

Cement

Lecture-4

Course Coordinator

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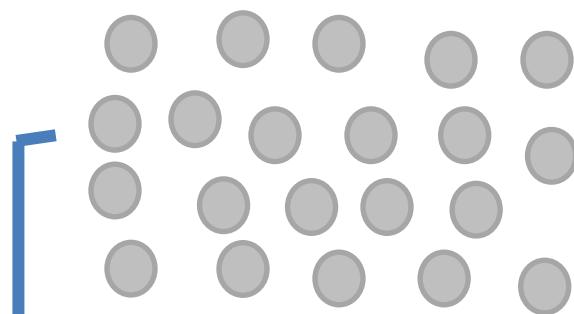
Content

- ✓ Cement storage
- ✓ Quality control parameter as per code provision
- ✓ Various types of cement available in market
- ✓ Classification as per American Society of Testing and Material
- ✓ Breif about Rapid hardening cement and Sulphate resistance
- ✓ Introduction of SCM

Why Systematic Storage of Cement is Important

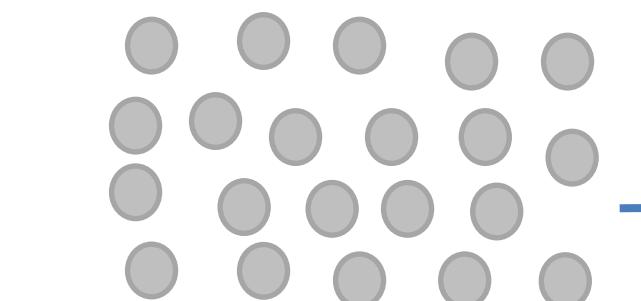
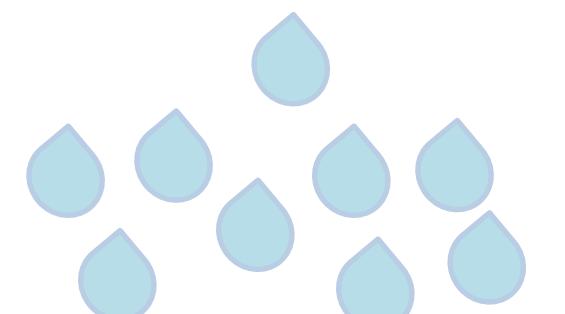


Cement → Hygroscopic nature

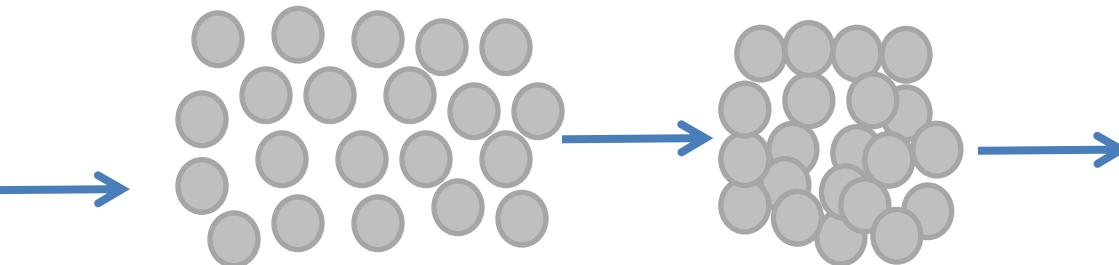


Cement Particles

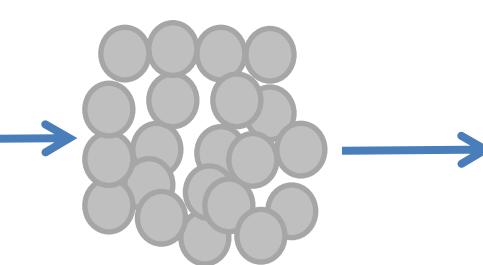
Water Droplets



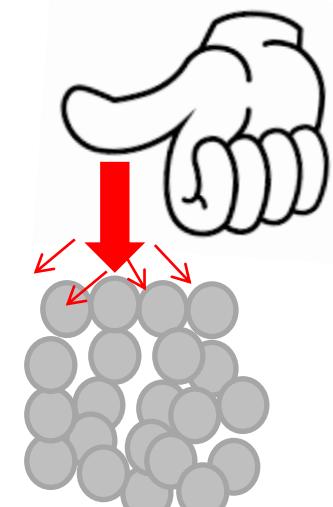
Cement Particles comes in contact of water



