



# Concrete Durability and Sustainability with slag based product

8<sup>th</sup> - May-2020

## Improved durability and sustainability properties of concrete having slag based product

- ✓ Green Products – Ecofriendly
- ✓ Strength - Compressive & Flexural Strength
- ✓ Heat of Hydration
- ✓ Chloride Ion Permeability & Chloride Migration (RCMT)
- ✓ Water Impermeability
- ✓ Abrasion resistance
- ✓ Water absorption of concrete
- ✓ Carbonation
- ✓ Corrosion resistance
- ✓ Sulfate resistance
- ✓ Alkali Aggregate Reaction



# India's First Green Cement – Maintaining the Eco System - Issued by CII



Estimated, assuming a blast furnace slag content 45% in Portland blast furnace slag cement

- JSW Slag Products (PSC / Concreel HD) - Eco Friendly  
The products of BF Slag are highly regarded as environment friendly materials that can protect the environment by limiting the exploitation of natural resources and reduce the amount of energy consumed in the mining of natural Resources.

## ENVIRONMENTAL PRODUCT DECLARATION OF AVERAGE PSC CEMENT

ISO 14020:2006, ISO 14025:2006, ISO 14040:2006, ISO 14044:2006, EN 15804:2012, EN 16908:2017

EPD registration number: S-P-01414  
 Publication date: 2019-10-11  
 Validity date: 2024-10-10  
 Geographical scope: India

### Minimum Utilization of Natural Resources

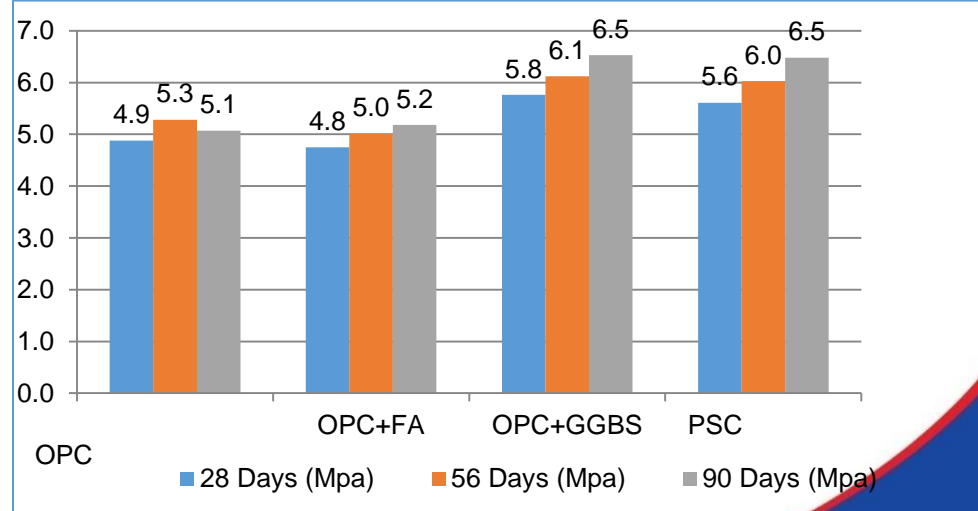
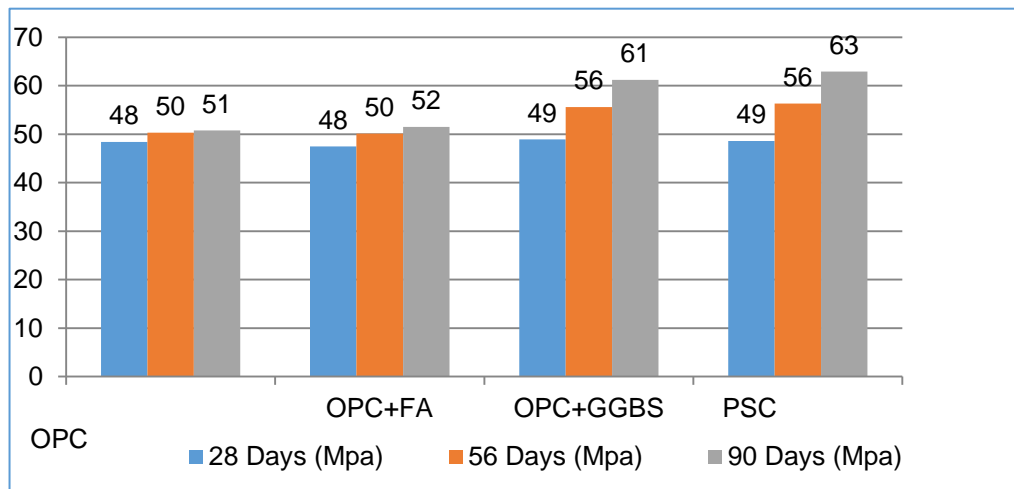


