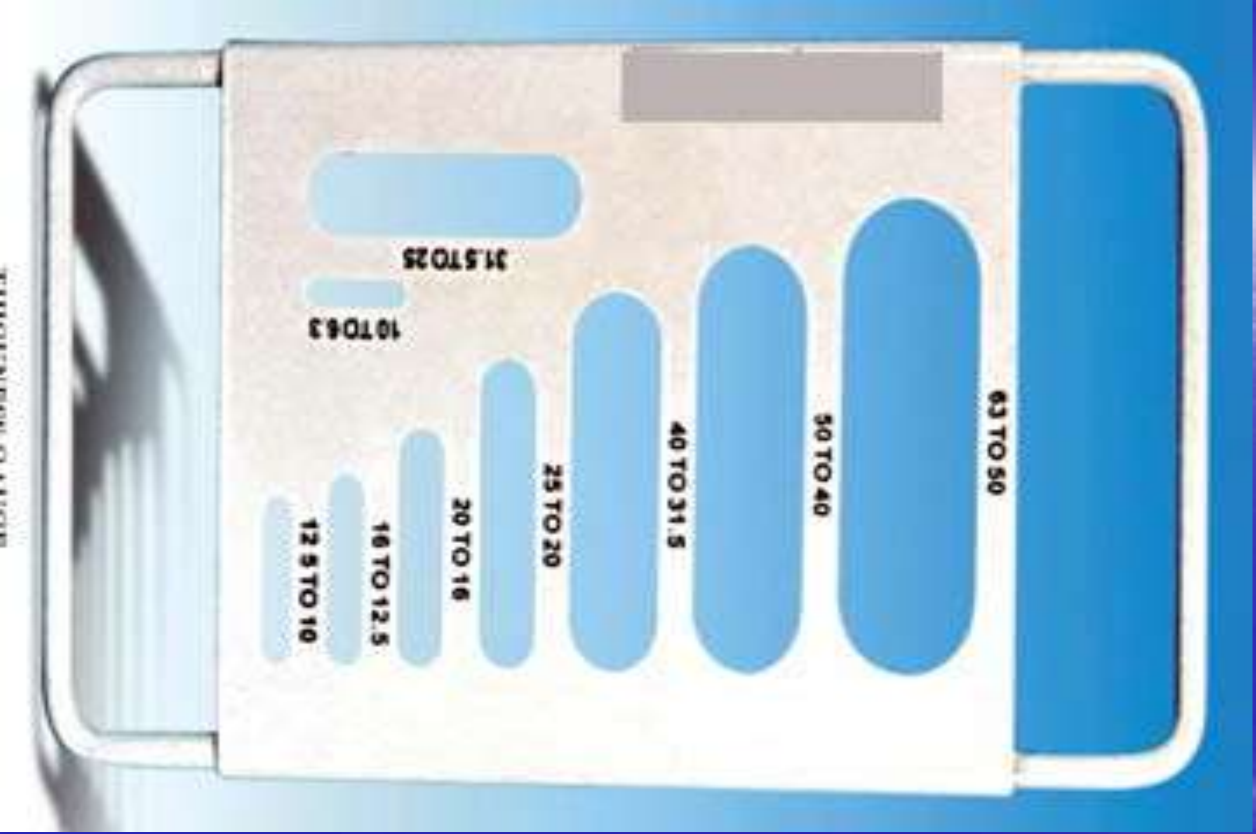
	Tested as per	Permissible limt maximum
Organic	IS 3025 part 18	200 mg/l
Inorganic	IS 3025 part 18	3000 mg/l
Sulphate as SO_3	IS 3025 part 24	400 mg/l
Chloride as cl	IS 3025 part 32	2000 mg/l for PCC 500 mg/l for RCC
Suspended matter	IS 3025 part 18	2000 mg/l

Permissible limits for solids in Water Cl. 5.4 of IS: 456-2000		
	Tested as per	Permissible limt maximum
Organic	IS 3025 part 18	200 mg/l
Inorganic	IS 3025 part 18	3000 mg/l
Sulphate as SO_3	IS 3025 part 24	400 mg/l
Chloride as cl	IS 3025 part 32	2000 mg/l for PCC 500 mg/l for RCC
Suspended matter	IS 3025 part 18	2000 mg/l

pH value of water shall not be less than 6.

Shape of aggregates



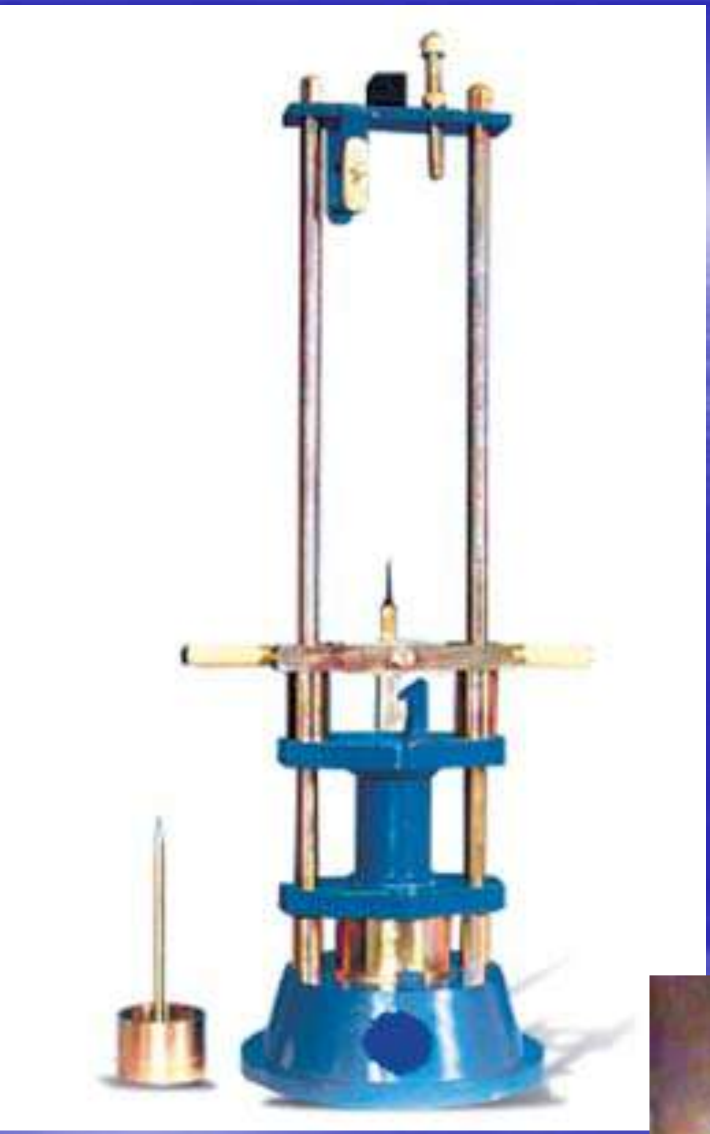


Flakiness Index Test

IS: 2386 part 1

Thickness of flaky material is less than 0.6 times mean size

IS sieves: 63,50,40,25,20, 16,12.5,10 and 6.3mm



Aggregate Impact test
IS; 2386 part 4

material passing 12.5 mm sieve and retained on 10 mm sieve is placed in mould in 3 layers by tamping 25 times for each layer. After 15 blows, material passing 2.36 mm sieve is weighed and compared with sample weight in %.

Requirements of coarse (single size) Aggregate Part of table 2 of IS: 383

IS Sieve Size	Percent by Weight Passing the Sieve		
	40 mm	20 mm	12.5 mm
63 mm	100	--	--
40 mm	85-100	100	--
20 mm	0-20	85-100	--
16 mm	--	--	100
12.5 mm	--	--	85-100
10 mm	0-5	0-20	0-45
4.75 mm	--	0-5	0-10

Requirements of coarse (graded size) aggregate as per table 2 of IS: 383

IS Sieve Size	Percent by Weight Passing the Sieve		
	40 mm	20 mm	12.5 mm
63 mm	100	--	--
40 mm	95-100	100	--
20 mm	30-70	95-100	100
12.5 mm	--	--	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

Maximum size of Coarse aggregate may be as large as possible within the limits specified, but in no case greater than ¼th of minimum thickness of member or 10mm less than the clear distance between individual reinforcement or 10mm less than clear cover to any reinforcement.

40 mm HBG single size metal for concrete- IS:383

IS Sieve mm	Cumulative% passing	% passing
40	92	85-100
20	9	0-20
10	2	0-5

40 mm HBG graded metal for concrete-IS:383 or MOSRT&H TABLE
Mixture of 40, 20 and 12.5 single sizes

IS Sieve mm	Cumulative% passing	% passing
40	95	95-100
20	50	30-70
10	26	10-35
4.75	2	0-5

20 mm HBG single size metal for concrete-IS:383

IS Sieve mm	Cumulative% passing	% passing
40	100	100
20	92	85-100
10	9	0-20
4.75	2	0-5

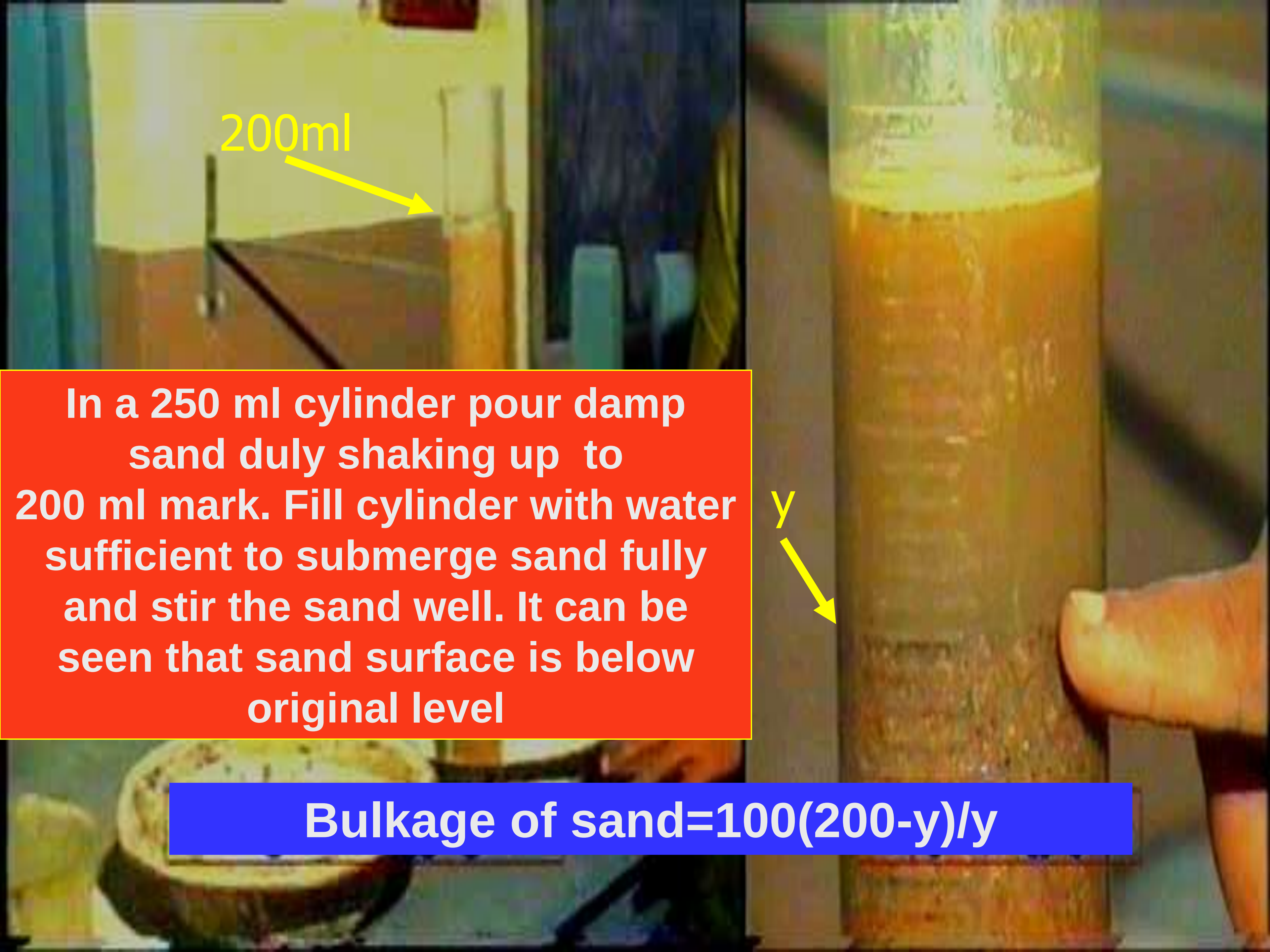
20 mm HBG graded metal for concrete.