Hydration Onset
Stage I



Hydration Onset
Stage I

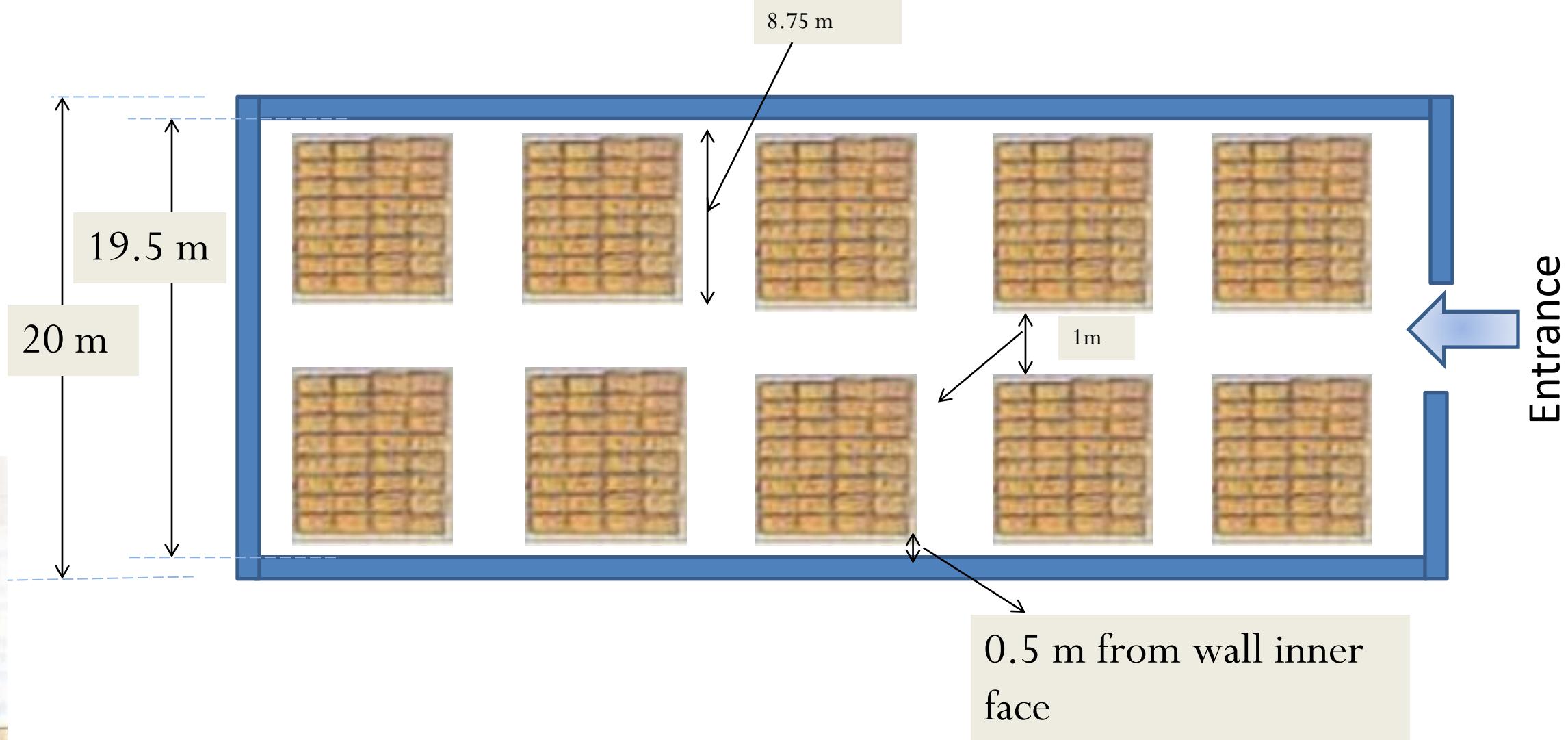
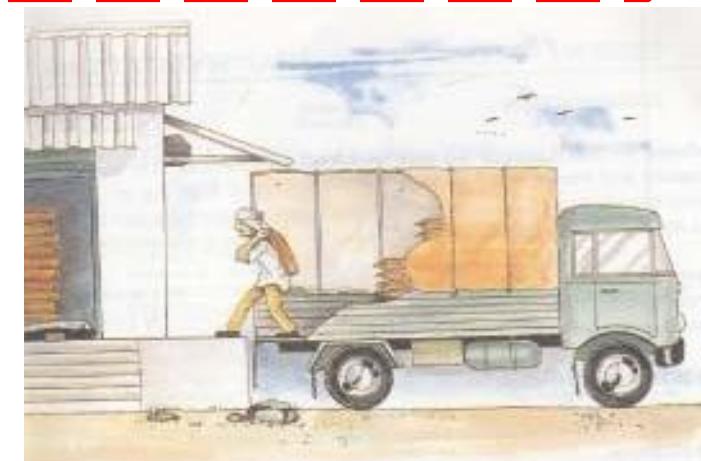