# Concrete Compressive & Flexural Strength Development



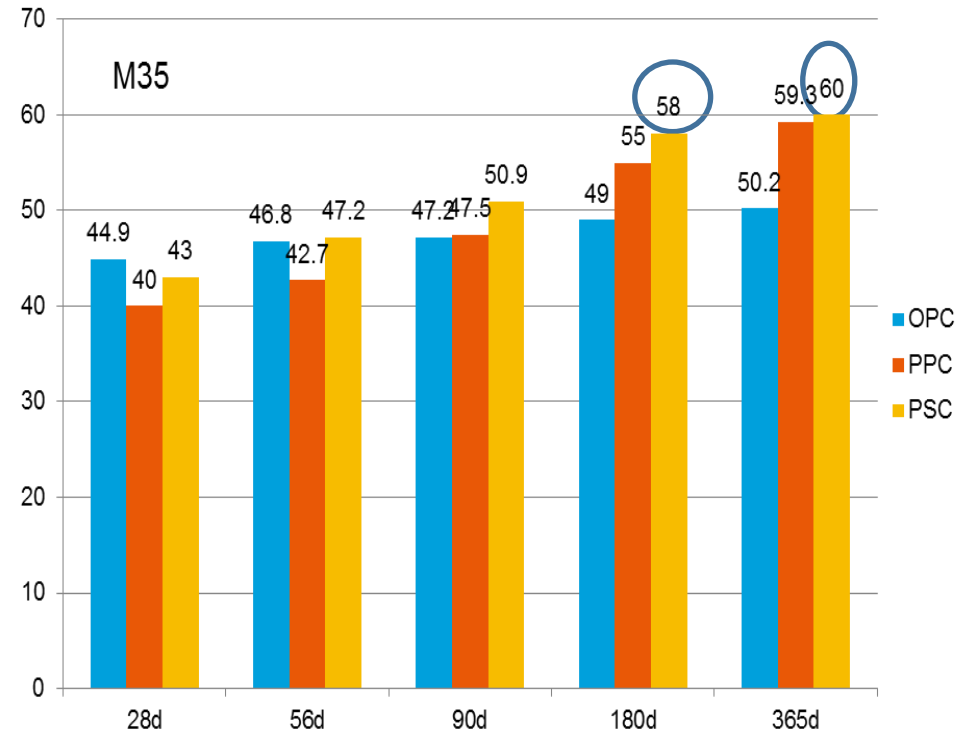
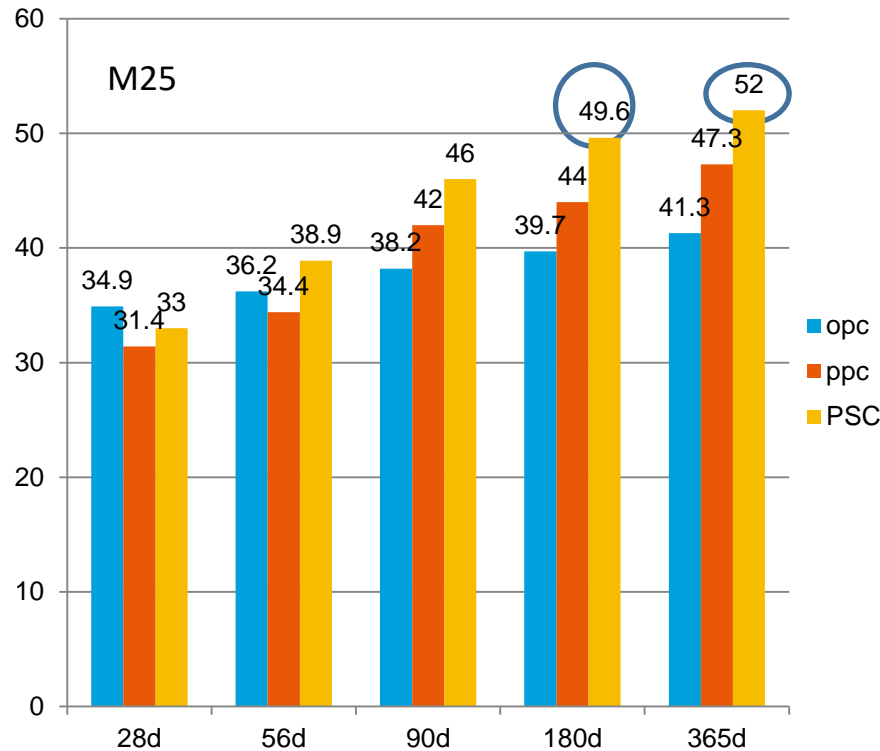
Concrete Compressive strength M40 - W/C 0.32					
Sr No	Description	Cementitious Content, Kg/Cum	28 Days (Mpa)	56 Days (Mpa)	90 Days (Mpa)
1	OPC	450	48.4	50.3	50.8
2	OPC + Fly Ash (21%)	470	47.5	50.1	51.5
3	OPC+ GGBS (40%)	470	48.9	55.6	61.2
4	PSC	470	48.6	56.3	62.9