Mixture of 20, 12.5 and 6.3mm single sizes

IS Sieve mm	Cumulative% passing	% passing
40	100	100
20	97	95-100
10	40	25-55
4.75	5	0-10

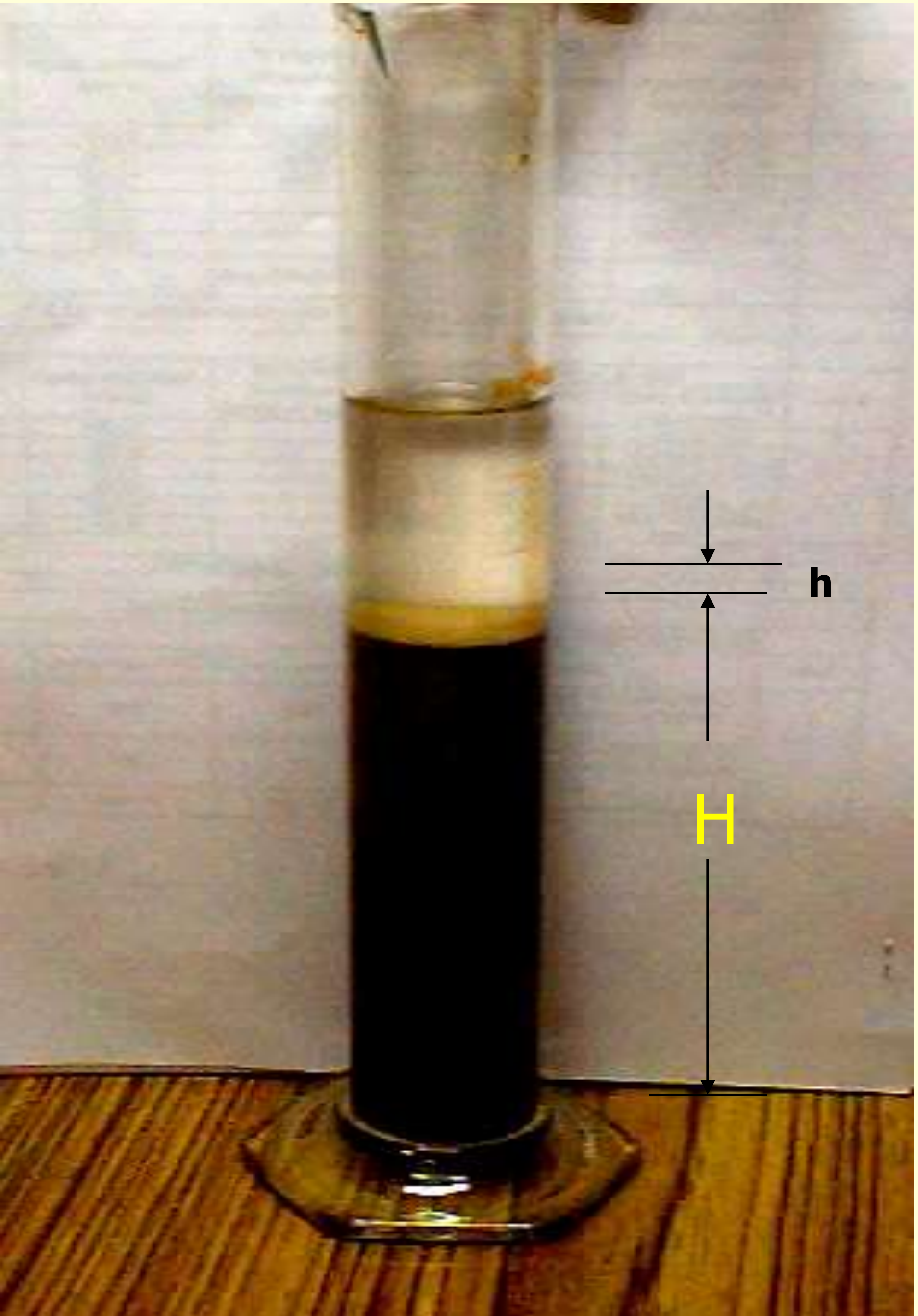
Properties	Limits of deleterious materials IS: 383-1970			
	Fine aggregates % by weight		Coarse aggregates % by weight	
	uncrushed	crushed	uncrushed	crushed
Coal and lignite	1.00	1.00	1.00	1.00
Clay lumps	1.00	1.00	1.00	1.00
Material finer than 75 micron	3.00	15.00	3.00	3.00
Shale	1.00	-	-	-
Total % of all Deleterious materials	5.00	2.00	5.00	5.00

Fineness Modulus of fine aggregates: 2.0 to 3.5
Zone-IV sand not suitable for RCC works



In a 250 ml cylinder pour damp sand duly shaking up to 200 ml mark. Fill cylinder with water sufficient to submerge sand fully and stir the sand well. It can be seen that sand surface is below original level

Bulkage of sand=100(200-y)/y



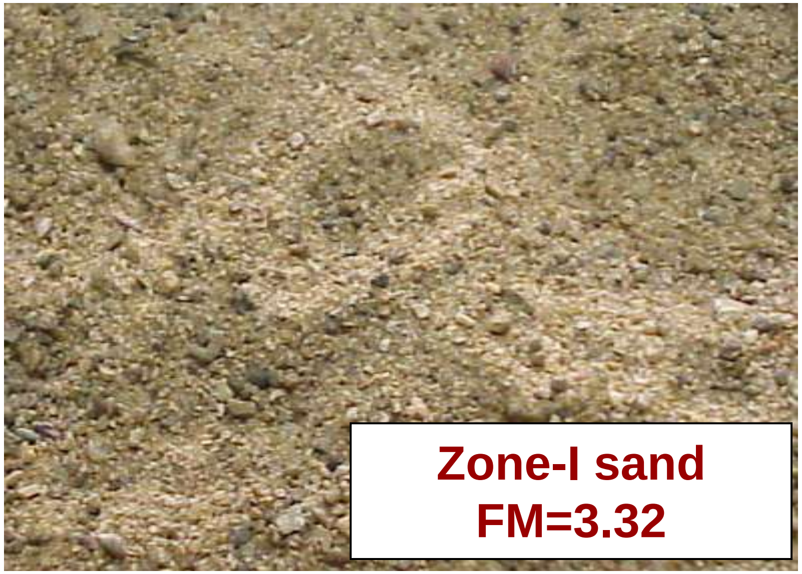
Silt content test

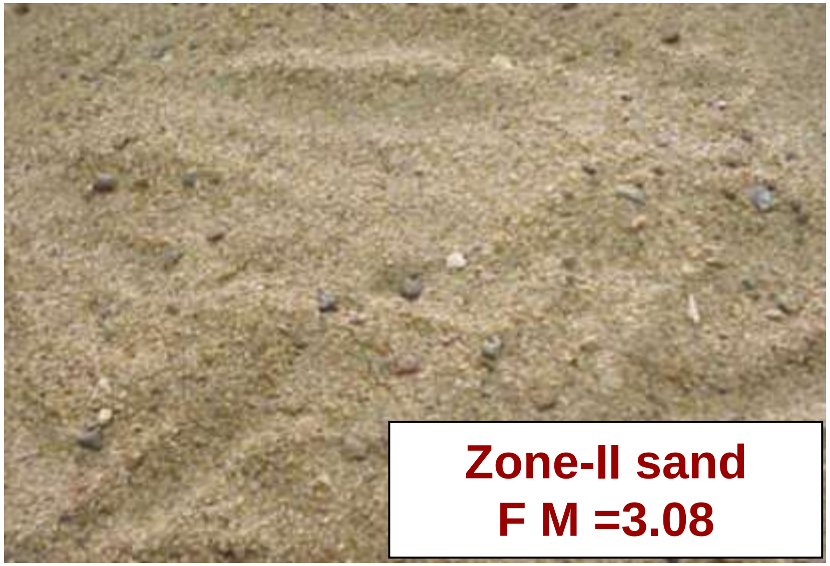
Fill 200 ml jar up to 100 ml level with sand.

Pour water up to 150 ml level and shake vigorously . Allow it for 3 hours to settle.

Silt content =

h/H x 100


Zone-I sand
FM=3.32


Zone-II sand
F M =3.08


Zone-III sand.
F.M =2.75

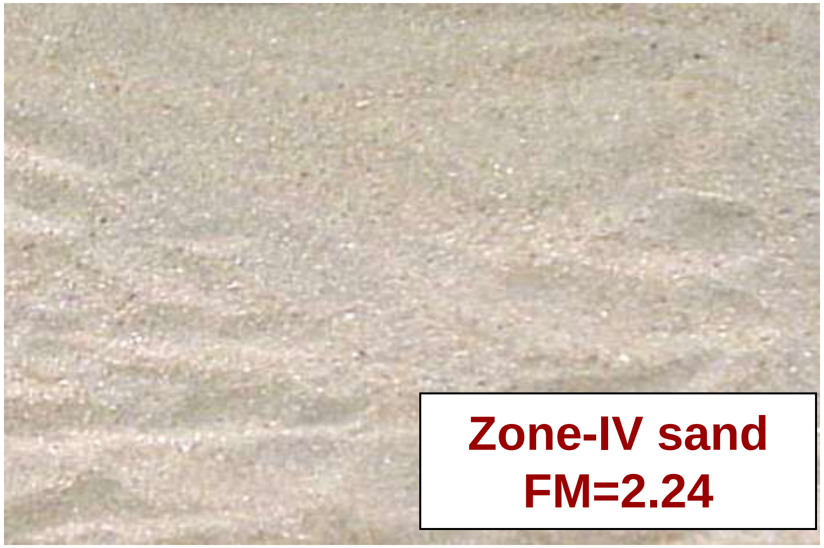

Zone-IV sand
FM=2.24

TABLE 4 0f IS: 383 FINE AGGREGATES

IS Sieve Designation	Percent passing for			
	Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10mm	100	100	100	100
4.75mm	90 – 100	90 – 100	90 – 100	95 – 100
2.36mm	60 – 95	75 – 100	85 – 100	95 – 100
1.18mm	30 – 70	55 – 90	75 – 100	90 – 100
600microns	15 – 34	35 – 59	60 – 79	80 – 100
300microns	5 – 20	8 – 30	12 – 40	15 – 50
150microns	0 – 10	0 – 10	0 – 10	0 - 15

Sand Sieving Machine

Mineral Admixtures

- Fly Ash (up to 25% as per IS 1489)
- Rice Husk Ash
- Silica Fume
- Slag (up to 65% as per IS 455)
- Metakaoline

Advantages in using Blended Cements

- Low heat of hydration
- Reduced permeability
- Increased durability
- Enhanced performance
- Reduced Alkali Silicate Reaction
- Continuous strength gain
- Increased workability

Portland Pozzolana Cement

CS + H → CSH + CaOH

CaOH + FA → CSH

- Increases CSH volume
- Denser CSH formed by secondary reaction
- Retards hydration in the early stages
- Accelerates during the middle stage
- Pore structure and composition

Portland Slag Cement

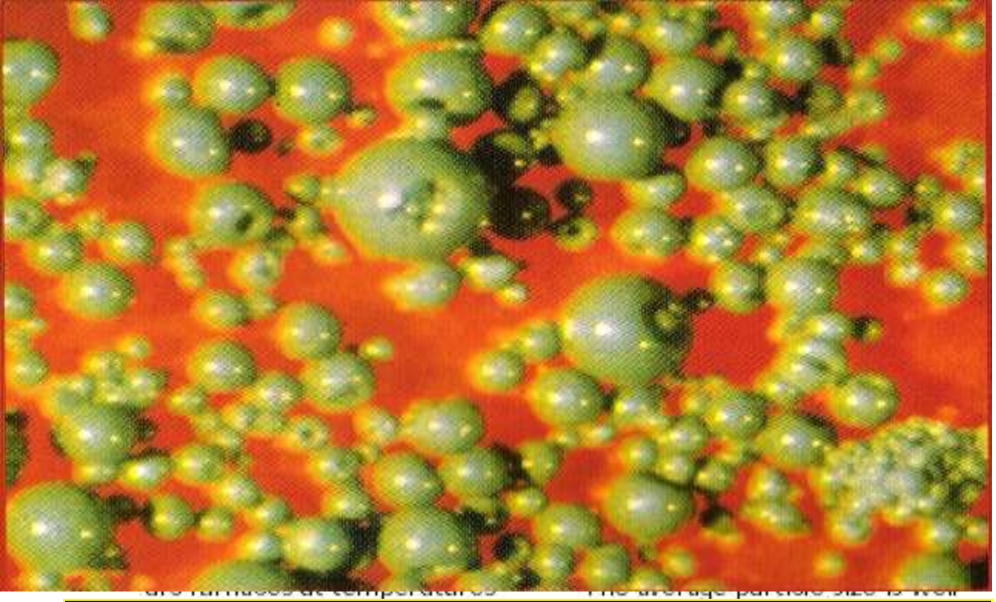
- Reduced C_3A in PSC
- Lower content of free CH
- Lower basic nature of CSH
- Sulphate resistant
- Chloride and Sulphate are present together

What is GGBS ?

Ground Granulated Blast furnace Slag (GGBS) is a Potential Hydraulic Material which is ground to very fine state under controlled conditions

The basic raw material for GGBS is Granulated Blast furnace Slag produced as a by-product in the manufacture of Pig Iron in the Blast furnace

To improve the Durability of the Concrete, usage of GGBS along with OPC is recommended in IS 456 : 2000, BS 6699 : 1986 & ASTM C989 : 1982



Micro Silica is an ultra fine material i.e., about 100 times finer than cement. It easily reacts with extra lime and blocks the finest of fine pores of concrete. It improves mechanical bonding of concrete

Micro Silica

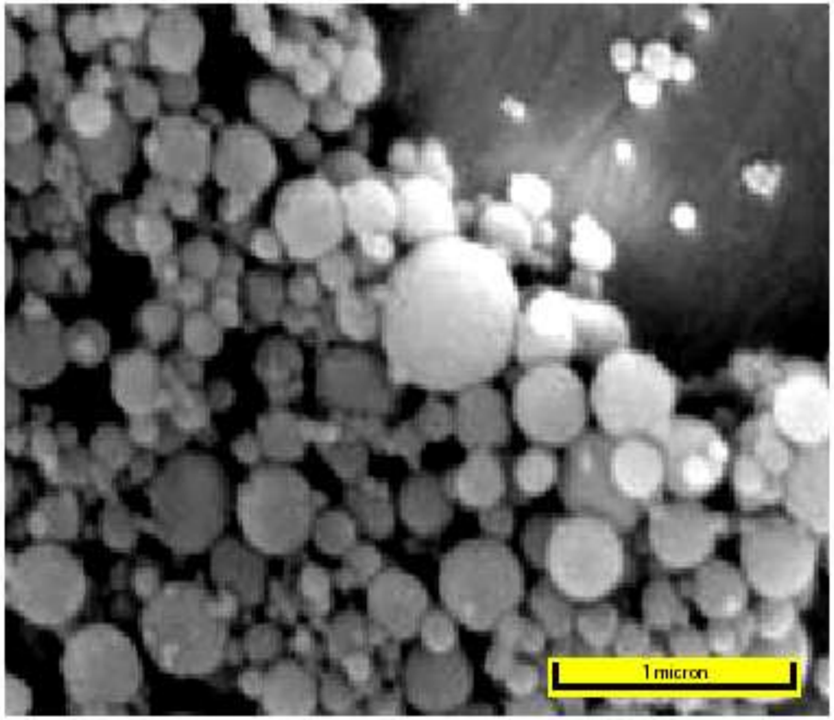


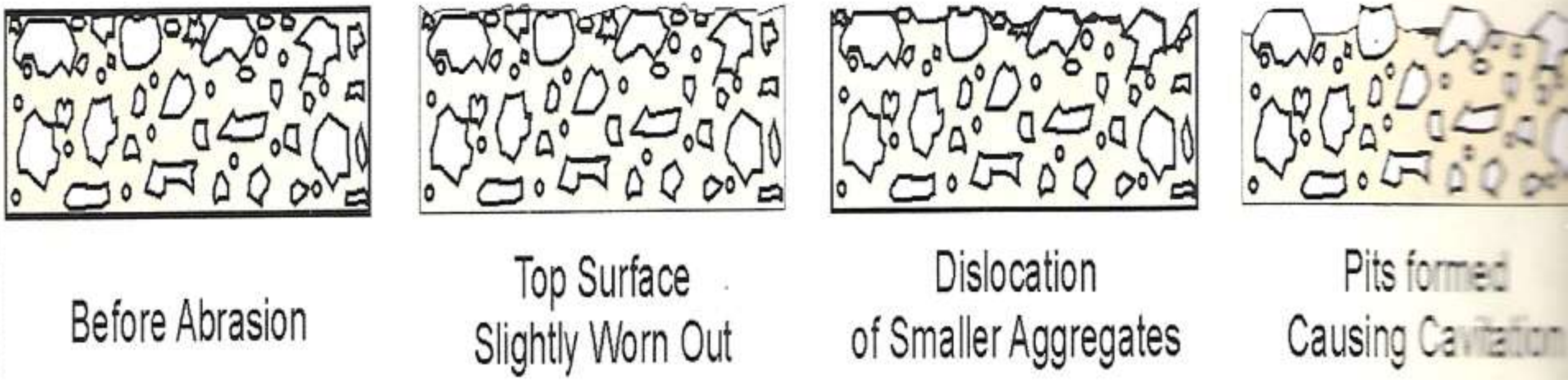
Fig. 1 Microsilica particles (SEM)

density in the region of 200kg/m³, it can be processed to densify it, making the bulk density around 650kg/m³, or it can be slurrified. This latter process involves the blending of the microsilica, normally straight from the filter silos, with an equal weight of water. The slurry is easy to transport, store, dose and mix into concrete.

