

Appendix B

NT Build 492 Test Data

Chloride migration coefficient results from concrete with various binder compositions are presented in the figures provided in this Appendix. Reported chloride migration coefficients were measured in accordance with the standard test method NT Build 492. The majority of results presented herein are from concrete at a 28-day maturity age, with limited number of tests completed slightly before or after this age. Such cases are identified in Table 1. Data provided in the following figures is comprised of:

- Values presented in *fib* Bulletins 34 and 76 (references [4] and [8] in Section 7.0 of the main body of this report, respectively),
- Test results from various concrete mix designs from states involved in the SHRP2 R19A project, and
- Additional test results from concrete produced in North America available to the authors.

The chloride migration coefficient results are subdivided in the following figures based on the binder composition, with the following ranges of binder composition and water-to-cementitious materials (w/cm) ratios represented:

- Portland cement + slag cement content from 0-80% slag by weight of the total cementitious material (Figure 1),
 - w/cm ratio: 0.32 – 0.60;
- Portland cement + fly ash content from 0-25% fly ash by weight of the total cementitious material (Figure 2),
 - w/cm ratio: 0.35 – 0.60;
- Portland cement + silica fume content from 0% to 10% silica fume by weight of the total cementitious material (Figure 3),
 - w/cm ratio: 0.35 – 0.60;
- Various ternary blends comprising combinations of Portland cement, slag cement, fly ash and/or silica fume (See Figure 4 for details on evaluated ternary combinations); slag cement from 0% to 80% slag by weight of the total cementitious material (Figure 4),
 - w/cm ratio: 0.32 – 0.60.

The test data from the individual states is compiled in Table 1. In case multiple results were available for a given concrete mix design (i.e., identical w/cm ratio and binder composition) from a single state, the averaged result is presented in the figures.