Concrete Flexural strength M40 - W/C 0.32					
Sr No	Description	Cementitious Content, Kg/Cum	28 Days (Mpa)	56 Days (Mpa)	90 Days (Mpa)
1	OPC	450	4.9	5.3	5.1
2	OPC+FA (21%)	470	4.8	5.0	5.2
3	OPC+GGBS (40%)	470	5.8	6.1	6.5
4	PSC	470	5.6	6.0	6.5



Source: JSW Cement Ltd, Dolvi Lab

# Compressive Strength development of Concrete



**PSC Based** Concrete always shows higher strengths beyond 28 days in comparison to those made with OPC Concrete and Fly Ash Concrete.

Source: CivilAid Laboratory , Bangalore

# Heat of Hydration

## Comparative Heat of Hydration

Sr No.	Heat of hydration (Kj/Kg) at	OPC Cement	PPC Cement	PSC Cement
1	3 Days	274.28	219.42	66.68
2	7 Days	853.45	663.31	228.46

Source – JSW Cement lab Dolvi

**JSW PSC Heat of Hydration-  
7 days- 232 kj/kg  
Tested at- NCCBM Ballabhgarh**



राष्ट्रीय सीमेन्ट एवं भवन सामग्री परिषद्  
(भारत सरकार के वाणिज्य एवं उद्योग मंत्रालय के शासनाधीन)  
**NATIONAL COUNCIL FOR CEMENT AND BUILDING MATERIALS**  
(Under the Administrative Control of Ministry of Commerce & Industry, Government of India)