Completely Hard

Layout Plan of Cement Storage House



- ✓ Use of wooden Planks
- ✓ Height of floor is 1 m high from N.G.L
- ✓ Not more than 10 bags stacks one over the above



Storage house above the ground level

Layout of Cement Storage House

Storage of Cement

1. Cement should be stored in storage houses which should have damp proof walls, roofs, and raised floors, to prevent the entry of moisture. The floor should be made of concrete 1:2:4 and 1.25m above the ground level.
2. Cement bag should be stacked close together

Storage of Cement

3. The bags of cement should be placed **30 cm** away from the walls all round, specially from the external walls.
4. Cement should be stacked not more than **ten bags** in height to prevent formation of clods under compaction due to heavy load

Storage of Cement

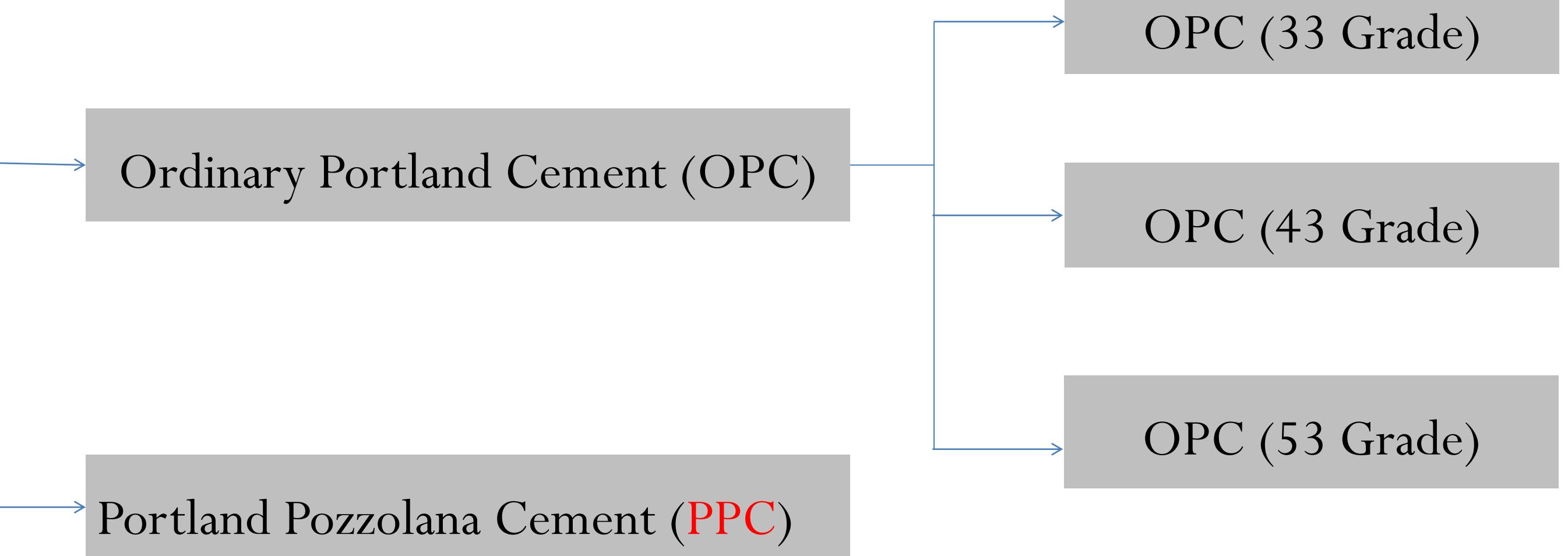
5. Stores should have less number of windows and ventilators meant for light purpose only
6. Storing of cement in rainy season should be avoided.
7. The storage should be done for a short period (old stored cement used first than the freshly stored cement)
8. At site the cement should be placed on a raised floor or wooden planks and kept covered with canvas cloth.