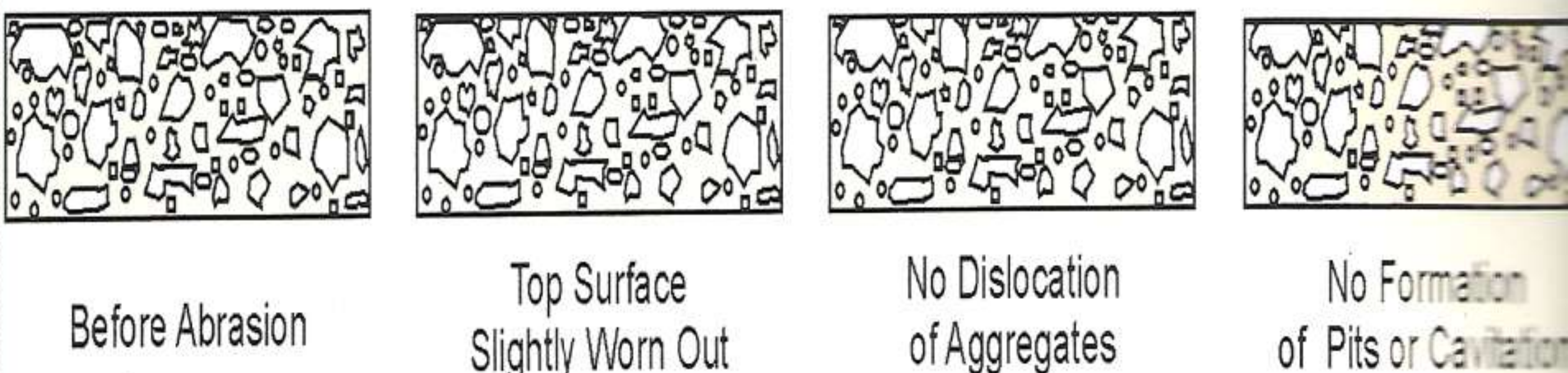
Standards for silica fume and with the new European Standard prEN 13263.

How does Elkem Microsilica work?

The ultrafine spheres fill the gaps between the cement grains, refining the voids in the fresh concrete (Fig. 4). The particles act like ball bearings



Schematic Representation of Abrasion in Conventional Concrete

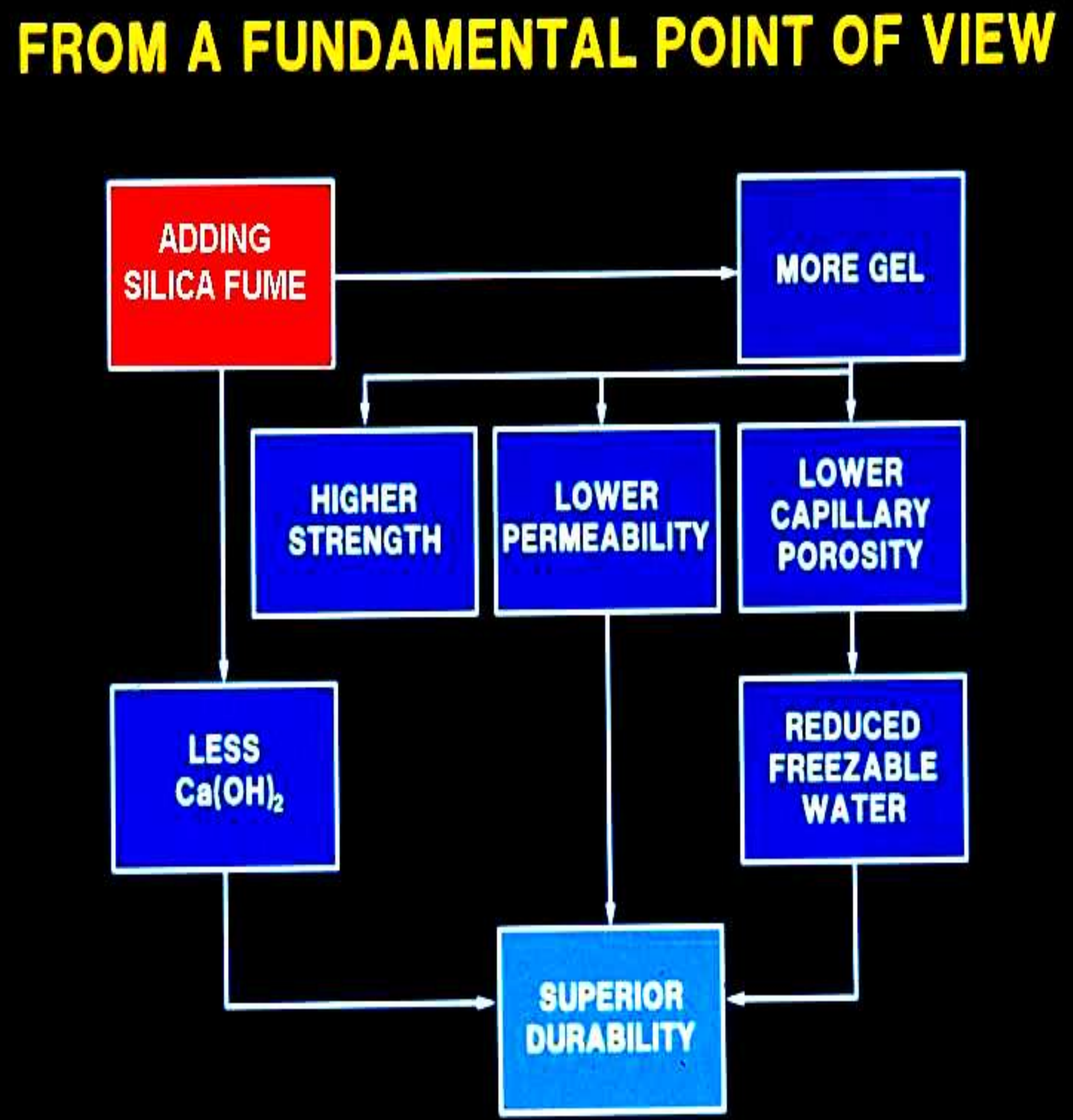


Schematic Representation of Abrasion in Microsilica Concrete

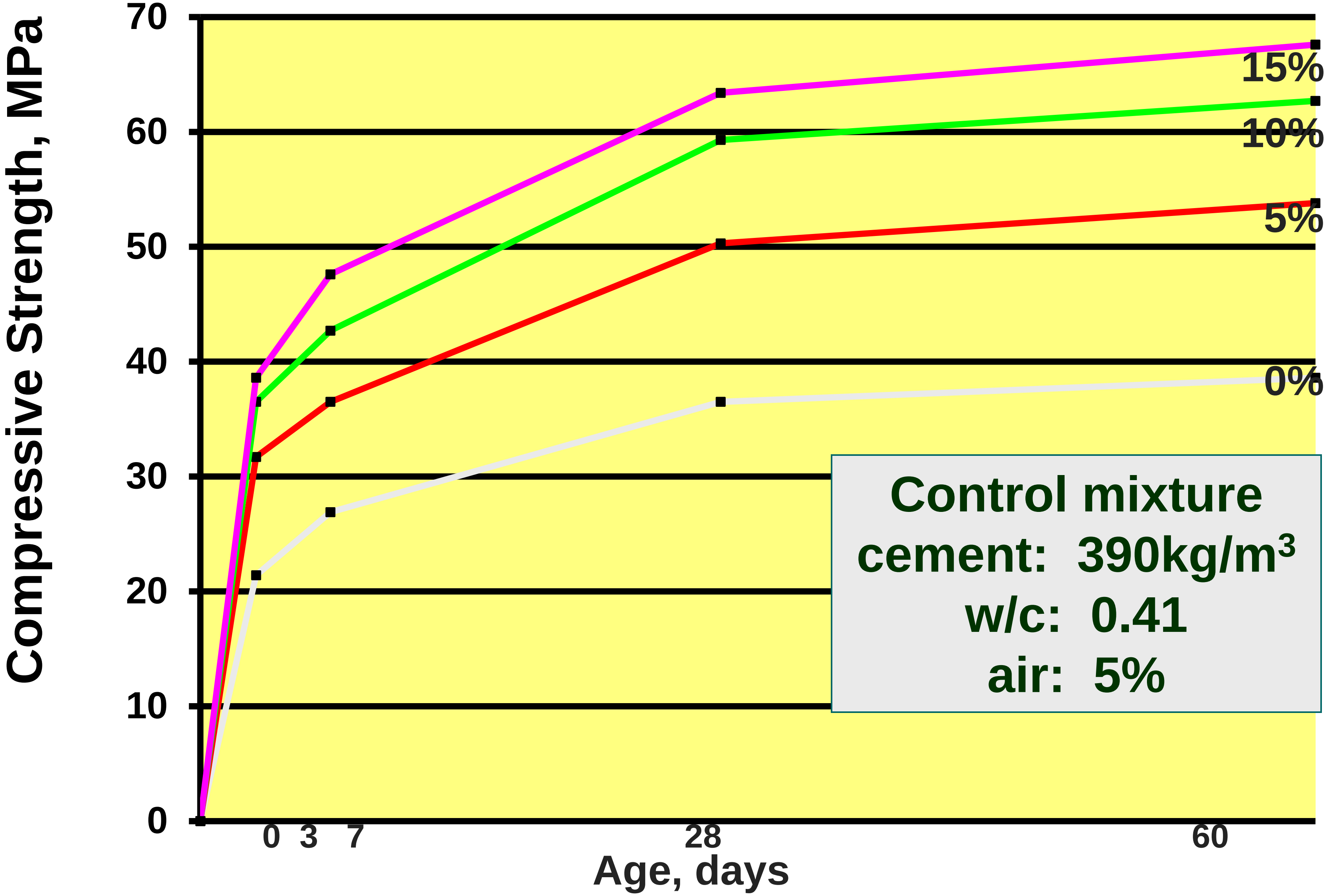
Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys in an electric-arc furnace. This photo, taken before environmental regulations were put into effect, shows silica fume being discharged from a smelter. Today, no silica fume is discharged to the environment in the United States. It is also known as condensed silica fume or microsilica

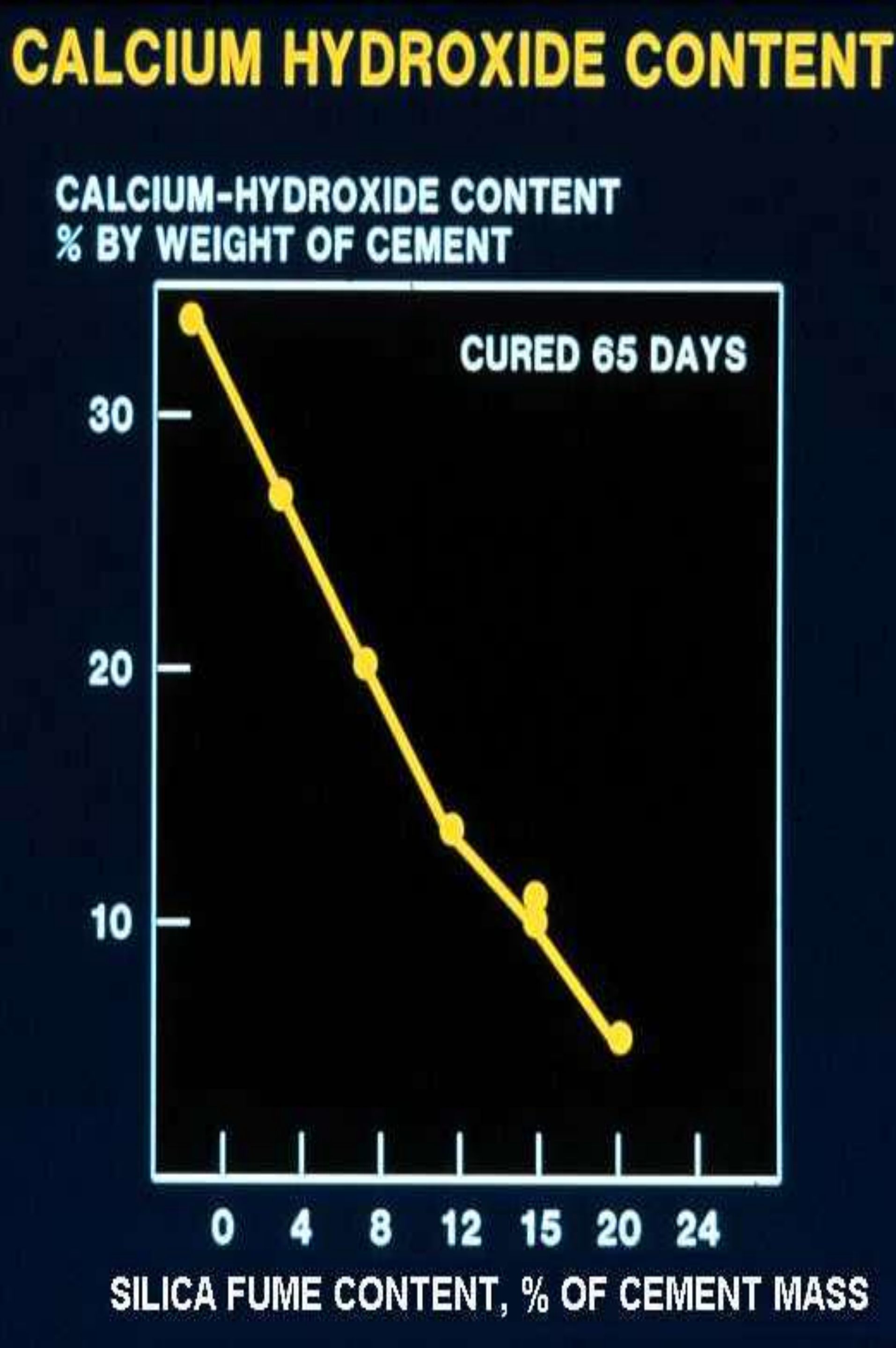
Silica Fume Product Forms

As-produced powder, Water-based slurry, Densified, Blended silica-fume cement, Pelletized