TC-5296

**TESTING LABORATORIES**  
INDEPENDENT TESTING LABORATORIES  
**TEST REPORT**

<b>Customer Address</b>	JSW CEMENT LIMITED JSW CENTRE, BANDRA KURLA COMPLEX, BANDRA (EAST), MUMBAI-400051, MAHARASHTRA	<b>No. : ITL/001385</b> <b>Date : 05/04/2018</b>
<b>Reference</b>	NIL, AGAINST MAIL, DTD.09/03/2018	
<b>Sample</b>	Said to be Portland slag Cement	
<b>Identification</b>	PSC	
<b>Condition of Sample</b>	UnSealed with ID Tag	
<b>Date of Receipt</b>	12/03/2018	<b>Laboratory Mark -</b> ITL3053/1/1
<b>Period of Testing</b>	14/03/2018 - 04/04/2018	
<b>Tested for Conformity to</b>		

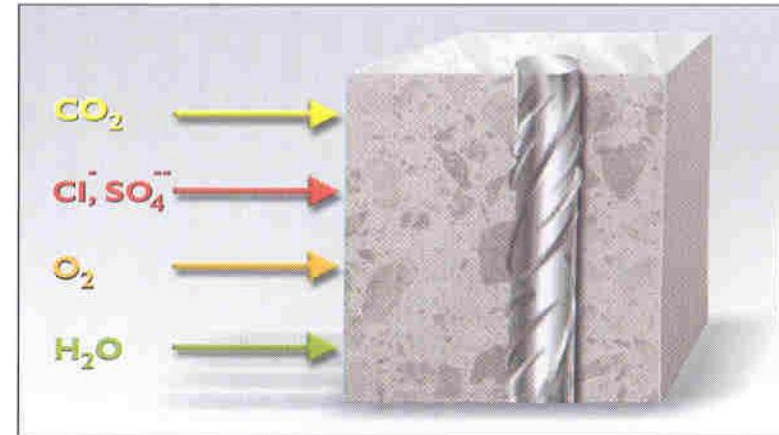
Sl No	Test Name	Test Method	Test Results
1	Heat of Hydration at 7Days	IS-4031(Pt-9):1988	232 KJ/Kg
***** END OF THE TEST REPORT *****			

**Conditions**

1. Results given above refer only to the sample supplied.
2. The Report is being issued on the specific understanding that NCB will not in any way be involved in any action following the interpretation of the above results.
3. This report shall not be reproduced except in full without written approval from NCB.
4. Tested Sample shall be retained for 90 days after reporting the results.
5. This report does not imply that the sample/material is approved or endorsed by NCB or NABL.

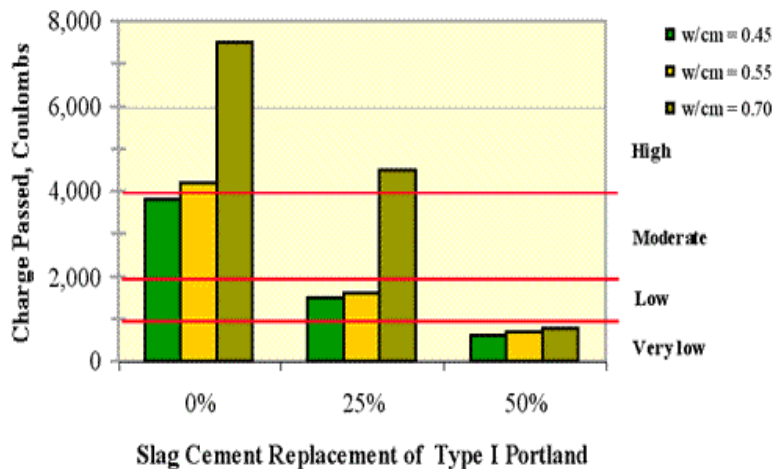


Corrosion of steel in OPC



Prevention of corrosion of steel in PSC

Figure 2: Effect of Slag Cement on Concrete Chloride Ion Penetrability<sup>2</sup> (ASTM C1202)