NT Build 492 test data for Slag Cements

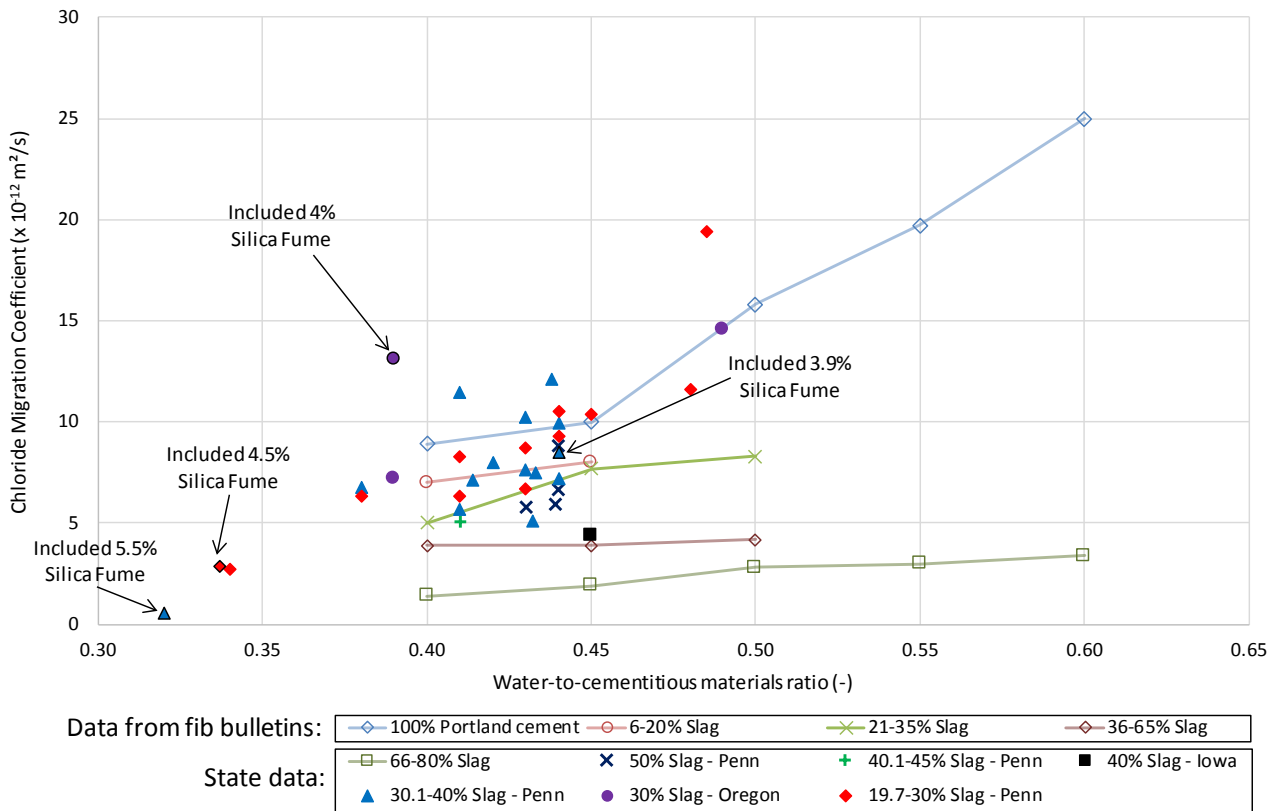


Figure 1: Chloride Migration Coefficients for Concrete Containing Portland Cement + Slag Cement.



NT Build 492 test data for Fly Ash Containing Concrete

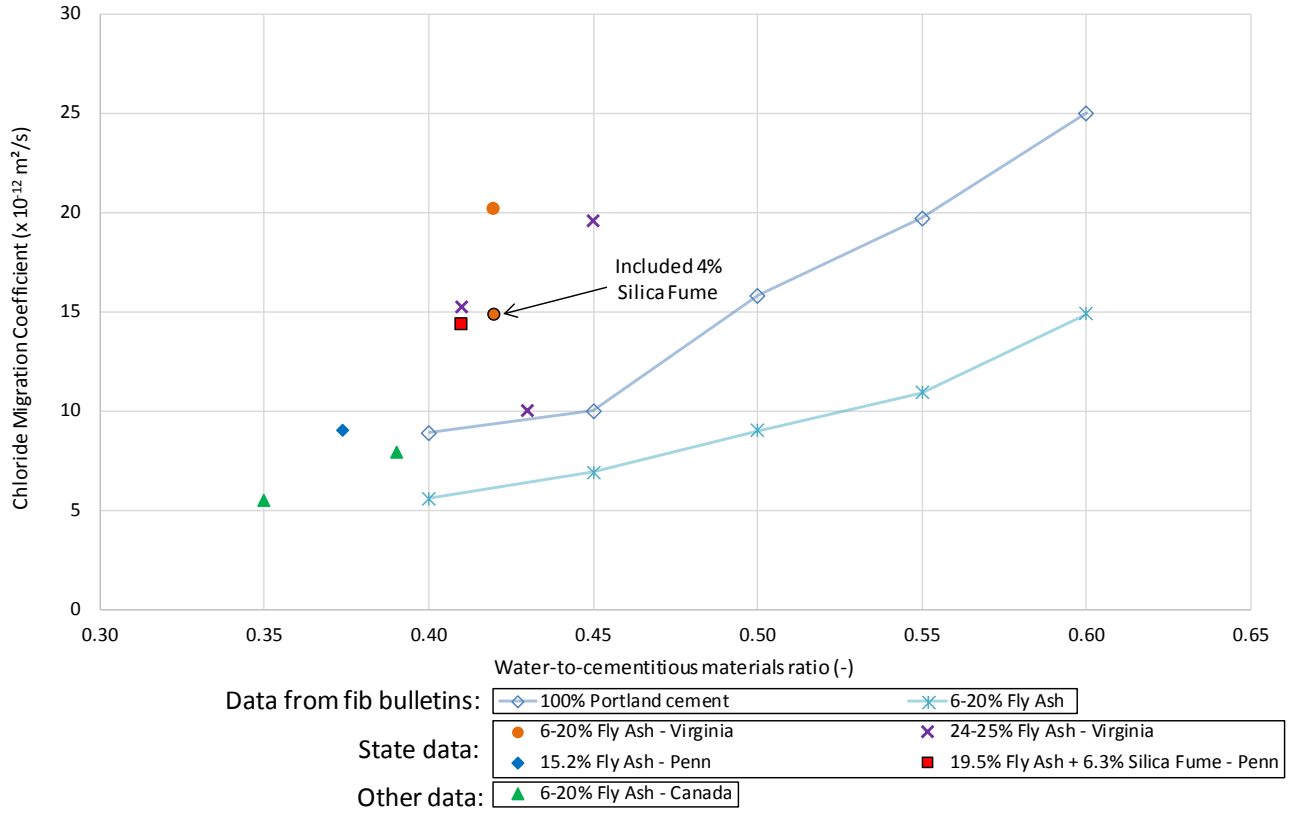


Figure 2: Chloride Migration Coefficients for Concrete Containing Portland Cement + Fly Ash.