Silica-Fume Concrete: Typical Strengths





portland cement + water

=

calcium silicate hydrate

+

calcium hydroxide

pozzolan + calcium hydroxide

+

water

=

calcium silicate hydrate

Presence of very small particlesc improve particle packing

Problems with Blended Cements

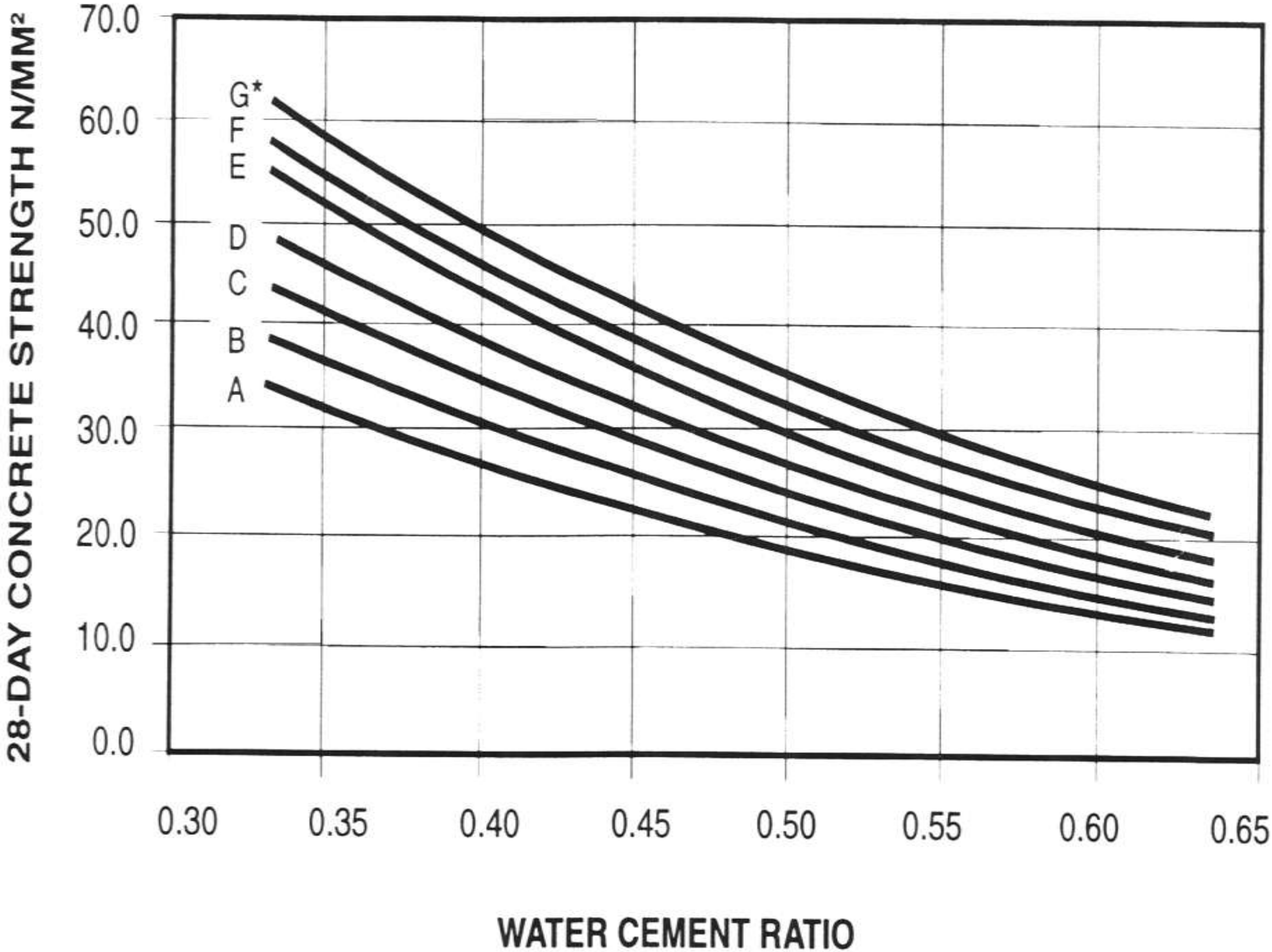
- Lower Early Strength Gain
- Longer Duration of Shuttering
- Continuous Curing
- Improper Blending
- Quality of Admixtures

Water - Cement ratio

Many feel that controlling W/C means reduction of water and there by production of stiff unworkable concrete mix. It is unfortunate that many in the field of concrete production have not realised that workability can be maintained at the desired level even while maintaining strict control over the low W/C. In simple words, if water is required to be increased, cement should also be increased such that specified W/C does not increase. Another simple way is to reduce the aggregate quantity or in other words to reduce the aggregate to cement ratio of the concrete mix.

It has been observed that cement water paste with more volume of water will also occupy greater total volume of space and after completion of hydration process will therefore end up with larger volume of capillary pores.

As the capillary pores in cement paste reduces the strength and increases and permeability of the concrete or mortar prepared using the paste decreases.


28-DAY CONCRETE STRENGTH N/MM²
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
G*
F
E
D
C
B
A
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
WATER CEMENT RATIO

Coefficient of Permeability for different W/C ratios:

S.No	W/C ratio	Coefficient of Permeability
1	0.35	1.05×10^{-3}
2	0.50	10.30×10^{-3}
3	0.65	1000×10^{-3}

Permeability for different W/C ratios at different curing periods

W/C	Curing period in days				
	1	3	7	28	90
0.32	5.60	0.30	0.12	0.00	0.00
0.40	18.70	0.59	0.07	0.07	0.00
0.50	214.00	14.70	2.35	0.19	0.00

Porosity (%) for different W/C ratios at different curing periods

W/C	Curing period				
	1	3	7	28	90
0.32	20.80	19.17	14.40	9.80	5.90
0.40	33.30	28.60	20.90	16.80	11.10
0.50	43.50	37.80	32.20	20.80	14.50

Chemical Admixtures - Plasticizers

Plasticizers are also called water reducing admixtures. Ordinary water reducing plasticizers which enable upto 15% of water reduction. High range water reducing super plasticizers which enable upto 30% of water reduction

The plasticizers are generally used to achieve the following:

a) In fresh concrete:

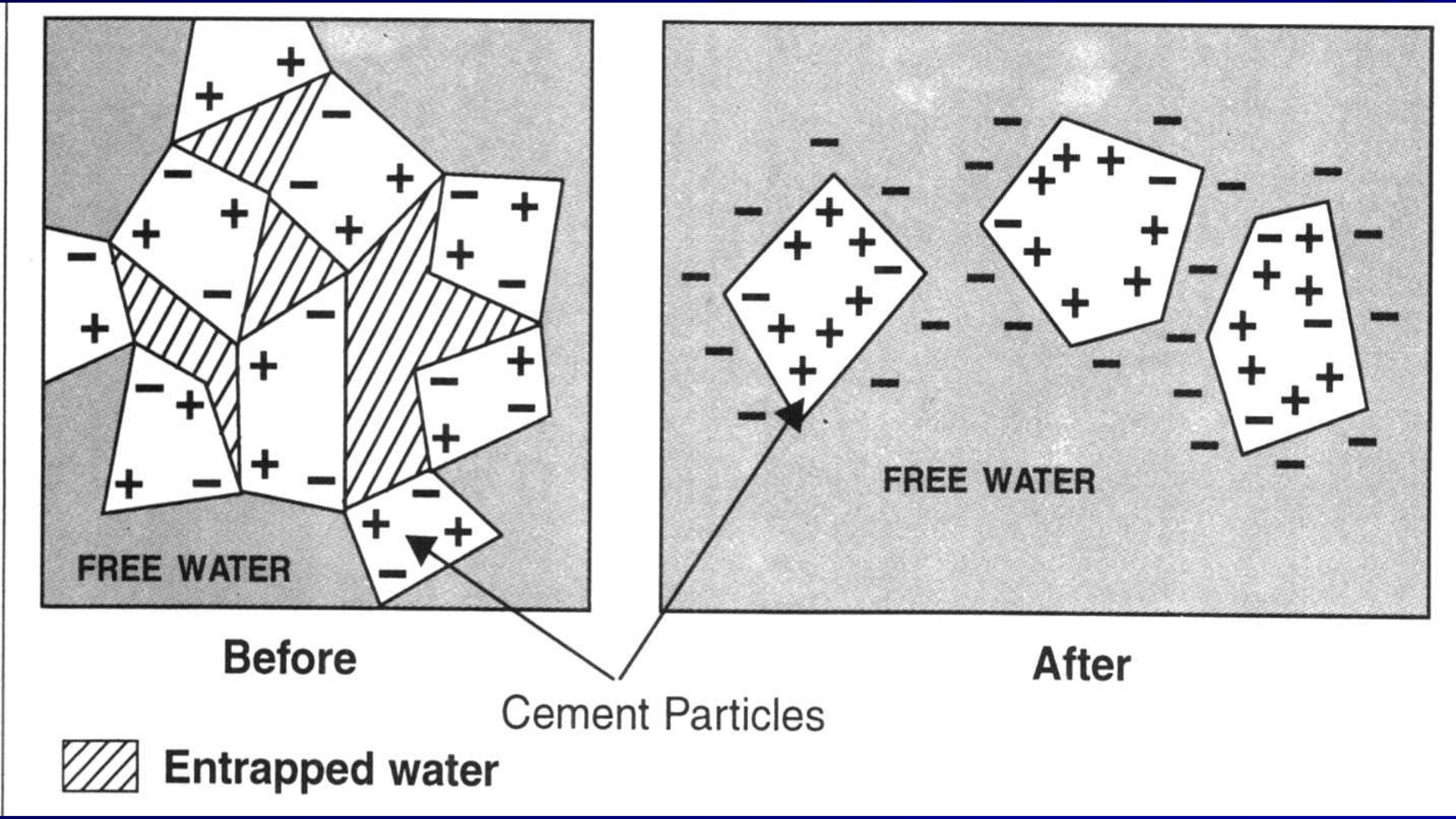
1) Increase workability and / or pumpability without increasing the water/cement ratio. 2) Improve cohesiveness and thereby reducing segregation or bleeding 3) Improve to some extent set retardation

b) In Hardened concrete:

1) Increase strength by reducing the water/cement ratio, maintaining same workability. 2) Reduce permeability and improve durability by reducing water/cement ratio. 3) Reduce heat of hydration and drying shrinkage by reducing cement content

Function of Plasticizers

Fine cement particles being very small clump together and flocculate when water is added to concrete. This ionic attraction between the particles trap considerable volume of water and hence water required for workability of concrete mix is not fully utilised. Negative charges are induced on the fine cement particles causing flocs to disperse and release the entrapped water. Water reducing admixtures or plasticizers therefore help to increase the flow of the concrete mix considerably.



Dispersion of entrapped air with the addition of plasticizer

Increase in Slump by adding plasticizer without changing cement content, water cement ratio

Concrete Mix	Cement Content (Kg/M^3)	W/C	Slump (mm)	Strength (Kg/cm^2) at	
				7 days	28 days
Reference mix without Plasticizer	440	0.37	25	390	540
Mix with Plasticizer	440	0.37	100	411	541

Increase in Compressive strength by reducing W/C ratio without increasing cement content					
Concrete Mix	Cement Content (Kg/M^3)	W/C	Slump (mm)	Strength (Kg/cm^2) at	
				7 days	28 days
Reference mix without Plasticizer	315	0.60	95	218	291
Mix with Plasticizer	315	0.53	90	285	375

Similar Compressive Strength achieved with reduced cement content

Concrete Mix	Cement Content (Kg/M^3)	W/C	Slump (mm)	Strength (Kg/cm^2) at	
				7 days	28 days
Reference mix without Plasticizer	460	0.43	100	320	420
Mix with Plasticizer	395	0.43	100	336	435

CEMWET SP-3000 (PCE) disperses cement particles and can maintain slump of concrete for more than two hours without affecting early development of strength and satisfies ASTMC-494 and IS 9103-99 at normal dosage. Due to high water reduction capacity all the properties of hardened concrete are improved significantly, namely permeability, shrinkage, creep, workability & modulus of elasticity.

CEMWET SP 3000 (PCE) is compatible with all types of cement such as OPC, PPC and Puzzolana, High Alumina Cement, Slag Cement.

ASIAN LABORATORIES

88, DSIDC Shed, Scheme-1, New Okhla Industrial Complex, Phase-II, New Delhi-110 020
Tel: 26386063, 26386507, 26386392, Telefax: 26386063
E-mail: asianlab@vsnl.net, Website: www.asianlaboratories.com

CEMWET SP-3000 (PCE)

A High Performance Fourth Generation Superplasticizer

CICO TECHNOLOGIES LIMITED

100 TQM

www.cicogroup.com

ISO 9001 : 2000

New Delhi : cicotech@cicogroup.com Mumbai:ctl_mumbai@cicogroup.com Chennai:cicochennai@cicogroup.com Kolkata:ctl_kolkata@cicogroup.com

that saves over 10% cement content

Over the years, at the heart of just about any construction of any repute or criticality in India it CICO the most trusted and preferred name in the Construction Chemicals with commitment to excellence in research and technology

.

CICO Admixture, when added to the green concrete activates repulsive force between cement particles and results in their more uniform dispersion. The Admixture produces durable and impermeable concrete with excellent surface finish. The addition of CICO Admixture increases the speed of concreting, through easy placement and compaction, as the concrete develops high cohesion, required for pumping of concrete.

CICO Admixture is available in different grades to suit different requirements.

- CICO PLAST N
- CICO PLAST SUPER
- CICO PLAST R
- CICO PLAST MMF
- CICO PLAST A
- CICO VISCOPLAST
- CICO PLAST SUPER-HS
- CICO PLAST SUPER C 300
- CICO PLAST PPR
- CICO PLAST AEA
- CICO MS
- CICO ROCKCRETE

Durability of Concrete

Durability of concrete is its ability to resist weathering action, chemical attack, abrasion, and all other deterioration processes.

Weathering includes environmental effects such as exposure to cycles of wetting and drying, heating and cooling, as also freezing and thawing.

