TECHNICAL BULLETIN # 6

Sulphate Resistant Concrete using HSe

Type HS equivalent cement

Alberta concrete producers have been making durable products for decades to withstand the widespread prevalence of sulphate rich soils and ground waters that epitomize much of the subsurface landscape of this province. “Kalicrete” (known today as Type HS cement) was developed and introduced to the Alberta market by the Canada Cement Company in 1930. It was purported to be the solution to placing concrete in high sulphate conditions. It has been employed very successfully for over 80 years. Type HS cement is still available but on a decreasing basis as combinations of Type GU cement with various supplementary cementitious materials (SCM’s) have proven to provide an equivalent solution along with several additional performance and durability attributes.

Today CSA A23.1 recognizes the cementing material approaches to provide durable, long-lasting concrete for use in High Sulphate exposure conditions*. The first approach involves the traditional one of using a Type HS - High Sulphate Resistant cement. The second approach developed in the 1980’s is to use blended cements that have supporting test data to demonstrate their performance to either Type MSb/HSb or MSLb/HSLb standards. Finally, the more common approach used by most Alberta concrete producers is to combine Type GU (General Use) or Type GUL (General Use Portland limestone) cements with an appropriate proportion of SCM’s, as determined in the same manner as Approach 2 above, during the batching process. In each case the cementing materials are combined with an appropriate proportion of coarse and fine aggregates, chemical admixtures and respect a maximum water to cementitious materials ratio(W/CM) for the corresponding sulphate exposure class S-1, S-2, and S-3

*CSA A23.1-14 Table 3

Thomas noted in 2013 and reiterated in 2016 that “With the exception of some Class C fly ashes that contain CaO (calcium oxide) contents in excess of 18% to 20% and possibly C_3A, SCM’s improve sulfate resistance by (Thomas 2013):

(a) Reducing the rate of ingress of sulfate ions due to increased resistance to fluid penetration;

(b) Diluting and, through pozzolanic reactions, reducing the content of calcium hydroxide in the paste (needed for gypsum and ettringite formation);
(c) Diluting the amount of C_3A in the total cementitious binder; and
(d) Possibly altering hydrated aluminate phases to ones less susceptible to sulfate attack, e.g. strätlingite."

In conclusion, field evidence of the Alberta use of moderate C_3A cements with local SCM's in concrete exposed to sulphate conditions supports these claims. Furthermore, in light of recent lab and field studies, there is further evidence to support the sustainability of this approach to providing durable concrete in this province as more cementing materials that lower the carbon footprint of concrete make their way into the market.

Table 3
Additional requirements for concrete subjected to sulphate attack*
(See Clauses 4.1.1.1.1, 4.1.1.6.2, 4.1.1.6.3, and L.3 and Tables 1, 7, 24, and 25.)

Class of exposure	Degree of exposure	Water-soluble sulphate (SO_4)† in soil sample, %	Sulphate (SO_4) in groundwater samples, mg/L‡	Water soluble sulphate (SO_4) in recycled aggregate sample, %	Cementing materials to be used§	Performance requirements§,§§ Maximum expansion when tested using CSA A3004-C8, % At 6 months	At 12 months††
S-1	Very severe	> 2.0	> 10 000	> 2.0	HS** ,HSb, HSLb or HSe	0.05	0.10
S-2	Severe	0.20–2.0	1500–10 000	0.60–2.0	HS**, HSb, HSLb or HSe	0.05	0.10
S-3	Moderate (including seawater exposure*)	0.10–0.20	150–1500	0.20–0.60	MS, MSb, MSe, MSLb, LH, LHb, HS**, HSb, HSLb or HSe	0.10	

**For sea water exposure, also see Clause 4.1.1.5.*
†In accordance with CSA A23.2-3B.
‡In accordance with CSA A23.2-2B.
§Where combinations of supplementary cementing materials and portland, portland-limestone, or blended hydraulic cements are to be used in the concrete mix design instead of the cementing materials listed, and provided they meet the performance requirements demonstrating equivalent performance against sulphate exposure, they shall be designated as MS equivalent (MSe) or HS equivalent (HSe) in the relevant sulphate exposures (see Clauses 4.1.1.6.2, 4.2.1.1, and 4.2.1.3, and 4.2.1.4).
***Type HS cement shall not be used in reinforced concrete exposed to both chlorides and sulphates, including seawater. See Clause 4.1.1.6.3.*
§§For demonstrating equivalent performance, use the testing frequency in Table 1 of CSA A3004-A1 and see the applicable notes to Table A3 in A3001 with regard to re-establishing compliance if the composition of the cementing materials used to establish compliance changes.

Ref: CSA A23.1-14

References:

1) CSA A23.1/A23.2 -14: *Concrete materials and methods of concrete construction/ Test methods and standard practices for concrete.* CSA Group. Mississauga, ON Canada 2014. Table from amended version reprinted June 2018.

2) Thomas, M. D. A. and Hooton, R. D., *Sulphate Resistance of Mortar and Concrete Produced with Portland Limestone Cement and Supplementary Cementing Materials*, Portland Cement Association, SN3285, Skokie, Illinois, USA, 2016, 25 pages.