NT Build 492 test data for Silica Fume Containing Concrete

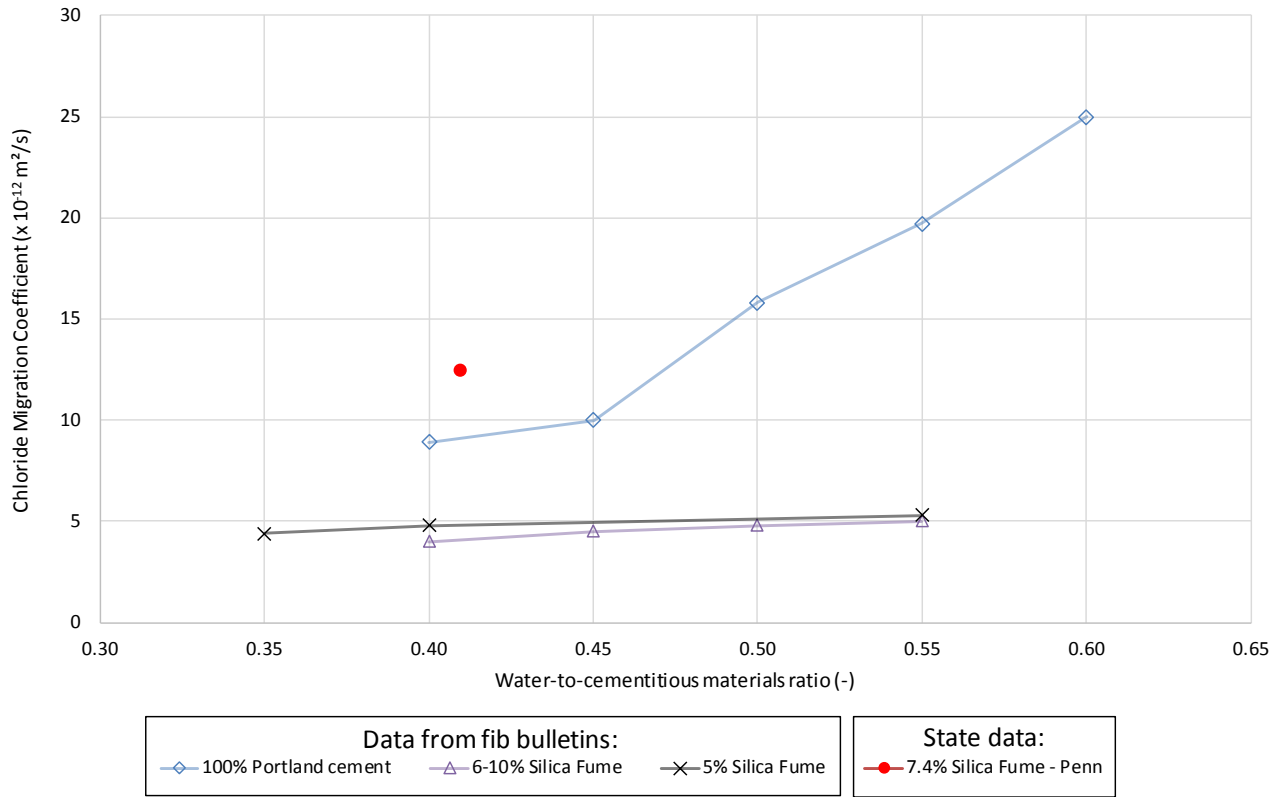


Figure 3: Chloride Migration Coefficients for Concrete Containing Portland Cement + Silica Fume.