Chemical deterioration process includes acid attack, expansive chemical attack due to Sulphate reaction, alkali aggregate reaction, corrosion of steel in concrete due to moisture and chloride ingress

Causes of deterioration of concrete

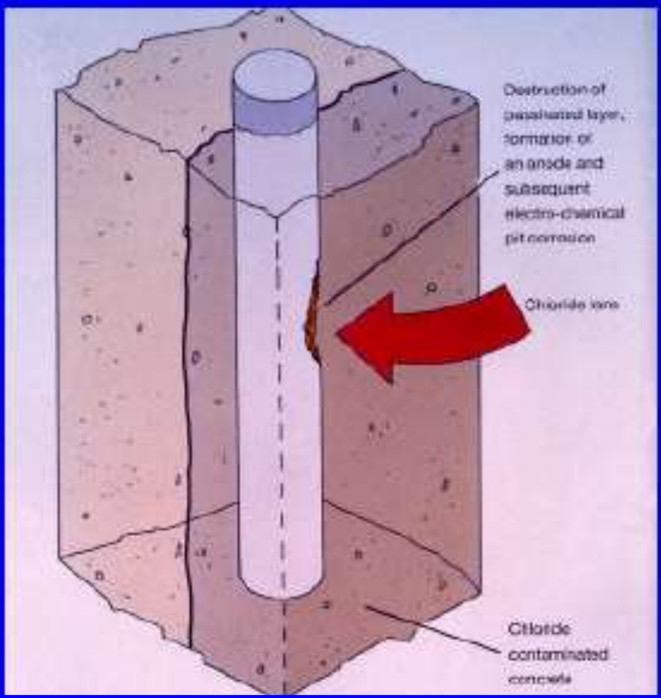
1) Porosity and permeability
2) Thermal and plastic cracking
3) Entry of chemicals (chlorides, sulfates, water, Carbon Dioxide)
4) Corrosion of reinforcement
5) Harmful effects of chloride
6) Carbonation: $Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$ (reduction of alkalinity - ph below 7)
7) Sulphate attack
8) Alkali aggregate reaction

Lime Leaching

Water can decompose any of the hydrated compounds present in concrete. If concrete comes in continuous contact with water or moisture, the free lime occurring in hardened concrete being easily soluble is the first compound to be attacked and will leach out. This lime extraction to the concrete surface increases both porosity and permeability. The soluble calcium hydroxide leaches through the capillary pores of concrete and leaves a passage for other pollutants such as water, chlorides and Sulphates to enter. This also causes alkalinity of concrete to drop initiating corrosion of steel within concrete.

Leaching of lime in Prakasam Barrage at Vijayawada.

Chloride Attack



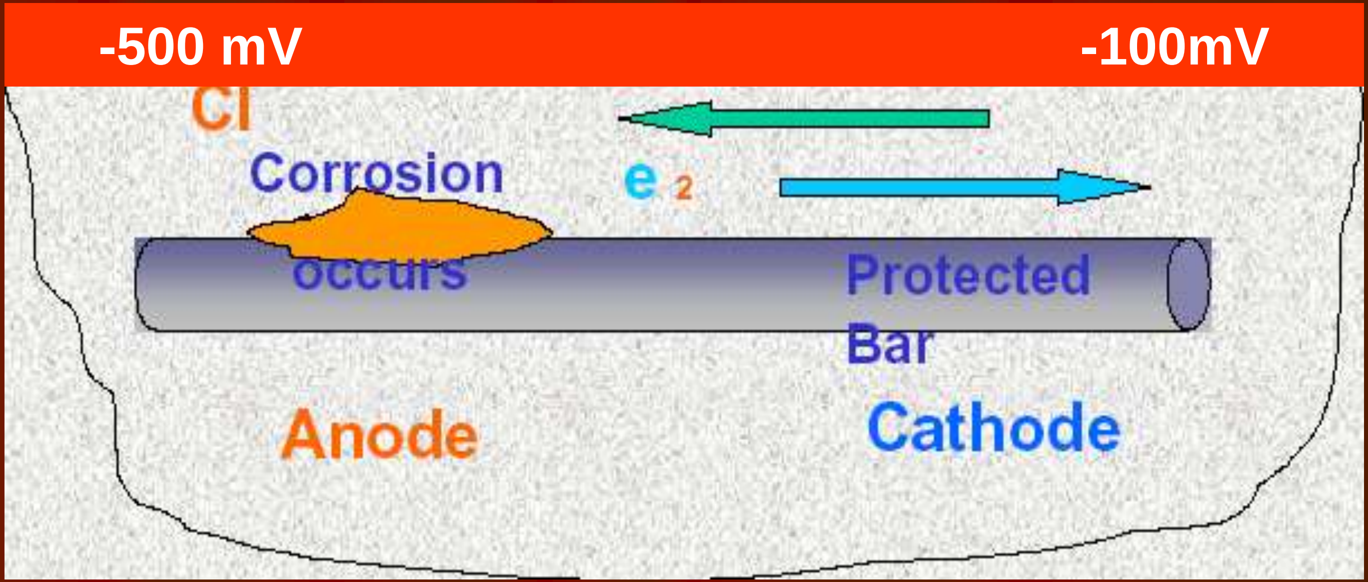
Chloride ions cause a serious electro-chemical corrosion process, which can lead to a loss of structural integrity

Corrosion of Steel

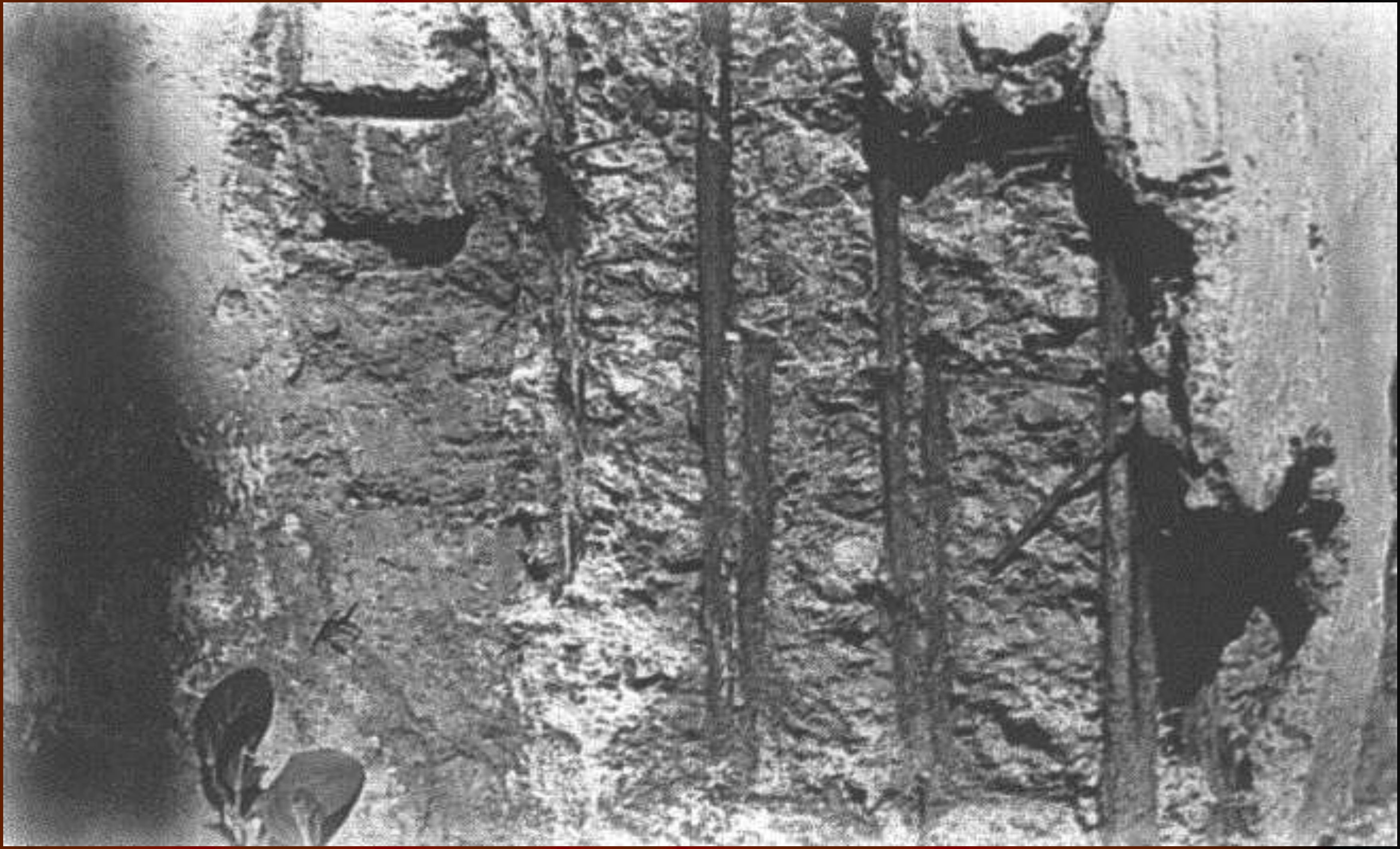
- Mechanism of corrosion of steel is an electro-chemical process. The electro-chemical process starts when there is a potential difference caused due to difference in concentration of dissolved ions such as alkalis, chlorides and oxygen, in the vicinity of steel. Due to the potential difference some parts of the metal become anodic and the other parts become cathodic. Dissolution or pitting of iron takes place and rust appears on the anodic part as iron gets converted to ferrous oxide or ferrous hydroxide. For this chemical process presence of moisture and oxygen is necessary. The concrete acts as an electrolyte and the electro-chemical process takes place.

- Depending on the state of oxidation, metal get converted to rust (corrosion product) which may occupy 6 to 8 times the original size of steel.

Electrochemical reactions in a typical corrosion cell in reinforced Concrete



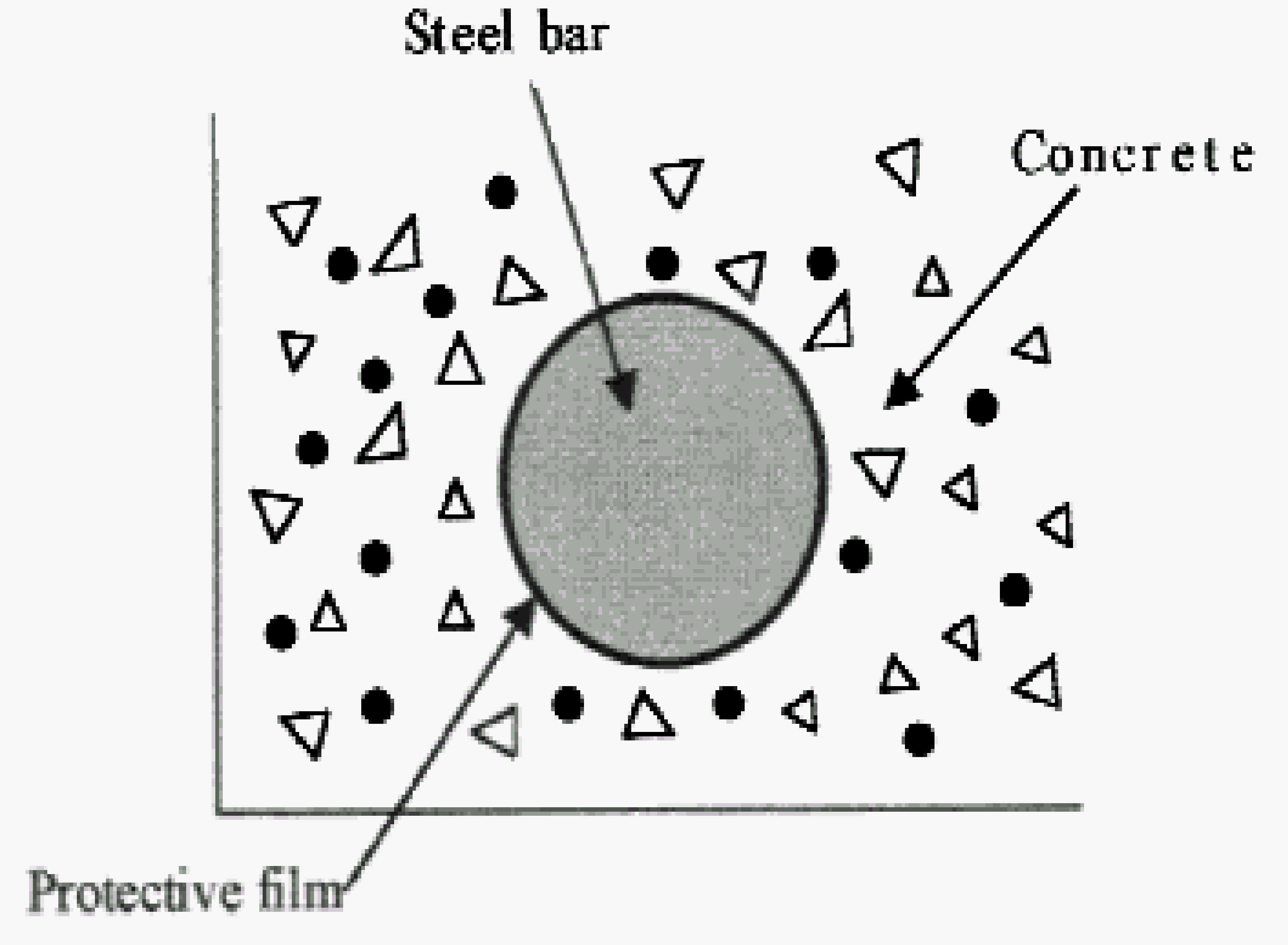
Rate of Chloride diffusion in OPC and Blended Cements	
Type of Cement	**Chloride Diffusion Sq.cm / S x 10**
OPC	4.47
Pozzolana Cement (70% OPC & 30% fly ash)	1.47
Slag Cement (35% OPC & 65% slag)	0.41
Sulphate Resistant Cement	10.0