Storage of Cement

9. Cement bag should not be placed directly on floors.
Wooden planks and iron sheets must be placed between them.
10. When cement is to be stored in **bulk form**, it should be stored in **air tight cylindrical containers**, known as **silos or bins**.

Grade of Cement

Grade of cement available in the market



What does Grade Represents?



The grade 33, 43 and 53 in cement mainly corresponds to the average compressive strength attained after 28 days (672 hours \pm 4 hours) in mega pascals (Mpa) of at least three mortar cubes composed of one part cement, 3 parts of standard sand (conforming to IS 650:1966) by mass and P/4 (P is the percentage of water required to produce a paste of standard consistency as per IS standard) + 3 percentage (of combined mass of cement plus sand) of water , prepared, stored and tested in the manner described in methods of physical test for hydraulic cement.

Portland Pozzolana Cement



Portland pozzolana cement produces **less heat of hydration** and offers greater resistance to the attack of **aggressive waters** than normal Portland cement. Moreover, it reduces the **leaching** of calcium hydroxide liberated during the setting and hydration of cement. It is particularly useful in marine and **hydraulic construction** and other mass concrete structures. Portland cement is usable under normal conditions.

Definition of Pozzolana



ASTM C 618 – 93 describes a **pozzolan** as a **silicious** and **aluminous** material which in itself possesses little or no cementitious value but will, in *finely divided form* and in the presence of moisture, chemically react with lime (liberated by hydrating Portland cement) at ordinary temperatures to form compounds possessing cementitious properties.

Quality Control of OPC 33 Cement



IS 269 : 2013

भारतीय मानक
साधारण पोर्टलैंड सीमेंट, 33 ग्रेड — विशिष्ट
(पाँचवा पुनरीक्षण)

Indian Standard
ORDINARY PORTLAND CEMENT,
33 GRADE — SPECIFICATION
(Fifth Revision)

ICS 91.100.10

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Table 3 Physical Requirements for Ordinary Portland Cement, 33 Grade
(Foreword and Clause 6)

Sl No.	Characteristic	Requirement	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Fineness, m^2/kg , Min	225	IS 4031 (Part 2)
ii)	Soundness:		IS 4031 (Part 3)
	a) By Le Chatelier method, mm, Max	10	
	b) By autoclave test method, percent, Max	0.8	
iii)	Setting time:	See Note 1	
	a) Initial, min, Min	30	IS 4031 (Part 5)
	b) Final, min, Max	600	
iv)	Compressive strength, MPa (see Note 4):		
	a) $72 \pm 1 \text{ h}$, Min	16	IS 4031 (Part 6)
	b) $168 \pm 2 \text{ h}$, Min	22	
	c) $672 \pm 4 \text{ h}$, Min	33	
	Max	48	
v)	Transverse strength (optional)	See Notes 3 and 4	IS 4031 (Part 8)

NOTES

Quality Control of OPC 43 Cement



IS 8112 : 1980
Indian Standard
**43 GRADE ORDINARY PORTLAND
CEMENT – SPECIFICATION**
(First Revision)

भारतीय मानक
 43 ग्रेड साधारण पोर्टलैंड सीमेंट – विशिष्ट
 (पहला पुनरीकाश)

Fourth Reprint (II), Y 1992

UDC 666.942.2

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 NEW DELHI 110002

**Table 1 Chemical Requirements for High Strength Portland Cement
(Clause 5.1)**

SI No.	Characteristic (1)	Requirement (3)
(2)		
i)	Ratio of percentage of lime to percentages of silica, alumina and iron oxide, when calculated by the formula: $\text{CaO} = 0.7 \text{ SO}_3 + 2.8 \text{ SiO}_2 + 1.2 \text{ Al}_2\text{O}_3 + 0.65 \text{ Fe}_2\text{O}_3$	Not greater than 1.02 and not less than 0.65
ii)	Ratio of percentage of alumina to that of iron oxide	Not less than 0.66
iii)	Insoluble residue, percent by mass	Not more than 2
iv)	Magnesia, percent by mass	Not more than 6
v)	Total sulphur content calculated as sulphuric anhydride (SO_3), percent by mass	Not more than 2.5 and 3.0 when tricalcium aluminate (see Note 1), percent by mass is 5 or less and greater than 5 respectively
vi)	Total loss on ignition	Not more than 5 percent

