

IMPROVING CONCRETE PROPERTIES WITH SLAG CEMENT

Replacing a portion of portland cement with slag cement in a concrete mixture is a useful method to improve concrete durability and improve overall concrete properties. The measurable improvements are:

Fresh Concrete:

- More consistent plastic properties
- Improved workability, finishability, pumpability
- Higher slump at same w/cm ratio
- Air content slightly lower, but very consistent
- Set time slower as more cement is replaced (20%: 30 mins, 40%: 60 mins)
- Lower heat of hydration for mass structures
- Cost savings of \$4 to \$7/cu.yd. using performance mix designs

Hardened Concrete:

- Higher compressive and flexural strengths. Early strength lower, similar at 7 days and much higher (1,000 – 2,000 psi) at later ages (28, 56, 90 days). 28 days 11 to 13 psi/lb vs 8 to 10 psi/lb straight cement/fly ash mixes.
- Permeability much lower (< 1,000 coulombs)
- Sulfate and ASR resistance much higher
- Freeze-thaw & abrasion resistance similar
- Lighter color

Impact of Slag Cement on Concrete Properties			
Fresh Concrete		Hardened Concrete	
Water Demand	↓	Early Strength	↓
Workability	↑	Later Age Strength	↑↑
Bleeding & Segregation	↓	Permeability	↓↓↓
Air Content	↓	Chloride Ingress	↓
Heat of Hydration	↓	ASR Potential	↓↓↓
Setting Time	↑	Sulfate Resistance	↑↑
Finishability	↑	Freeze Thaw Resistance	↔↔
Pumpability	↑	Abrasion Resistance	↔↔
Plastic Shrinkage	↔↔	Drying Shrinkage	↔↔

SLAG CEMENT PERFORMANCE

Test Results (564 lbs/cu.yd.)	Control	20% Slag Cement	40% Slag Cement
w/Cm Ratio	0.45	0.41	0.39
Slump (inches)	4	4	4
Air Content (%)	7.5	5.9	6.8
Initial Set (500 psi) (hours)	4.6	4.0	5.5
1 Day Compressive Strength (psi)	2,450	2,640	1,620
7 Day Compressive Strength (psi)	4,530	4,980	4,820
28 Day Compressive Strength (psi)	5,090	5,600	6,440
28 Day Compressive Strength (psi/lb)	9.0	9.9	11.4
7 Day Flexural Strength (psi)	640	790	640
28 Day Flexural Strength (psi)	760	810	910
56 Day RCP (Coulombs)	2,115	1132	955
Shrinkage 56 days (28 days air cured)	-0.026	-0.025	-0.023
Freeze-Thaw Durability Factor	95	99	83
28 Day Surface Resistivity	12	16	24

SLAG CEMENT REPLACEMENT BASED ON APPLICATIONS

Applications	% Replacement
Concrete paving	25-50%
Exterior flatwork not exposed to deicer salts	25-50%
Exterior flatwork exposed to deicer salts with $w/cm < 0.45$	15-20%
Interior flatwork	25-50%
Footings	30-65%
Walls, columns, tilt-up panels	25-50%
Pre-cast / Pre-stressed concrete	20-50%
Concrete blocks / pavers	20-50%
High strength	25-50%
ASR mitigation	25-70%
Sulfate resistance Type II equivalence	25-70%
Lower permeability	25-65%
Mass concrete	50-80%