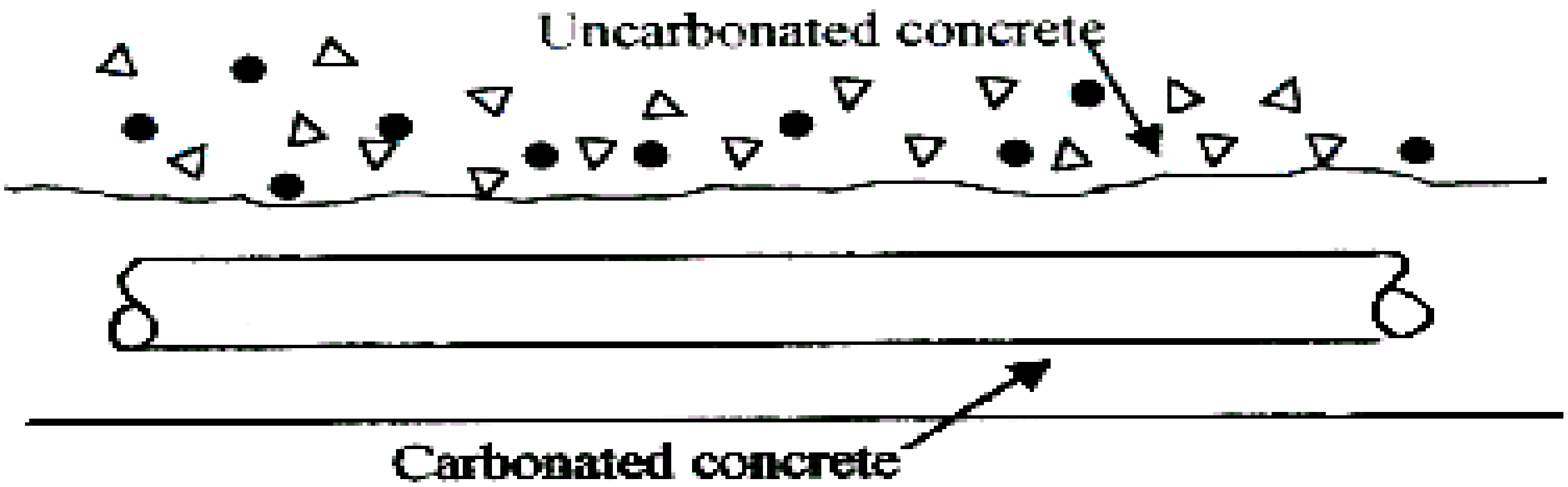


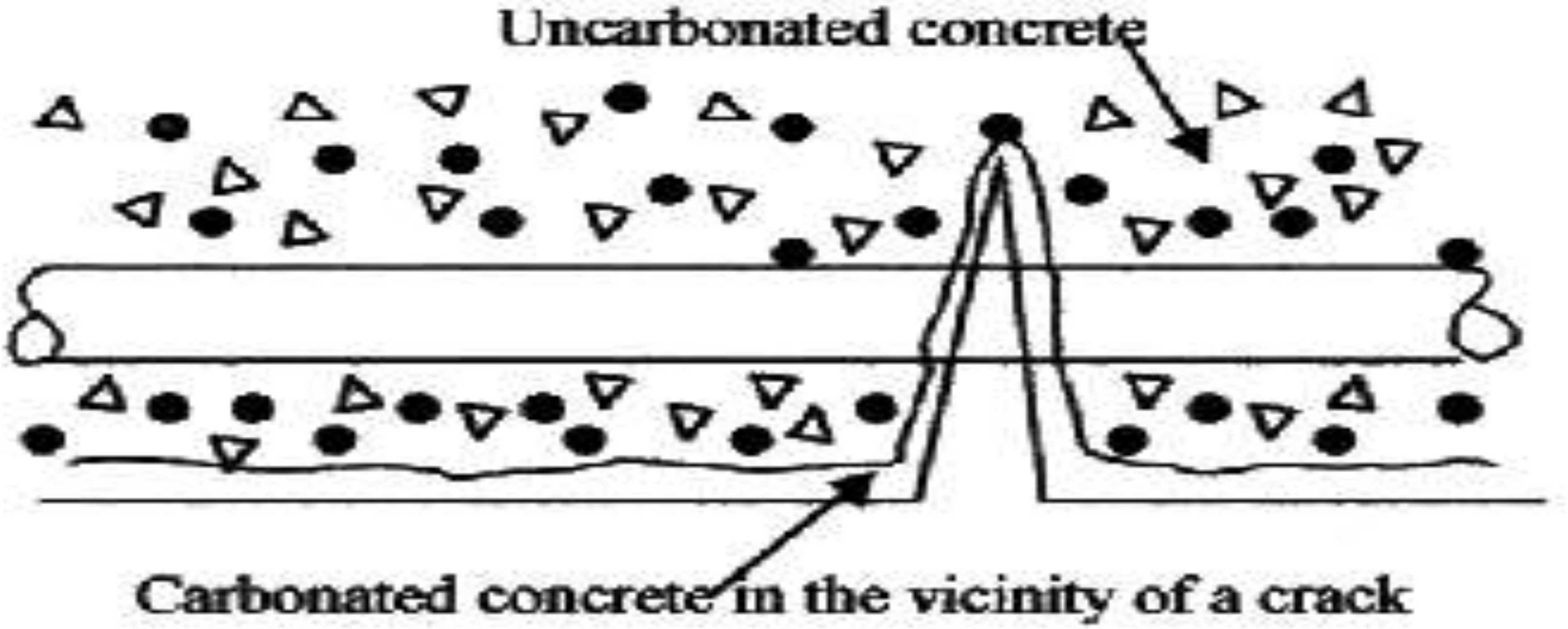
Spalling of concrete of a building column due to rusting of steel

Carbonation

- The carbon dioxide in the atmosphere in presence of water reacts with the concrete surface and concrete gets carbonated or in other words turns acidic. This chemical reaction starts at the surface and gradually goes within the concrete mass and is generally measured as depth of carbonation.
- Concrete is an alkaline substance and provides excellent protection to reinforcement embedded inside. The alkaline environment forms a protective oxide film which passivates the steel and protects it from corrosion. Concrete initially has a pH value of above 13.
- Due to leaching, carbonation and defective construction practice the pH value drops rapidly. Once the pH value of concrete in the cover area drops below 10, corrosion of steel reinforcement is inevitable and therefore concrete durability is at stake.


Steel bar
Concrete
Protective film


Uncarbonated concrete
Carbonated concrete


Uncarbonated concrete
Carbonated concrete in the vicinity of a crack

Rate of Carbonation depends on:

1 Concrete Quality

2 Environmental conditions

3 Type of cement used

Estimated 20 years Carbonation depths for different grades of concrete		
Sr. No.	Estimated 20 yrs. depth (mm)	28 days compressive strength (N/mm^2)
1.	6mm	58.00
2.	14mm	41.50
3.	22mm	31.50
4.	33mm	21.00

Sulphate Reaction

Sulphates are generally found in ground water and subsoil. Sea water also contains large quantity of Sulphates. Sulphates can be naturally occurring or could be as a consequence of industrial waste.

Blended cements have low C_3A content and also enable production of pastes containing small amount of calcium hydroxide. The Pozzolana cements have also shown great Sulphate resistance which is probably due to the composition and the structure of the pores in hydrated pastes.

Alkali Aggregate Reaction

Several harmful chemical reactions between aggregates and ordinary Portland cements have been reported. The most common reaction is the one between certain types of silica occurring aggregates and alkalies present in cement. The type of silica which are alkali reactive are opal, chalcedony and tridymite.

Due to this reaction a gel made up of alkaline – earth silicate is formed. This gel has a tendency to absorb water and swell. The swelling causes internal stress and when this stress exceeds the tensile strength of the pastes cracking of concrete can occur.

This problem cannot be always solved by changing the aggregates. Therefore cement of appropriate chemical composition has to be used.

Using blast furnace slag cements and Pozzolanic cements is yet another solution.

Ingredients for Highly Durable Concrete

1. Very low porosity through the development of a tight and refined pore structure of the cement paste
2. Very low permeability of the concrete
3. High resistance to chemical attack
4. Low heat of hydration
5. High early strength and continued strength development
6. Low water-binder ratio
7. High workability and control slump loss
8. Low bleeding and plastic shrinkage
9. Dimensional or volume stability
10. High elastic modulus
11. Low thermal stress
12. Low creep

Factors to be controlled for producing durable concrete

a) Structural design,
b) Study of environment in which structure is located
c) Water cement ratio, cement content, concrete grade
d) Cover and cover block quality,
e) Materials quality and mix design
f) Workability and cohesiveness of concrete mix
g) batching, mixing, transporting, compacting and curing
h) Maintenance and usage in service life

Durable Concrete Strategy

A material strategy to develop a high-durability concrete, that is high strength through durability rather than high durability through strength.

A management strategy to develop efficient protective system to protect concrete and steel from aggressive environmental attack.

A design strategy to integrate material properties with structural performance that will ensure material stability and structural integrity.

Emeritus Professor Narayana Swamy

Environmental Exposure Conditions Table 3 of IS: 456-2000

Mild
Moderate
Severe
Very Severe
Extreme

Mild Exposure Condition

Concrete surfaces protected against weather or aggressive conditions, except those in coastal area

Moderate Exposure Condition

Concrete surfaces sheltered from severe rain or freezing of whilst wet.

Concrete exposed to condensation and rain.

Concrete continuously under water.

Concrete in contact or buried under non aggressive soil/ground water.

Concrete surfaces sheltered from saturated salt air in coastal area

Severe Exposure Condition

Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.

Concrete completely immersed in sea water

Concrete exposed to coastal environment

Very Severe Exposure Condition

Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil/ground water

Extreme Exposure Condition

Surfaces of members in tidal zone.

Members in direct contact with liquid/solid aggressive chemicals

Exposure Conditions as per IRC: 21-2000

Code of Practice for road bridges section III

Severe: Marine environment: alternative wetting and drying due to sea spray; alternative wetting and drying combined with freezing;

Buried in soil having corrosive effect; members in contact with water where the velocity of flow and the bed material are likely to cause erosion

Moderate: Conditions other than severe

Minimum Cement content, Minimum Grade of Concrete and maximum water-cement ratio for different exposure conditions
Table 5 of IS: 456-2000

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum cement content kg/CuM	Maximum free water cement ratio	Minimum Grade of concrete	Minimum cement content kg/CuM	Maximum free water cement ratio	Minimum Grade of concrete
Mild	220	0.60	-	300	0.55	M20
Moderate	240	0.60	M15	300	0.50	M25
Severe	250	0.50	M20	320	0.45	M30
Very severe	260	0.45	M20	340	0.45	M35
Extreme	280	0.40	M25	360	0.40	M40

Requirements of minimum concrete grade, minimum cement content and maximum water cement ratio as per IRC: 21-2000

structural member	min. grade of concrete conditions of exposure		min. cement content conditions of exposure		max. water cement ratio conditions of exposure	
	moderate	severe	moderate	severe	moderate	severe
PCC	M15	M20	250	310	0.5	0.45
RCC	M20	M25	310	360	0.45	0.4

Note: quantity of cement apply for 20mm aggregates. For larger aggregates reduction up to 10% and for smaller aggregates increase up to 10% is ermitted

Development length factors of bars for limit state method as per IS: 456-2000				
Concrete Grade	Mild steel bars		Deformed bars	
	Tension	Compression	Tension	Compression
M 20	46	37	47	38
M 25	39	32	41	33
M 30	37	29	38	31
M 35	32	26	34	27
M 40	30	24	30	24

Development length (l_d)= factor× bar dia

Lap length in flexural tension= greater of l_d or 30 ø

Lap length in direct tension = greater of 2 l_d or 30 ø

Lap length in compression = greater of l_d or 24 ø

Development length in multiples of dia as per IRC:21

Concrete grade		M20	M25	M30	M35	M40 & above
	bar gr.					
Bonding zone I favourable	Fe 500	66	56	48	42	42
	Fe 415	55	46	40	35	35
	Fe 240	65	60	55	50	50
Bonding Zone-II Un-favourable	Fe 500	1.4 times the values given for bonding zone-II				
	Fe 415					
	Fe 240					

Detailing of Reinforcement

- Layout of steel bars
- Anchorages
- Splices (location and stagger)
- Curtailment
- Concrete Cover
- Bar sizes
- Lap lengths
- Free spaces around bars

Requirements of good detailing

- Simple to fabricate and place
- Control cracks (width as well as length)
- Joints as strong as members
- Along stress trajectories (deviation < 20^{o})
- Bar sizes as few as possible
- Spacing module (bars, stirrups, and ties)

Table 9 Proportions for Nominal Mix Concrete

(Clause *9.3 and 9.3.1 of IS:456)*

Grade of Concrete	Total Quantity of Dry Aggregates by Mass per 50kg of Cement, to be taken as the sum of the Individual Masses of Fine and Coarse Aggregates, kg, Max	Proportion of Fine Aggregate to Coarse Aggregate (by Mass)	Quantity of Water per 50kg of Cement, Max
(1)	(2)	(3)	(4)
M5	800	Generally 1:2 but subjected to an upper limit of 1:1½ and a lower limit of 1:2½	60
M7.5	625		45
M10	480		34
M15	330		32
M20	250		30

Some Controlled Concrete Mixes used in R&B works

Concrete Grade	Proportion by Weight			W:C ratio	Cement Kg/cum
	Cement	Sand	Metal		
M 15	1	2.71	5.27	0.7	240
M 20	1	1.73	3.25	0.52	360
M 20	1	2.51	3.76	0.6	297
M 25	1	2.13	3.19	0.52	342
M 25	1	1.54	2.9	0.45	400
M 30	1	1.84	2.76	0.46	387
M 30	1	1.24	2.32	0.42	470
M 40	1	1.067	3.332	0.38	421
M 40	1	0.94	3.09	0.36	450

Controlled Concrete Mixes of NHAI works

Concrete Grade	Proportion by Weight			W:C ratio	Cement Kg/cum
	Cement	Sand	Metal		
M 15	1	2.09	4.5	0.5	300
M 20	1	2.19	3.61	0.45	370
M 20	1	1.87	3.97	0.45	340
M 25	1	1.35	3.23	0.40	342
M 25	1	1.41	3.24	0.45	410
M 35	1	1.25	2.99	0.40	430

Control concrete mixes with Blended Cements

Concrete Grade	Proportion by Weight			W:C ratio	Cement Kg/cum
	Cement	Sand	Metal		
M20	1	2.45	3.50	0.56	310
M25	1	2.30	3.25	0.54	330
M30	1	1.85	2.75	0.48	385

Cement used in above mixes is ACC Suraksha

M20	1	1.98	3.73	0.59	320
M30	1	1.48	3.05	0.48	392
M40	1	1	2.87	0.40	450

Cement used in above mixes is Birla Plus

Material quantities per cum as per MORT&H standard data 2003

Type & grade of concrete	Coarse aggregates			sand	cement
	40mm	20mm	12.5mm		
PCC M15	0.54	0.27	0.09	0.45	275
PCC M20	0.36	0.36	0.18	0.45	344
RCC M20		0.54	0.36	0.45	347
PCC M25	0.36	0.36	0.18	0.45	399
RCC M25		0.54	0.36	0.45	403
PCC M30	0.36	0.36	0.18	0.45	405
RCC M30		0.54	0.36	0.45	401
RCC M35		0.54	0.36	0.45	422

CONCRETE MIX DESIGN with GGBS

Ready Mix Plant (RMC), Hyderabad

PARTICULARS	Grade M15
OPC 53 Grade	150 Kgs/M^3
Ground Granulated Blast furnace Slag	150 Kgs/M^3
Sand	360 Kgs/M^3
Crusher Dust	360 Kgs/M^3
Aggregates 10 mm	500 Kgs/M^3
20 mm	650 Kgs/M^3
Water/Binder Ratio	0.62
Slump	80 mm
Compressive Strength (N/mm^2) 28 Days	41.50

