Silica Fume - Low Heat Concrete

SILICA FUME LOW HEAT CONCRETE

By substituting up to 4 parts of cement with 1 part of silica fume the total heat generating capacity of concrete is reduced. Weight for weight silica fume generates approximately the same amount of heat as cement, so the temperature rise and differential are reduced at all element thicknesses.

By slowing the rate of hydration, thereby giving time for heat to escape, slag and fly ash reduce temperature rise and differential. Bamforth's curves (fig 1) show that the effectiveness of this diminishes as the element thickness increases. In thick sections the heat is locked in.

Using Bamforth's curves we can establish that there is a point where the silica fume reduces heat more effectively than slag (fig 2).

To more precisely quantify the relative effectiveness of different cementitious systems tests were undertaken at Taywood Engineering's laboratories in Perth, Australia.

The adiabatic temperature rise of four concretes mixes (Table 1) designed to have the same 28 day compressive strength (fig 3), was measured. These were input into a computer simulation of temperature rise and temperature differential in an 800mm thick section.

	OPC	CSF	Slag	Slag & CSF
Assumptions				
CSF Efficiency		3.3		3.2
Slagment Eff.			0.9	0.9
Mix Design				
OPC	399	310	147	124
CSF		27		
Slag			272	231
Cementitious	399	337	419	374
CSF (%)		8		5
Slag (%)			65	
w/c	0.4	0.4	0.4	0.4
Est 28d f'c	50	50	50	50

Table 1 - Mix designs for OPC, silica fume and slag concrete's designed to have the same strength.

CONCRETE BENEFITS

LOW TEMPERATURE RISE AND TEMPERATURE DIFFERENTIAL

- Silica fume is the only effective supplementary cementitious material in thick sections.

HIGH EARLY AGE STRENGTH

- No delay to prop and formwork removal
- Early finishing

HIGH DURABILITY

- Resistant to sulphates, chlorides and acids
- Shorter curing period

WATERPROOF

- The silica fume low heat concrete will act as an integral waterproofer as well

SIMPLE PLACING

- Less risk of segregation
- Improved pumpability

LOW SHRINKAGE AND CREEP

Figures 5 and 6 shows that insulation would be used to minimise temperature differentials as peak temperature is not an issue. In the 800mm section silica fume low heat concrete is as effective as the slag concrete but has far higher early age strengths. In thicker sections the silica fume low heat concrete performs better than the slag.

Silica fume low heat concrete is designed to meet the specific maximum temperature and temperature differential requirements of a project.

Figure 1 - As the concrete thickness increases, heat is locked in and the use of fly ash and slag to delay heat of hydration and temperature rise become ineffective.

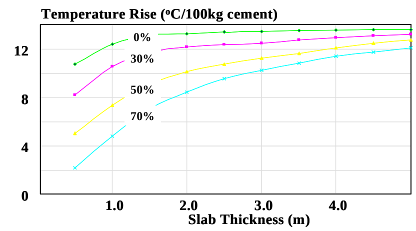


Figure 2 - Bamforth's curves are used to show that in thicker slabs slag concrete will be out performed by silica fume concrete.

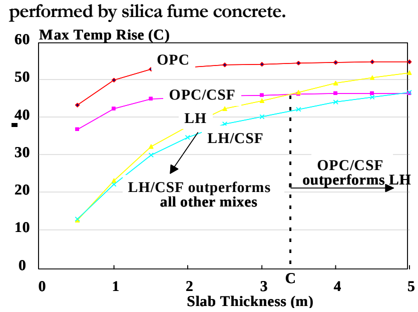


Figure 3 - The strength development curves show that silica fume low heat concrete has higher early age strengths than slag cements.

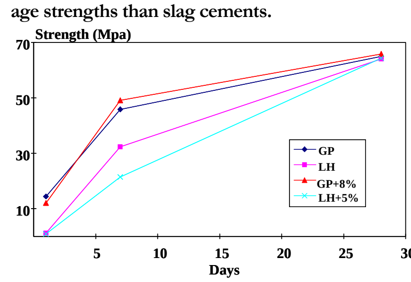


Figure 4 - Computer analysis shows that at 800mm thick slag and silica fume concretes give similar temperature differentials.