Setting Time

Initial setting time in minutes – Not less than 30 minutes

Final setting time in minutes - Not more than 600 minutes

Compressive Strength

Average compressive strength of at least three cube mortar cubes (area of face 50 cm^2)

72 ± 1 hour not less than - 23 Mpa

168 ± 2 hour not less than - 33 Mpa

672 ± 4 hour not less than - 43 Mpa

Quality Control of OPC 53 Cement



IS 12269 : 2013

भारतीय मानक
साधारण पोर्टलैंड सीमेंट, 53 ग्रेड — विशिष्टि
(पहला पुनरीक्षण)

Indian Standard
ORDINARY PORTLAND CEMENT,
53 GRADE — SPECIFICATION
(First Revision)

ICS 91.100.10

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NEW DELHI 110002

Price Group 5

IS 12269 OPC-53 Grade Specification
8/5/2020

Table 3 Physical Requirements for Ordinary Portland Cement, 53 Grade
(Foreword and Clause 6)

Sl No. (1)	Characteristic (2)	Requirement (3)	Method of Test, Ref to (4)
i)	Fineness, m^2/kg , <i>Min</i>	225 370 for 53-S grade	IS 4031 (Part 2)
ii)	Soundness: a) By Le Chatelier method, mm, <i>Max</i> b) By autoclave test method, percent, <i>Max</i>	10 0.8 } See Note 1	IS 4031 (Part 3)
iii)	Setting time: a) Initial, min, <i>Min</i>	30	IS 4031 (Part 5)
	b) Final, min, <i>Max</i>	60 for 53-S grade } See Note 2	
iv)	Compressive strength, MPa (see Note 4): a) $72 \pm 1 \text{ h}$, <i>Min</i> b) $168 \pm 2 \text{ h}$, <i>Min</i>	27 37	IS 4031 (Part 6)
	c) $672 \pm 4 \text{ h}$, <i>Min</i>	37.5 for 53-S grade	
v)	Transverse strength (optional)	53 See Notes 3 and 4	IS 4031 (Part 8)

NOTES

1 In the event of cements failing to comply with any one or both the requirements of soundness specified in this table, further tests in respect of each failure shall be made as described in IS 4031 (Part 3), from another portion of the same sample after aeration. The aeration shall be done by spreading out the sample to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total period of 7 days. The expansion of cements so aerated shall be not more than 5 mm and 0.6 percent when tested by Le Chatelier method and autoclave test respectively. For 53-S grade cement, the requirement of soundness of unaerated cement shall be maximum expansion of 5 mm when tested by the Le-Chatelier method.

2 If cement exhibits false set, the ratio of final penetration measured after 5 min of completion of mixing period to the initial penetration measured exactly after 20 s of completion of mixing period, expressed as percent, shall be not less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS 4031 (Part 5) after breaking the false set, shall conform to the value given in this table.

3 By agreement between the purchaser and the manufacturer, transverse strength test of plastic mortar in accordance with the method described in IS 4031 (Part 8) may be specified. The permissible values of the transverse strength shall be mutually agreed to between the purchaser and the supplier at the time of placing the order.

4 Notwithstanding the compressive and transverse strength requirements specified as per this table, the cement shall show a progressive increase in strength from the strength at 72 h.

Quality Control of PPC Cement



Setting Time

Initial setting time in minutes – Not less than 30 minutes (*Min*)

Final setting time in minutes - Not more than 600 minutes (*Max*)

The fly ash constituent shall not be less than 10 percent and not more than 25 percent by mass of Portland-pozzolana cement.