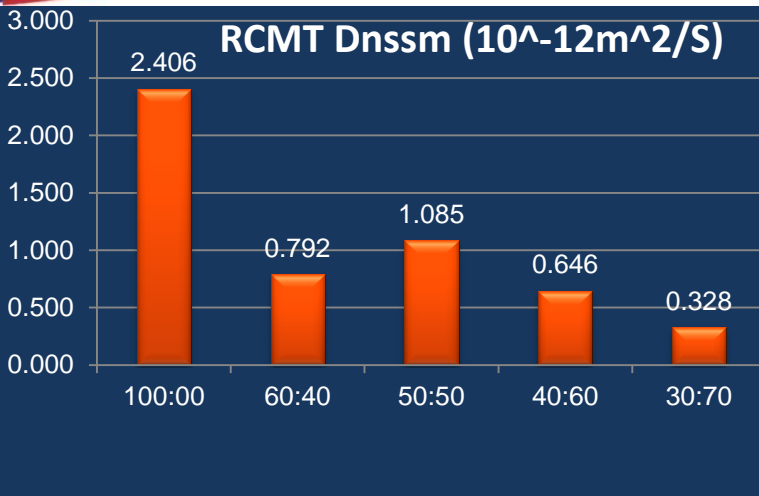
Chloride Ion Penetrability Limits as per ASTM C 1202 -97	
Charges (Coulombs)	CL Ion Penetrability
> 4000	High
2000 – 4000	Moderate
1000 – 2000	Low
100 - 1000	Very Low
< 100	Negligible

GGBS replacement level	Chloride Ion Penetrability (Coulombs) ,Average
0%	2220
25%	1034
40%	628
50%	526

Source RMC India Readymix

# Chloride Migration (RCMT)

## Project specification-Mumbai Trans Harbour Link for chloride migration test NT Build 492



Chloride Migration Coefficient Test Chloride Migration Coefficient Test shall be tested as per NT Build 492.

Non-steady state migration coefficient (x10 <sup>-12</sup> m <sup>2</sup> /s)	Concrete quality
<2	Very good
2-8	Good
8-16	Normal
>16	Poor

For Substructure, Chloride migration coefficient shall be less than 2x10<sup>-12</sup>m<sup>2</sup>/s. For superstructure, Chloride migration coefficient shall be (2-8) x10<sup>-12</sup>m<sup>2</sup>/s

Results achieved less than 2 x 10<sup>-12</sup> m<sup>2</sup>/s with GGBS replacement of 60% in M45 Pile & Pile Cap at MTHL project

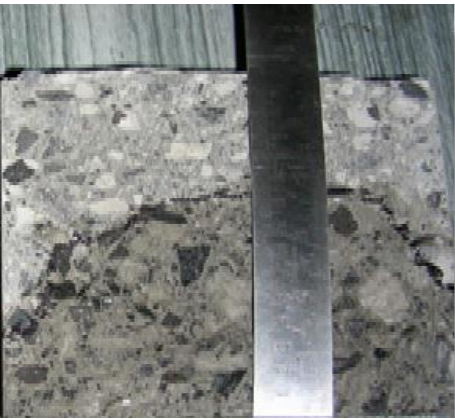
Reference : - IIT Mumbai



Project site photos MTHL Mumbai



## POTENTIAL USE OF GGBFS AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL IN CONCRETE (IIT Mumbai Project code: [15JSWC001](#))



WATER PERMEABILITY RES ULT** – conforming to DIN 1048		
TYPE	GGBS Replacem ent Level	Mean mm
OPC	0%	21
OPC+GGBS	25%	18
OPC+GGBS	40%	15
OPC+GGBS	50%	10