NT Build 492 test data for Ternary Blends

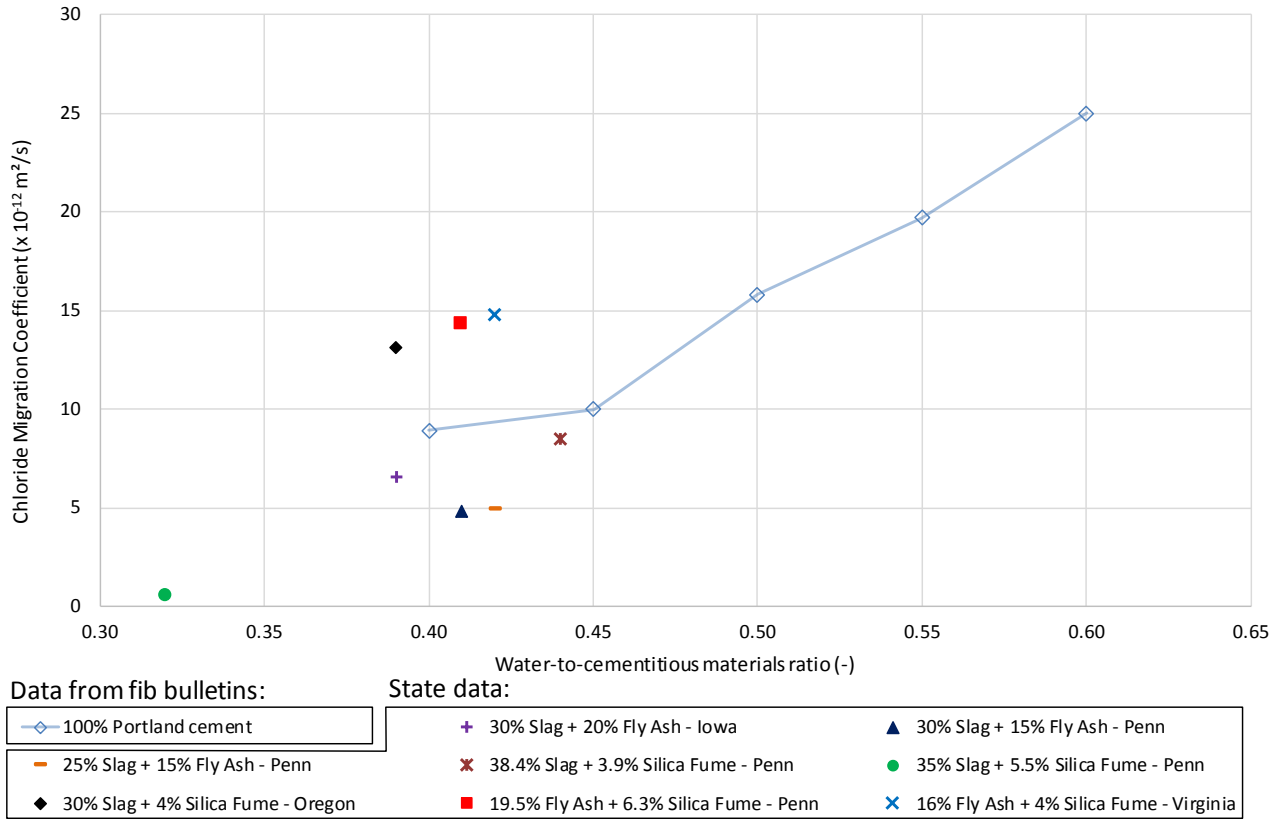


Figure 4: Chloride Migration Coefficients for Concrete Containing Ternary Blends.

Table 1: Overview of Chloride Migration Coefficient Data for Various Concrete Mix Designs from States Involved in the SHRP2 R19A Project.

State	Cement type per ASTM C150 or C595	w/cm ratio (-)	Supplementary cementitious material ¹⁾			Chloride migration coefficient ²⁾
			Slag cement	Fly ash	Silica fume	
Oregon	N.D. ³⁾	0.39	30%	-	4%	13.0
		0.49	30%	-	-	14.6
		N.D.				9.6
		0.39	-	30%	4%	13.2
		0.39	30%	-	-	7.2
Iowa	I/II	0.39	30%	20%	-	7.5
						5.6
Virginia	II	0.41	-	24%	-	15.2
	I/II	0.42	-	16%	4%	15.01
	I/II	0.42	-	16%	4%	12.51
	I/II	0.42	-	16%	4%	12.36
	I/II	0.42	-	16%	4%	16.35
	I/II	0.42	-	16%	4%	13.42
	I/II	0.42	-	16%	4%	17.37
	I/II	0.42	-	16%	4%	16.72
	I/II	0.42	-	16%	4%	13.63
	I/II	0.42	-	16%	4%	15.78
	I/II	0.42	-	20%	-	22.3
	I/II	0.42	-	20%	-	18
	II	0.43	-	24%	-	9.04
	II	0.43	-	24%	-	6.26
	II	0.43	-	24%	-	14.8
	II	0.45	-	25%	-	19.6
II	0.45	40%	-	-	4.4	
Pennsylvania	Type I	0.43	50%	-	-	5.78 ⁵⁾
	Type II	0.439	50%	-	-	5.96
	Type I	0.44	50%	-	-	6.64
	Type I/II	0.44	50%	-	-	8.85
	Type I/II	0.42	45%	-	-	6.23
	Type I/II	0.41	41.7%	-	-	5.10
	Type IS/40	0.38	40%	-	-	6.76
	Type I/II	0.41	40%	-	-	5.09

Table 1: Overview of Chloride Migration Coefficient Data for Various Concrete Mix Designs from States Involved in the SHRP2 R19A Project.