Compressive Strength

Average compressive strength of at least three cube mortar cubes (area of face 50 cm²)

72 ± 1 hour not less than - 16 Mpa

168 ± 2 hour not less than - 22 Mpa

672 ± 4 hour not less than - 33 Mpa

Soundness using Le chatlier method shall not have an expansion of more than 10mm

Fineness tested using air permeability method shall be not less than 300m² /kg

Quality control of cement

Sr. No	Characteristics	Requirement (33 grade) IS 269- 1989	Requirement (43 grade) IS 8112-1989	Requirement (53 grade) IS 12269: 1987	Portland Pozzolana Cement IS 1489:1989 (Part-1)
1	Fineness m ² /kg, Min	225	225	225	300
2	Soundness:				
	(a) By Lee Chatelier method, mm Max	10	10	10	10
	(b) By Auto Clave Test Method, Percent, Max	0.8	0.8	0.8	0.8
3	Setting Time				
	(a) Initial, min, Min	30	30	30	30
	(b) Final, min, Min	600	600	600	600
4	Compressive Strength, MPa				
	(a) 72 ± 1 h, Min	16	23	27	16
	(b) 168 ± 2 h, Min	22	33	37	22
	(c) 672 ± 4 h, Min	33	43	53	33

Other type of Cement available in the Marker

Ordinary Portland Cement

OPC 33 Grade
IS 269: 1989

OPC 53 Grade
IS 12269: 1987

Rapid Hardening Cement
IS 8041: 1990

Sulphate Resisting Cement
IS 12330: 1988

High Alumina Cement
IS 6452: 1989

Portland Slag Cement

IS 455: 1989

Super Sulphated Cement
IS 6909: 1990

Low Heat Cement
IS 12600: 1989

Portland Pozzolana Cement

IS 1489 (Part I)
1991 (fly ash based) IS 1489 (Part II)
 1991 (Calcined clay
 based)