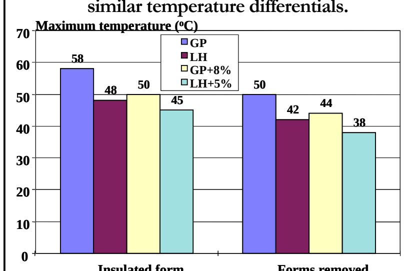
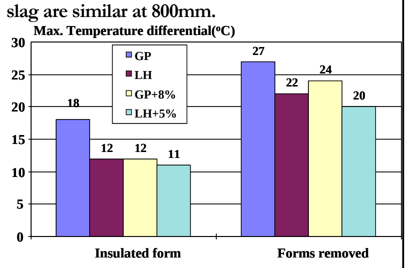


Figure 5 - Computer analysis based on adiabatic temperature rise shows that temperature differentials for silica fume and slag are similar at 800mm.



SILICA FUME LOW HEAT CONCRETE

SPECIFICATION

Where Silica fume Silica fume is to be permitted the general specification clauses outlined on the "Silica Fume " brochure should be included in the concrete specification. Additionally, Silica fume low heat concrete can be specified by including the following clauses in the standard concrete specification:

Silica fume Low Heat Concrete shall be supplied with the following physical properties:

Characteristic Strength:

Min compressive strength

3 day ____MPa;
7 day ____MPa;
28 day ____MPa;

Temperature Requirements

Max. Temp. Rise: 70°C;

Aggregate Type	Max. Temp. Differential:
Gravel	20°C
Granite	28°C
Limestone	39°C
Lightweight	55°C

A report showing that the proposed mix and placing method with meet these requirements shall be submitted to the Engineer for approval before placing any silica fume low heat concrete.

TECHNICAL SUPPORT

LOW HEAT CONCRETE

Detailed advice can be provided on the potential temperature rise and differential for Silica fume Low Heat Concrete as placed in various curing situations. The effect on thermal cracking can be provided.

GENERAL

Scancem Materials are able to provide technical support related to most aspects of the use of concrete in construction. This support takes the form of:-

- Meeting with the Owner, Architect, Engineer and/or Contractor to develop a cost effective and technically appropriate Silica fume Concrete option that invariably offers advantages to all parties; "the win, win, win approach"
- Presentation to interested parties on the mechanisms by which Silica fume Concrete provides solutions to construction problems.
- Report preparation that details the design methods and assumptions used for any analysis undertaken and includes published papers supporting the use of these design methods.
- Use of computer models to calculate dosages of special additives.

SUGGESTED READING

1. Bamforth, P., "Insitu measurement of the effect of partial Portland cement replacement using either fly ash or ground granulated blast furnace slag on the performance of mass concrete". Proc. Inst. Civ. Engs. Parts pp777-800. London 1980.
2. Fidjestol, P., "Use of Condensed Silica fume Concrete in Scandinavia: Case Histories," Presented at the CANMET International Workshop on Condensed Silica fume in Concrete, Montreal, Canada, 1987.
3. Helland, S., "Temperature and strength Development in Concrete with W/C Ratio Less than 0.40", Proc Utilisation of High Strength Concrete, Stavenger, 1987.
4. Lessard, S., Aitcin, P.C., and Regourd, M., "Development of a Low Heat of Hydration Blended Cement", Proceedings CANMET/ACI First International Conference on the Use of Fly Ash, Silica fume, Slag and Other Mineral By-Products in Concrete, Montebello, 1983, pp 747-764.
5. Maage, M., "Strength and Heat Development in Concrete: Influence of fly Ash and Condensed Silica fume", Proceedings CANMET/ACI First International Conference on the Use of Fly Ash, Silica fume, Slag and Other Mineral By-Products in Concrete, Montebello, 1983, pp 923-940.
6. Meland, I., "Influence of Condensed Silica fume and Fly Ash on the Heat of Evolution in Cement Pastes", Proceedings CANMET/ACI First International Conference on the Use of Fly Ash, Silica fume, Slag and Other Mineral By-Products in Concrete, Montebello, 1983, pp 665-676.

Figure 6 - 6m deep pour at Suntec City Centre where 100kg /m³ of cement was replaced by 25kg/m³ of silica fume to reduce temperature rise by 10°C and provide the same strength.

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