

## Technical Bulletin

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#### Producing Sulphate Resistant Concrete with Whitemud<sup>MK</sup>

Whitemud<sup>MK</sup> Metakaolin can be used in combination with CSA Type GU cements and Type F and C-Intermediate Fly Ash to make sulphate resistant concrete provided the requirements of CSA A23.1-04 for sulphate resistant concrete are met.

Engineers and concrete specifiers need only specify the sulphate exposure class from CSA A23.1-04, Table 1 and that concrete meet also the appropriate requirements of Table 2, 3 and 4. There is no need to specify the cement type.

It is then the responsibility of the concrete producer to ensure that all the relevant conditions concerning concrete for S1, S2, S3 or other specified exposure conditions are followed. Producers have several options including that of using combinations of cementing materials that provide equivalent (or better) performance. The following outlines the technical requirements for equivalent performance.

#### **Sulphate Resistant Concrete**

All concrete designed to be resistant to sulphate attack must be produced in accordance with Clause 4.1.1.6 of CSA A23.1-04 *Concrete Materials and Methods of Construction*. Specifically, the requirements of clause 4.1.1.6.2 and Tables 2 and 3 must be adhered to.

Table 3 defines three classifications of exposure according to the concentration of sulphates to which the concrete may be exposed. They are specifically:

- S-1 Very severe
- S-2 Severe
- S-3 Moderate

The concrete requirements in Table 2 for each exposure class defined in Table 3 are summarized below. Additional criteria for air content and curing are included and should be reviewed and followed.

**A23.1-04 Table 2**

Exposure Class	Maximum water-to-cementing materials ratio	Minimum compressive strength at 56d (MPa)
S1	0.40	35
S2	0.45	32
S3	0.50	30

The required cementing materials are also defined in Table 3. In addition, Table 3 includes the footnote that ***Cementing material combinations with equivalent performance may be used.*** Clause 4.1.6.2 included below describes the performance requirements for alternative combinations of cementing materials.

### A23.1-04 Clause 4.1.1.6.2

For concrete subject to potential sulphate attack, the specified 56 d compressive strength, the water-to-cementing materials ratio, and the cement type shall be in accordance with Tables 2 and 3. *Supplementary cementing materials may be used in combination with a hydraulic cement or a blended cement, provided that the mixture of cementing materials meets the relevant requirements of CSA A3001 for Type HS cement for S-1 and S-2 exposure or Type MS or HS cement for Type S-3 exposure.*

The relevant performance requirement from CSA A3001 for Supplementary Cementing Materials to be used is that maximum expansion of test specimens in test method A3004-C8 (ASTM C 1012) meet the criteria in Table 1 below.

Table 1 also shows results of testing with Whitemud<sup>MK</sup> performed at the University of Toronto. The test results are attached as Appendix I to this document. The C<sub>3</sub>A of the Type GU cement tested in combination with Whitemud<sup>MK</sup> was 10.4%

**Table 1 – Performance Requirements and Whitemud<sup>MK</sup> Performance**

Cementing Material Type	Max. % Expansion allowed at 6 Months (CSA A3004 - C8)	Max. % Expansion allowed at 12 Months (CSA A3004 -C8)	% Expansion with Whitemud <sup>MK</sup> used at 10% cement replacement (18 Months)	% Expansion with Whitemud <sup>MK</sup> used at 15% cement replacement (18 Months)
MS	0.10		0.08	0.04
HS	0.05	0.10		

These test results show that a cementing material combination using a minimum of 10% Whitemud<sup>MK</sup> in combination with GU cements of 10% C<sub>3</sub>A or less, performs equivalent to or better than that required by CSA A3001 and CSA A 23.1-04.

When Type F or Type C-Intermediate (CI) fly ash is used in combination with Whitemud<sup>MK</sup> additional protection is provided.

Appendix I  
Mortar Bar Expansion - CSA A3004-C8 / ASTM C-1012 (Testing Performed by the University of Toronto)