Coloured Cement White
Cement)
IS 8042: 1989

Hydrophobic Cement
IS 8043: 1991

Masonry Cement
IS 3466: 1988

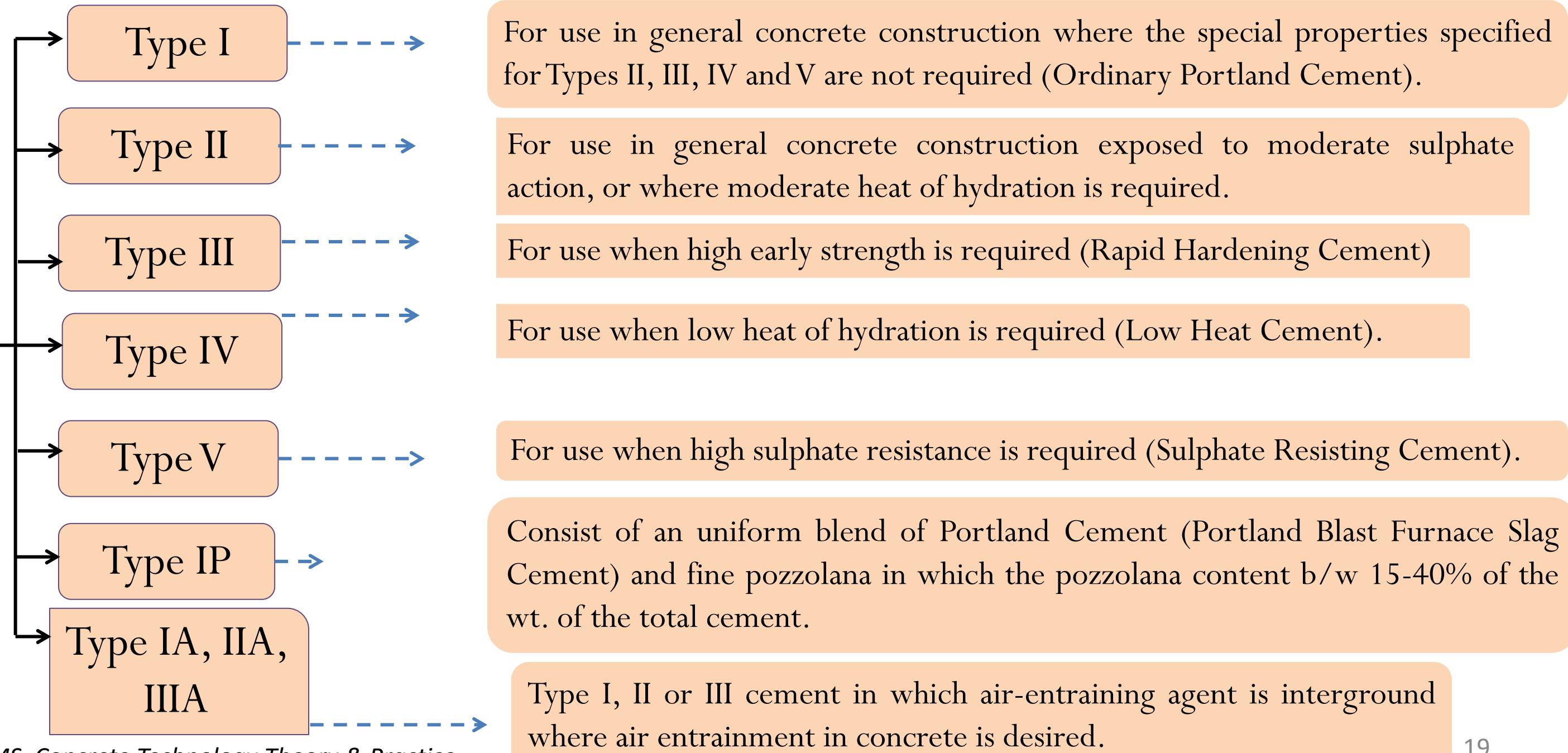
Oil Well Cement
IS 8229: 1986

Concrete Sleeper Grade
Cement
IRS-T 40: 1985

American Society of Testing and Material Classification of Cement



Classification of Cement as per ASTM



Brief about Rapid Hardening Cement (IS 8041-1990)



- ✓ Develop Strength Rapidly
- ✓ 3 days Strength equal to 7 days strength of OPC
- ✓ Rapid hardening should not be confused with quick setting cement which only sets quickly
- ✓ Higher surface area (Specific surface area not less than 3250 sq. cm per gram) and higher C₃S and lower C₂S is the reason for the rapid strength development.
- ✓ Higher fineness lead to higher surface area which react with the water and higher C₃S results in quicker hydration.
- ✓ Exhibit higher heat of hydration and should not be used for mass concrete construction i.e. Dam construction

This cement is recommended for in following situations;

1. In Pre-fabricated concrete construction
2. Where formwork is required to be removed early for re-use elsewhere.
3. Road repair works
4. In cold weather concrete where the rapid rate of strength development reduces the vulnerability of concrete of frost damage.

Brief about Sulphate Resisting Cement (IS 8041-1990)



- ✓ Sulphates react with the free calcium hydroxide in set cement to form calcium sulphate and with hydrate of calcium aluminate to form calcium sulphaaluminate (volume of which is approximately 227% of the volume of the original aluminates).
- ✓ This expansion within the frame work of hardened cement paste results in cracks and subsequent disruption.
- ✓ Solid sulphate do not attack the cement compound. Sulphates in solution permeate into hardened concrete and attack calcium hydroxide, hydrated calcium aluminate and even hydrated silicates. The above is known as sulphate attack.
- ✓ Sulphate attack is greatly accelerated if accompanied by alternate wetting and drying which normally takes place in marine structures in the zone of tidal variations.

Brief about Sulphate Resisting Cement (IS 8041-1990)



- ✓ Lower C₃A content effective in resisting the sulphate attack. Cement with low C₃A and comparatively low C4AF is known as Sulphate Resistant Cement

- ✓ This cement has a high silicate content. C₃A generally limits to 5%.

The use of sulphate resisting cement is recommended under the following conditions:

1. Concrete to be used in marine condition;
2. Concrete to be used in foundation and basement, where soil is infested with sulphates;
3. Concrete used for fabrication of pipes which are likely to be buried in marshy region or sulphate bearing soils;
4. Concrete to be used in the construction of sewage treatment works.

Supplementary Cementitious Material (SCM)



Following are the SCM materials which are being used nowadays in Building construction.

Cement



Fly Ash



Rice Husk Ash



Silica Fume



<https://www.lafarge.ca/en/cement>

<https://theconstructor.org/building/fly-ash-properties-types-mechanism/26654/>

<http://www.pioneercarbon.com/rice-husk-ash.html>

<http://www.aloy-silicon.com/news/Three-advantages-of-silica-fume-in-concrete.html>

Summary

- ✓ Methodology to store the cement
- ✓ Quality control parameter as per code provision
- ✓ Various types of cement available in market
- ✓ Classification as per American Society of Testing and Material
- ✓ Brief about Rapid hardening cement and Sulphate resistance cement
- ✓ Introduction of SCM

Thank You