Concrete Mix Design with GGBS

- HI TECH CITY, Hyderabad
- Construction Company : L & T, ECC

PARTICULARS	Grade M 50	Grade M 50
OPC 53 Grade	250 Kgs/M^3	350 Kgs/M^3
Duncan GGBS	250 Kgs/M^3	150 Kgs/M^3
Sand	757 Kgs/M^3	757 Kgs/M^3
Aggregates 10 mm	421 Kgs/M^3	421 Kgs/M^3
20 mm	505 Kgs/M^3	505 Kgs/M^3
Water/Binder Ratio	0.33	0.33
Slump	80 mm	95 mm
Compressive Strength (N/mm^2)		
7 Days	38.90	47.30
21 Days	51.90	59.0
28 Days	58.40	60.0

Some Control concrete mixes used in ORR works

Si.no.	Grade of Concrete	Cement OPC53 Grade	Cement Qty.	W/C Ratio	Admixture Brand	% of Admixture	% of CA	% of FA
1.	M15 PCC	RAMCO	280	0.50	BASF 861 M3(M)	0.4	63	37
2.	M15 PCC	RAMCO	280	0.50	Shaliplast SP 431	0.4	63	37
3.	M15 PCC	Maha Gold	280	0.50	Shaliplast SP 431	0.4	63	37
4.	M15 PCC	Maha Gold	280	0.50	BASF 861 M3(M)	0.4	63	37
5.	M15 PCC	Vasavadatta	280	0.50	Shaliplast SP 431	0.4	63	37
6.	M15 PCC	Vasavadatta	280	0.50	BASF 861 M3(M)	0.5	63	37
7.	M20 PCC	Maha Gold	300	0.50	Shaliplast SP 431	0.5	64	36
8.	M 20 PCC	Maha Gold	300	0.50	-	Nil	64	36
9.	M15 PCC	RAMCO	300	0.50	Shaliplast SP 431	0.5	64	36
10	M15 PCC	RAMCO	300	0.50	-	Nil	64	36
11.	M15 PCC	RAMCO	320	0.45	Shaliplast SP 431	0.5	64	36
12.	M15 PCC	Vasavadatta	320	0.45	Shaliplast SP 431	0.8	63	37
13.	M20 RCC	Vasavadatta	320	0.45	BASF 861 M3(M)	0.8	63	37
14.	M25 RCC	RAMCO	350	0.45	Shaliplast SP 431	1.0	62	38
15.	M25 PCC	Maha Gold	350	0.45	Shaliplast SP 431	1.0	62	38

Some Control concrete mixes used in ORR works

Si.no.	Grade of Concrete	Cement OPC53 Grade	Cement Qty.	W/C Ratio	Admixture Brand	% of Admixture	% of CA	% of FA
16.	M25 RCC	Vasavadatta	350	0.45	Shaliplast SP 431	1.0	62	38
17.	M 30 RCC	RAMCO	380	0.45	BASF 861 M3(M)	0.8	63	37
18.	M 30 RCC	RAMCO	380	0.45	Shaliplast SP 431	0.8	63	37
19.	M 30 RCC	Maha Gold	380	0.45	Shaliplast SP 431	0.8	63	37
20.	M 30 RCC	Maha Gold	380	0.45	BASF 861 M3(M)	0.8	63	37
21.	M 30 RCC	Vasavadatta	380	0.45	Shaliplast SP 431	0.8	63	37
22.	M 30 RCC	Vasavadatta	380	0.45	BASF 861 M3(M)	0.7	63	37
23.	M 35 RCC	RAMCO	400	0.40	BASF RHEO BUILD 861 M3 (M)	1.0	64	36
24.	M 35 RCC	RAMCO	400	0.40	Shaliplast SP 431	1.0	64	36
25.	M 35 RCC	Vasavadatta	400	0.40	BASF RHEO BUILD 861 M3 (M)	0.8	64	36
26.	M 35 RCC	Vasavadatta	400	0.40	Shaliplast SP 431	1.0	64	36
27.	M 35 RCC (for plies)	Vasavadatta	420	0.42	BASF 1100i Super Plasticizer	1.2	60	40
28.	M 40 RCC	RAMCO	420	0.38	BASF RHEO BUILD 861 M3 (M)	0.8	64	36
29.	M 40 PSC	Vasavadatta	420	0.36	BASF 1100i Super Plasticizer	0.8	60	40
30.	M 45 RCC	RAMCO	420	0.38	BASF RHEO BUILD 861 M3 (M)	0.7	64	36
31.	M 45 PSC	Vasavadatta	450	0.36	BASF 1100i Super Plasticizer	0.8	60	40

Mini Weigh batching plant and CC mixer

TRUCK MOUNTED CONTINUOUS CONCRETE MIXE

BANGALORE	CHENNAI	DELHI	KOLKATA	PUNE
Tel.: 080 - 4113 1838	Tel.: 044 - 2431 5535	Tel.: 011 - 2574 6338	Tel.: 033 - 4001 9355	Tel.: 020 - 2712 2989
Fax: 080 - 2220 0119	Fax: 044 - 2434 2855	Fax: 011 - 2576 6364	Fax: 033 - 4001 9344	Fax: 020 - 2712 2332
emagblr@airtelbroadband.in	emagmds@md4.vsnl.net.in	emagdel@vsnl.net	emagcal@gmail.com	emagpune@vsnl.net

CONCRETE MOBILE
BATCHING MACHINE

Manufactured In
HYDERABAD

Single Bin

Rs **4.25** Lakhs

Three Bin

Rs **4.50** Lakhs

- Capacity : 12 Cu. Mtr/Hr(max)
- Electronic Weighing System
- In-built Water feeding System
- Ex-Stock

+ 4%VAT+Transport
(Excise Duty included)

Dealers Enquiry Solicited

Manufactured by :

ACME CONSTRUCTION EQUIPMENTS

ACME

1-1-164/2, Near Yashoda Hospital, R.P.Road, Secunderabad - 500 003.
Ph : 040-27704820, 66317720, Fax : 040-27704820
E-mail : acmemachines@gmail.com, WEB:www.acme555.com
Marketing : Inamdar-09246584825, Khan-09246365055.

On Wheel Concrete Batching Plant with Pan Mixer

- Fully automated Feeding System
- Pneumatically controlled Gates
- Can be used at compact places
- More Power : Output ratio in its class

On Wheel Concrete Batching Plant with Reversible Mixer

- Can be used in road projects
- Necessity of shifting every 15 to 20 days

Universal Construction Machinery & Equipment Ltd.

Universal House,
Warje Naka,
Pune - 411 052.
Maharashtra, India.

Tel: +91 20 2523 0777,
+91 20 6500 8033.
Fax: +91 20 2523 1777
Toll Free - 1800 233 1777

Email:
sales@uceindia.com

Export:
export@uceindia.com

Universal at Work

New Delhi | Mumbai | Kolkatta | Bangalore | Hyderabad | Ahmedabad | Nagpur | Kolhapur | Jaipur | Goa | Chandigarh | Nasik | Guwahati

Weigh batching Concrete mixing plant – control panel

Weigh batching Concrete mixing plant – bins and transit mixer

Weigh batching Concrete mixing plant – concrete failing on conveyer belt

Weigh batching Concrete mixing plant – conveyer belt

Weigh batching Concrete mixing plant – loading transit mixer

Conventional concrete mixer using weigh batcher

Mobile Ready Mix Plant with weigh batching
Capacity: 60 tons per day

Mobile Ready Mix Plant with weigh batching
Capacity: 60 tons per day

Concreting is in progress with concrete pump

Concreting (M25 grade) in progress for well steining
Transit mixer and concrete pump are used

Nominal Cover to Meet Durability Requirements as per IS:456-2000

Exposure	Nominal Concrete Cover in mm not less than
Mild	20
Moderate	30
Severe	45
Very sever	50
Extreme	75

Notes: 1.For main reinforcement up to 12mm diameter bar for mild exposure the nominal cover maybe reduced by 5mm. 2.Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by +10mm/0mm 3.For exposure condition 'severe' and 'very severe', reduction of 5 mm may be made, where concrete grade is M35 and above.

Workability of Concrete

Placing conditions	Degree of workability	Slump (mm)
Blinding concrete, Shallow sections; Pavements using pavers	Very low	Compaction Factor: 0.75 to 0.80
Mass concrete; Lightly rein-forced sections in slabs, beams, walls, columns, Floors, Hand placed pavements; Canal lining; Strip footings	Low	25 to 75
Heavily reinforced sections in slabs, beams, walls, columns; Slip form work; Pumped concrete	Medium	50 to 100; 75 to 100
Trench fill; In-situ piling	High	100 to 150
Tremie concrete	Very high	Flow method

Slump Test: concrete mix placed in mould in four layers. Each layer tamped 25 times by 16mm dia tamping rod

Requirement of Formwork

- To get required shape, size, finish, position and alignment of concrete members
- To have load carrying capacity without distortion
- To have design for quick erection and removal
- To handle easily using available equipment and manpower
- Joints between formwork must be tight enough to prevent leakage
- To provide easy and safe access for concrete handling and placing
- To avoid damage to concrete or formwork itself while stripping

FORMWORK FOR CONCRETE WORKS

❖**Workmanship:** The formwork shall be robust and strong and joints are leak proof. Close watch shall be maintained to check for settlement of formwork during concreting. Any settlement of formwork during concreting shall be promptly rectified.

❖**Reuse of formwork:** When formwork is dismantled and before reuse all components shall be cleaned of deposits of soil, concrete or other unwanted materials. All bent steel props shall be straightened before reuse and the maximum deviation from straightness is 1/600 of the length.

Steel Formwork

Good centering arrangements for external plinth beam

Single stage Shuttering for columns is giving good finishing

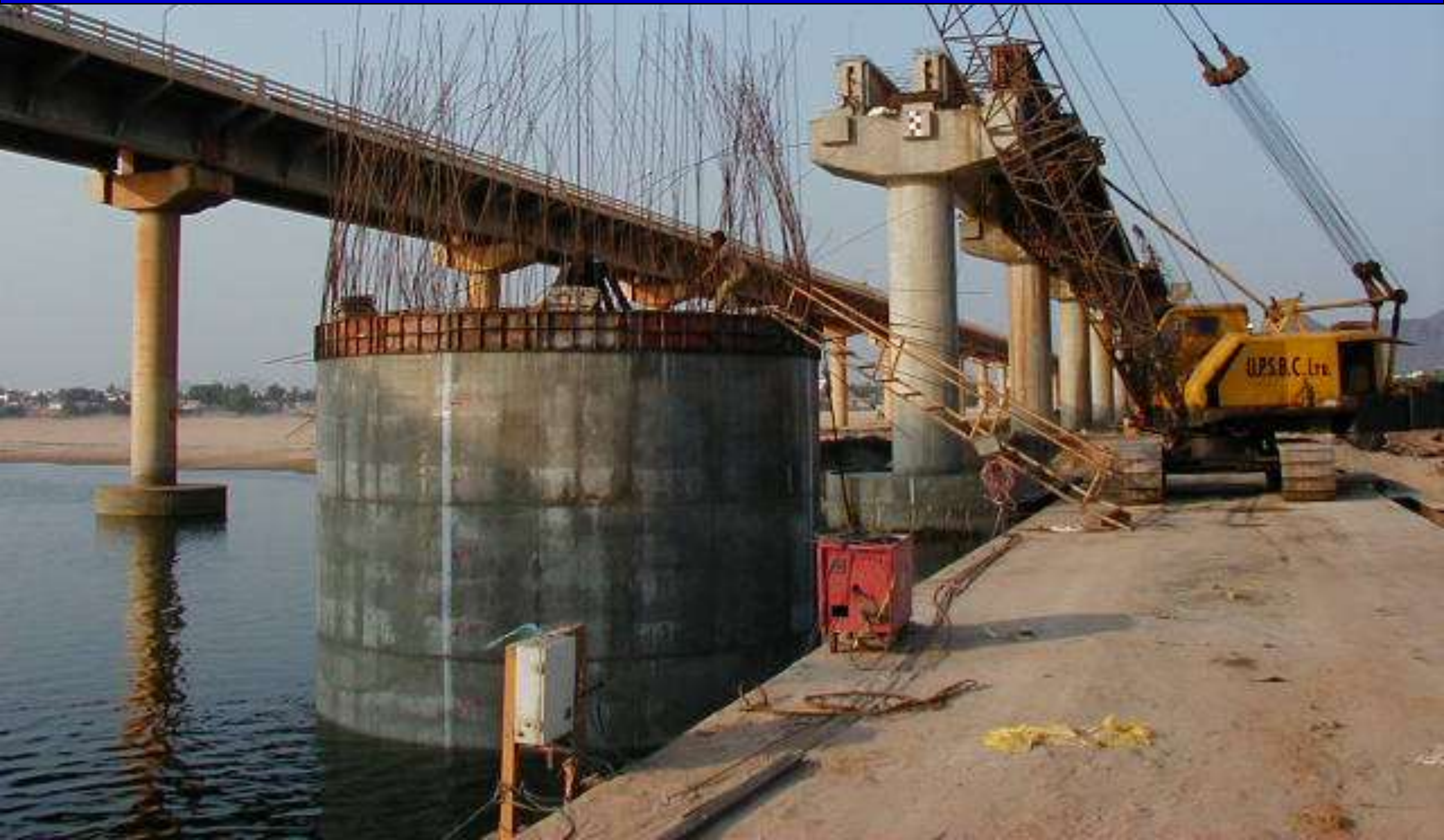
Single stage Shuttering for columns is giving good finishing


Ugly finish due to improper stage shuttering for columns

Poor workmanship, improper shuttering and no control on quality gave an ugly appearance to the building




0.5m collar is used for maintaining the alignment of shutters Observe the finish of concrete surface of piers. It is with M35 concrete using 20mm and 12mm chips in 3:2 ratio. Blending of GGBS was also done.



Stripping Time (11.3 of IS:456)

Type of Formwork	*Minimum Period Before Striking Formwork*
(a) Vertical formwork to columns, wells, beams	**16 – 24 hrs**
(b) Soffit formwork to slabs **(Props to be refixed immediately after removal of formwork)**	**3 days**
(c) Soffit formwork to beams **(Props to be refixed immediately after removal of formwork)**	**7 days**
(d) Props to slabs: **1) Spanning up to 4.5m** **2) Spanning over 4.5m**	 **7 days** **14 days**
(e) Props to beams and arches: **1) Spanning up to 6m** **2) Spanning over 6m**	 **14 days** **21 days**

Curing

The chemical action between cement and water which results in the setting or hardening of concrete or mortar. Although there is normally adequate quantity of water for full hydration when the mortar or concrete mix is prepared, it is important to ensure that the water is either retained or replenished to enable the chemical reaction to be continued till such time the required strength is gained. In order to help the hydration process to continue, water in the capillaries should be prevented from evaporating.