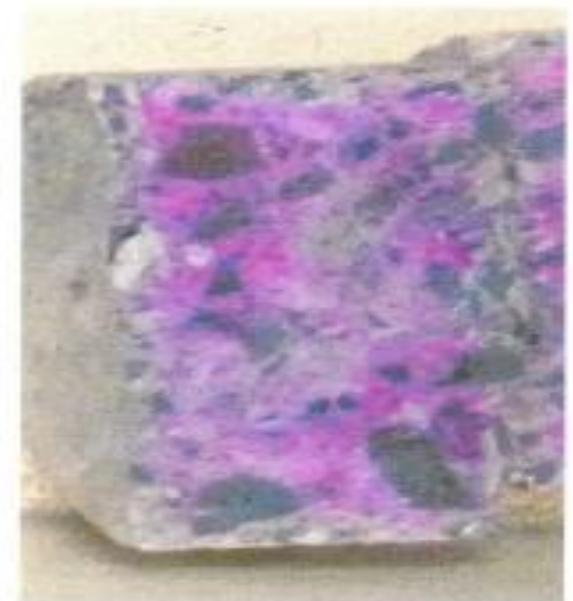
S.No.	COMBINATIONS		W/B	Density		Setting Time		DURABILITY TESTING	
	Cement	Slag		Fresh	Hardened	Initial	Final	Abrasion Resistance	Water Absorption
	(% )			Kg/ m3		Minutes		(% mass loss)	(%)
1	60	40	0.34	2655	2464	398	512	<b>0.180</b>	<b>2.50</b>
2	50	50	0.34	2650	2443	353	467	<b>0.179</b>	<b>3.12</b>
3	40	60	0.34	2640	2468	309	464	<b>0.196</b>	<b>2.88</b>
4	30	70	0.34	2674	2430	331	471	<b>0.169</b>	<b>1.82</b>

## POTENTIAL USE OF GGBFS AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL IN CONCRETE (IIT Mumbai Project code: [15JSWC001](#))

Carbonation Depth of concrete		
Mix Ration	28 Days	56 Days
OPC:GGBS	(mm)	(mm)
100:00	15.00	11.50
60:40	6.70	4.20
50:50	12.30	5.30
40:60	8.00	7.30
30:70	9.70	8.30



(Left side) Carbonation at 28 days [60:40]

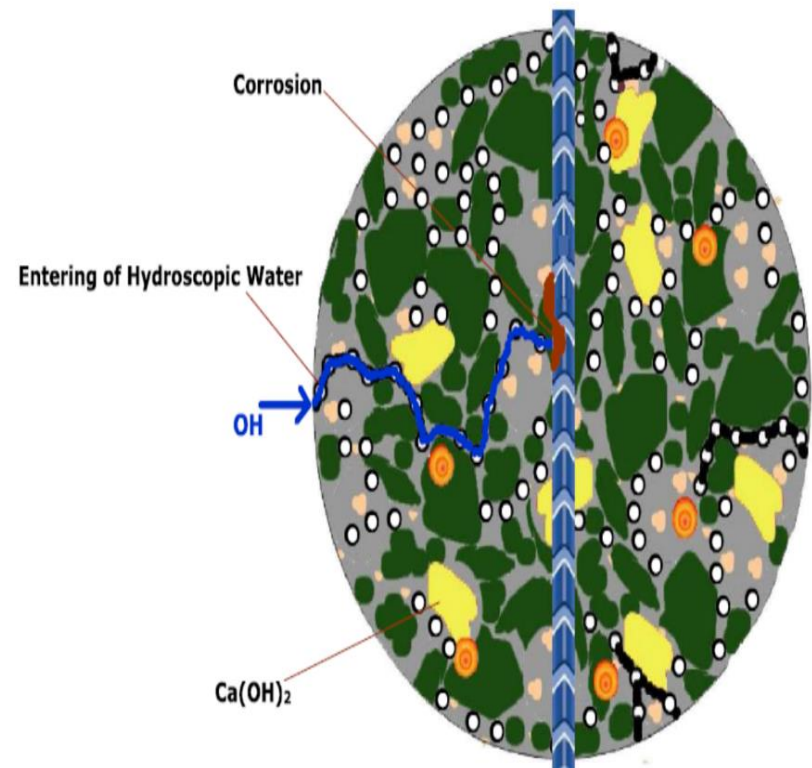
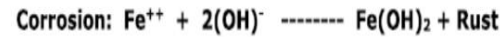