State	Cement type per ASTM C150 or C595	w/cm ratio (-)	Supplementary cementitious material ¹⁾			Chloride migration coefficient ²⁾
			Slag cement	Fly ash	Silica fume	
Pennsylvania	Type I/II	0.41	40%	-	-	6.30
	Type II	0.42	40%	-	-	8.21
	Type IS(40)	0.42	40%	-	-	4.92 ⁶⁾
	Type IS/40	0.42	40%	-	-	10.79
	Type IS/40	0.43	40%	-	-	7.54
	Type IS/40	0.43	40%	-	-	9.48
	Type II	0.43	40%	-	-	6.40
	Type I	0.43	40%	-	-	7.12
	Type I/II	0.432	40%	-	-	5.09
	Type I	0.433	40%	-	-	7.49
	Type II	0.438	40%	-	-	17.24
	Type II	0.438	40%	-	-	6.98
	Type I	0.44	38.4%	-	3.9%	8.49
	Type I/II	0.44	35.1%	-	-	8.15
	Type I/II	0.44	35.1%	-	-	11.71 ⁶⁾
	Type I	0.32	35%	-	5.5%	0.55
	Type I LA	0.41	35%	-	-	11.46
	Type I	0.414	35%	-	-	7.16
	Type I	0.43	35%	-	-	10.24
	Type I	0.44	35%	-	-	6.53
	Type I/II	0.44	35%	-	-	9.99
	Type I	0.44	35%	-	-	4.98
	Type I/II	0.41	30.4%	-	-	6.27
	Type I/II	0.41	30.2%	-	-	6.34
	Type I/II	0.41	30%	15%	-	4.85 ⁶⁾
	Type I LA	0.43	30%	-	-	5.71
	Type IS/30	0.43	30%	-	-	4.75
	Type I	0.43	30%	-	-	9.68
	Type I	0.34	28%	-	-	2.74
	Type I/II	0.41	28%	-	-	8.31
Type I/II	0.43	28%	-	-	8.73	
Type I	0.44	28%	-	-	9.33	

Table 1: Overview of Chloride Migration Coefficient Data for Various Concrete Mix Designs from States Involved in the SHRP2 R19A Project.

State	Cement type per ASTM C150 or C595	w/cm ratio (-)	Supplementary cementitious material ¹⁾			Chloride migration coefficient ²⁾
			Slag cement	Fly ash	Silica fume	
Pennsylvania	Type III	0.337	27.4%	-	4.5%	2.89
	Type I/II	0.42	25%	15%	-	4.94
	Type I	0.44	25%	-	-	10.51
	Type I	0.45	25%	-	-	10.37 ⁵⁾
	Type I	0.48	25%	-	-	9.96
	Type I/II	0.48	25%	-	-	7.29
	Type I/II	0.48	25%	-	-	17.56
	Type I/II	0.485	25%	-	-	19.42
	Type I	0.38	19.7%	-	-	6.32
	Type III	0.374	-	15.2%	-	9.02
	Type I/II	0.41	-	19.5%	6.3%	13.33
	Type I/II	0.41	-	19.5%	6.3%	16.00
	Type I/II	0.41	-	19.5%	6.3%	13.59
	Type I	0.41	-	-	7.4%	12.42
	Type IS	0.43	N.D.	-	-	6.63
	Type IS	0.43	N.D.	-	-	9.20
	Type IS	0.431	N.D.	-	-	7.46
	Type IS	0.45	N.D.	-	-	7.06 ⁷⁾
	Type IS	0.45	N.D.	-	-	7.74
	Type I	0.44		100% Cement		
Type I	0.48		100% Cement			30.62
Type I	0.48		100% Cement			23.42
Type I	0.49		100% Cement			24.81

1) Content of supplementary cementitious materials reported as % weight of the total cementitious material content

2) $\times 10^{-12}$ m²/s. Measured according to NT Build 492, generally at an age of 28 maturity days, except where noted otherwise.

3) N.D. – Not described

4) Data point not included in figures above due to insufficient detail on concrete mix design.

5) Measured at 27 maturity days

6) Measured at 29 maturity days

7) Measured at 30 maturity days