Curing plays a very significant role in concrete and mortar performance and needs full attention of the persons involved in the construction. Since cement hydration is very rapid in the first few days, it is very important for enough water to be retained in the concrete or mortar

Curing methods

- By maintaining the presence of mixing water during the early hardening period. Methods generally deployed are Ponding or Immersion, Spraying, Sprinkling, fogging, wet covering using Hessian cloth or gunny bags etc.,

- By preventing loss of mixing water by sealing the exposed surface of concrete. The exposed surfaces are generallly covered by curing compound, impervious paper, plastic sheets or by leaving formwork in place.

Curing by Ponding for roof slab

Curing by Ponding for culvert slab

Curing by Hay tying

Curing by covering with gunny bag covers

Curing of cubes along with the structure to know about the representative strength of concrete.

One technique that has been frequently and successfully used during silica-fume concrete placement is fogging. The approach is to increase the humidity above the surface of the concrete and decrease the rate of evaporation. Fogging should not be used to apply additional water to the surface of the concrete to aid in finishing.

Applying curing compound while concrete is still fresh

Here, curing compound is being applied to silica-fume concrete in a parking structure shortly after brooming. In many cases, the use of curing compound is the preliminary curing method; it is intended to protect the concrete until it gains enough strength to allow placing wet curing materials on the deck without marring the surface. On this particular project, wet burlap and plastic sheeting were used for the final curing.

Moist curing after concrete hardens

In this photo, the burlap and plastic sheeting have been applied. For most applications of silica-fume concrete, wet curing will provide better in-place concrete quality than the use of curing compound alone.

Compaction of Concrete

Compaction is necessary to remove entrapped air present in concrete after it is mixed, transported and placed. Compaction also eliminates stone pockets and remove all types of voids that may possibly left in the concrete, causing reduction in strength and durability.

Compaction by Vibration

On vibration, concrete mix gets fluidized resulting in entrapped air raising to the surface and conctrete denser

Internal Vibrators (Pin Vibrators) and
External Vibrators(Form Vibrators, Vibration tables and Surface Vibrators) are available

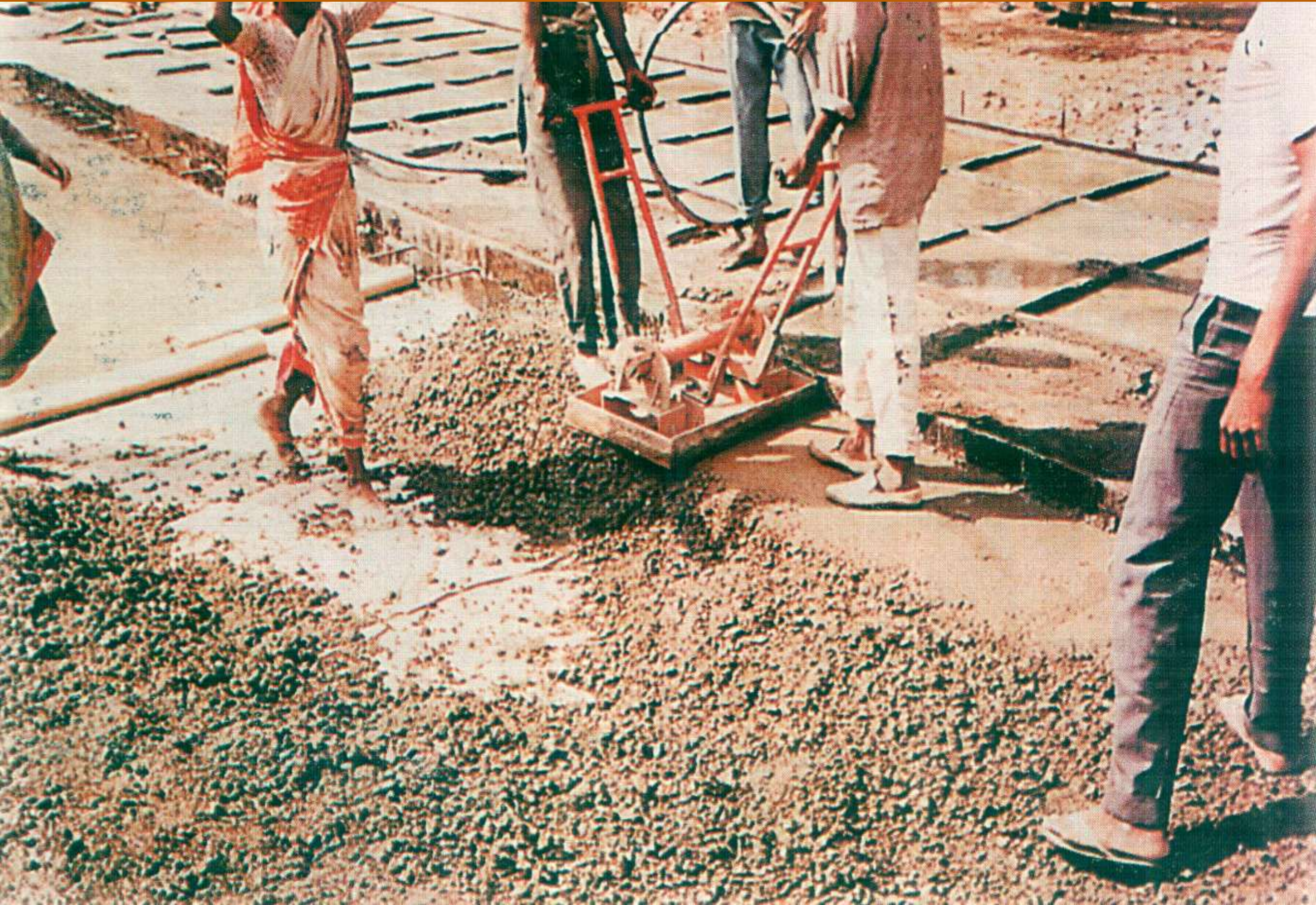
Guidelines for compaction with Pin Vibrator

1) Insert poker quickly and allow it to penetrate by its own weight to the bottom of layer so that the entrapped air is removed uniformly.
2) Leave the poker in concrete for 10 seconds. Compaction time depends on slump.
3) Poker must be inserted quickly, but withdrawal must be slow so that the hole left by the poker is filled up as it is being withdrawn.
4) Locations of poker insertion should be staggered.
5) Avoid touching the form work and reinforcement with poker.
6) Poker should extend upto 100mm into the previous layer.
7) It is safer to over vibrate than under vibrate.

Concrete compacting using Screed Vibrator

Vibrating the concrete mix placed for beams and slab concrete

Concrete comaction using plate vibrator



Sampling and Acceptance Criteria

Test result of a sample = average strength of 3 specimens
Individual variation = not more than ± 15% of average

Sampling frequency	
Quantity of concrete In cum	No. of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 and above	4 + 1 per Additional $50m^3$

Acceptance criteria as per Table 11 of IS-456		
Grade	Mean of 4 non-overlapping consecutive test results in N/mm^2	Individual test results N/mm^2
M 15	$\geq f_{ck}$ + 0.825 SD or f_{ck} + 3 N/mm^2	$\geq f_{ck}$ -3 N/mm^2
M 20 or above	$\geq f_{ck}$ + 0.825 SD or f_{ck} + 4 N/mm^2	$\geq f_{ck}$ -4 N/mm^2

Acceptance criteria as per IRC:21-2000 for bridges.

When both the following conditions are met, the concrete complies with the specified compressive strength	
Mean strength determined from any group of 4 consecutive test results should exceed f_{ck} by 3 N/mm^2	Strength of any Individual test sample is not less than f_{ck} - 3 N/mm^2

Note: Sampling frequency is the same as per IS:456-2000

Core cutting machine for concrete and BT surfacing with cores and saw. Compressive strength of cores shall not be less than 85% of cube strength

Brick Work
APPS 501

Bricks must have correct size, shape and sharp square edges. Bricks shall not break when dropped from 1m height, shall give ringing sound when struck with each other and leave no impression with finger nails.

1)Mortar joint thickness shall not exceed 10mm in Ist class bricks and 12mm in 2 nd class bricks.

2) Crushing strength (shall not be less than 75 Kg/Sqcm for bricks for NCRMP works) and water absorption (shall be less than 20%)

3) Bricks shall be soaked at least for 1 hour before use.

4) Brick work should be raised uniformly and height of work ina day shall be less than 1.5m.Difference in height between two different portions shall be less than 1m.

5) When the mortar is green, the face joints should be raked to a depth of 12 to 19 mm.

Water absorption < 20%. Dry bricks for 4 hours at 100 to 110º C, weigh(W_1), immerse in water for 24 hours at 27 ± 2ºC and weigh again(W_2). $WA = (W_2 - W_1) \div W_1 \times 100$

Compressive strength: Grind the 2 long faces,apply cement mortar, wrap with gunny bag for 24 hours, immerse in water for 3days. Measure the brick and place it in testing machine with 3mm plywood planks on top & bottom

Buildings of Indian Institute of Management Ahmedabad All the buildings in the sprawling compound were constructed about 30 years back and are without any plastering or finishing. Some cracks upto 2mm wide are observed

Brick work with FALG bricks being constructed by CPWD
Weight = 2.5 kg (VTPS), 3.0 to 3.25 kg (others).
Compressive strength varies from 100 to 125 kg/cm^2

Interlocking bricks used for the construction of compound wall at Vijayawada constructed by Railways

Stone Masonry

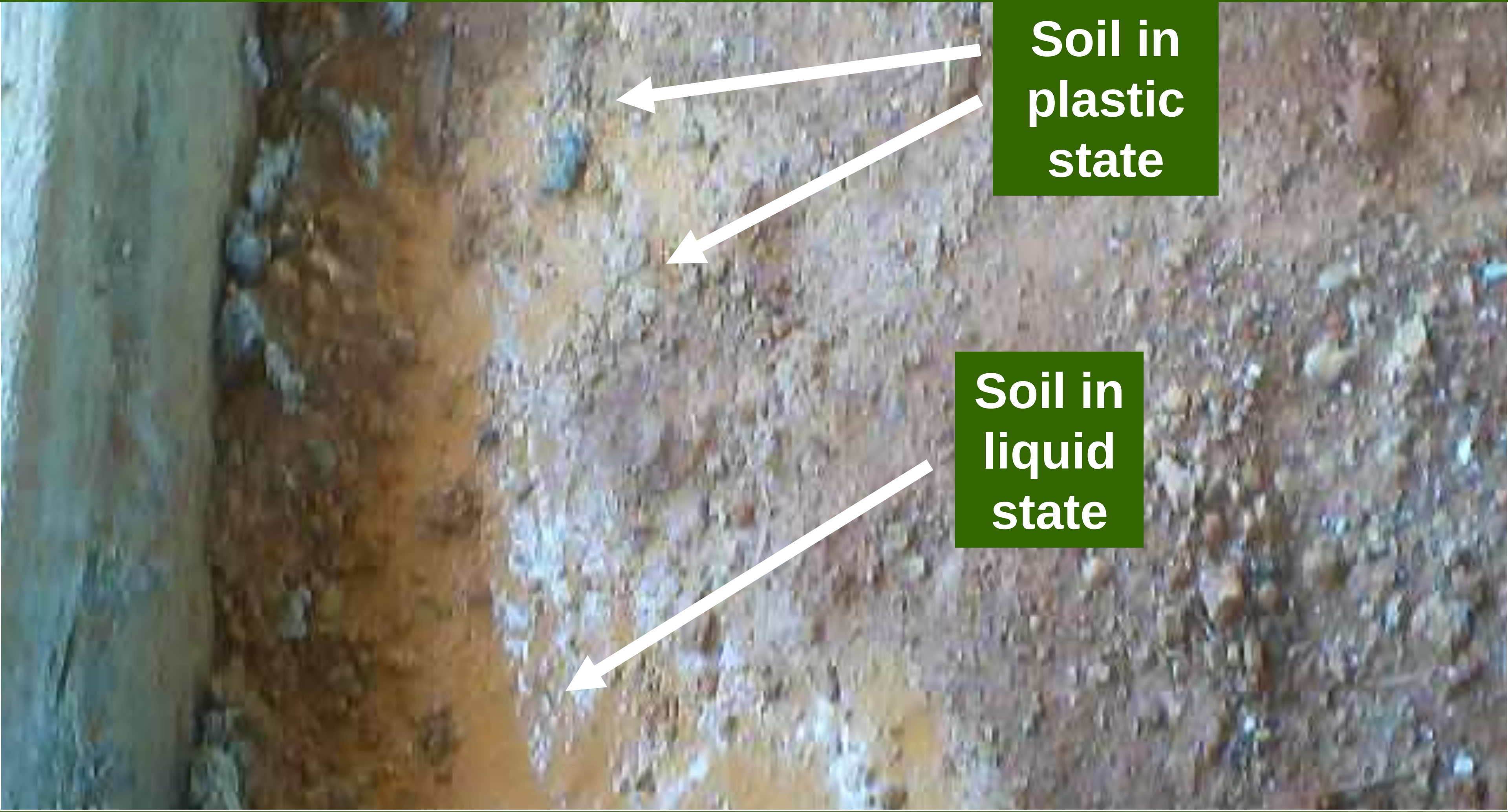
APSS 601

1) Bond: A stone in any course shall over lap the stone in the course below, i.e. Joints parallel to the pressure in two adjoining courses shall not lie too closely in the same vertical line.
2) Bond stones shall be built in the walls at intervals of 2M in length and 0.6 M in height and shall run through the wall if the wall is not more than 600 mm in thickness. If the wall is more than 600 mm thick a line of headers shall be laid from face to back, each header overlapping the other by at least 150 mm. The bond stones shall be clearly marked on both the faces.

Filling basement with gravelly soil is to be done with extreme care. It has to be spread in thin layers, watering by sprinkling only and compaction by earthen compactors. If soaking is done, gravel becomes very slushy and it is impossible to compact. Even after drying for a long time, only top layer will be dried and that too will not regain original state. Here, holes drilled to the bottom of fill and flooded with water. Entire gravelly soil has to be removed as the wet soil remains in soft plastic condition and creates problems for flooring

It is very difficult to even set foot on it as gravelly soil has absorbed water fully and become plastic as water content crossed plastic limit value. Imagine the presence of soil in similar condition below a road. This is the main reason why roads in our state are getting prematurely damaged.

If gravelly soil is proposed for top of the basement fill, it has to be compacted thoroughly by maintaining water content around Optimum Moisture Content. Care should be taken to sprinkle water in such a way that at no place water content exceeds plastic limit value.




Air gap below
plinth beam


Brick on edge to cover
air gap of 100mm