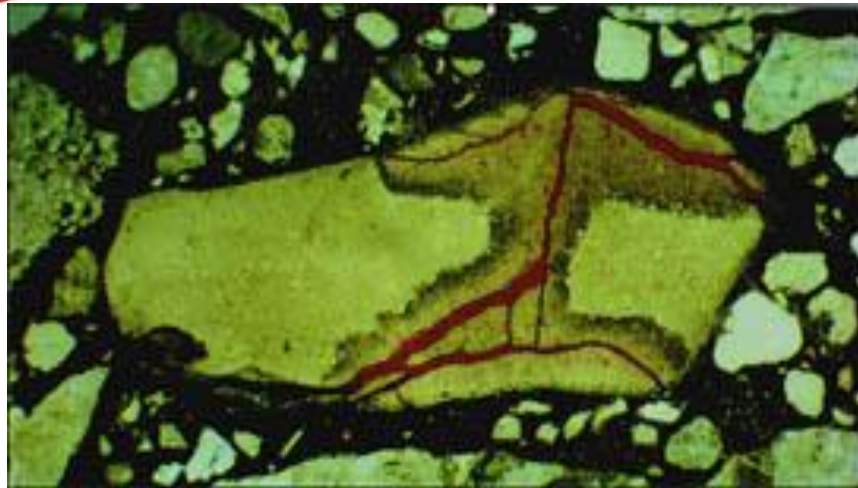
(Right side) Carbonation at 56 days [60:40]

# Corrosion Resistant & Sulphate resistance

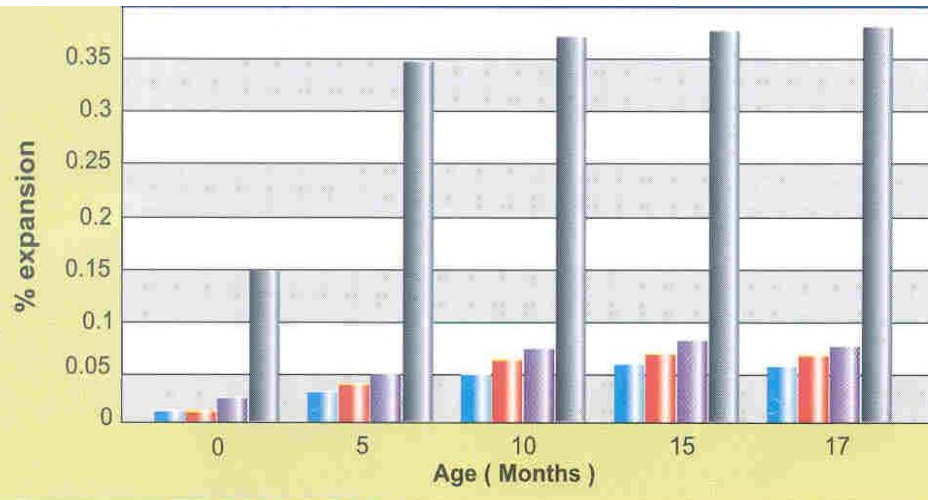
Portland slag cement/GGBS lead to increase electrical resistivity of concrete and reduce diffusivity of chloride ions from outside. The resistance to corrosion of reinforced steel in concrete is enhanced due to less proportion of chloride ions available in pore solution.

Cement	Diffusivity $10^{-9} \text{ Cm}^2/\text{g}$
OPC	44.7
PPC (70:30)	14.7
<b>PSC (45:55)</b>	<b>4.10</b>





When a critical amount of reactive aggregate is present, sufficient gel can be formed to cause disruptive expansion and cracking of the concrete.



**Daqing Railway Bridge, China**

M40 – Total cementitious content- 535kg/cum , Project site -Jamnagar Gujrat.  
 concrete tested at - NCCBM Ballabhgarh,  
 Aggregate used in study were alkali active , arranged by NCCBM

■	OPC (40%)+GGBS (60%)
■	OPC (50%)+GGBS(50%)
■	OPC (60%)+GGBS(40%)
■	OPC (100%)

**Thanks**