

## Performance of OPUS SCM™ made from low-grade clays



OPUS SCM™ is a supplementary cementitious material (SCM) manufactured from locally available rocks. One example of a raw material category is low-grade clays: clay-containing materials that are often considered a waste stream in or are too impure for other processes. For example, clays that contain a low amount of kaolinite making these unsuitable for calcination, shale overburden from a limestone quarry, waste slate fines, quartz sands with high clay content, etc. While often of little value for other purposes, after vitrification in Terra's proprietary reactor, these materials tend to perform extremely well as an SCM.

To illustrate this, Table 1 summarizes test results for concrete

mixes containing 20% OPUS SCM made from clay materials. Each of these starting materials contained 30-57% clay & mica minerals, but ≤ 10% kaolinite. For all samples, a commercial concrete mix with a cementitious content of 611 lb/yd<sup>3</sup> (6.5 sack) was made, using OPUS SCM at 20% Portland cement (Type I/II) replacement. All concrete mixes were air entrained. Water reducing admixtures were used to maintain a water-cement ratio of 0.4 while targeting a 4" slump. For comparison, control mixes with 100% Portland cement resulted in 28-day compressive strengths in the range 5920-6590 psi. The OPUS SCM mixes reached 92-111% of the reference strength at 28 days.

**Table 1: Composition and performance of OPUS SCM made from clay materials.**

Feedstock	Mineralogical Composition (from XRD) (wt%)					Concrete Compressive Strength @20% Replacement (psi)					Concrete Properties			
	Clays & micas (% kaolinite)	Carbonates	Feldspars	Quartz	Other	day 3	day 7	day 14	day 28	% of 100% OPC Strength (on day 28)	Unit weight (pcf)	Slump (")	Air Content	Initial Set (h:min)
Shale overburden	37 (0% kaolinite)	4	19	40	0	4120	4670	5330	6030	97%	145.2	4.75	5.5%	4:46
Quartz sand + clay	36 (0% kaolinite)	4	5	54	1	3850	4625	5105	5970	95%	145.2	4.75	5.3%	5:26
Slate fines	50 (0% kaolinite)	0	17	33	0	4410	4979	5650	6600	111%	145.6	4.8	5.4%	5:08
Shale overburden	55 (3% kaolinite)	0	14	30	3	4330	5160	6040	6300	101%	145.6	4.25	5.0%	4:40
Shale overburden	47 (4% kaolinite)	19	11	22	1	4030	4730	5600	6140	102%	142.0	4.25	7.2%	6:22
Weathered bedrock	30 (5% kaolinite)	1	31	36	2	4310	4640	5190	6030	92%	144.0	5.0	5.9%	5:08
Shale overburden	57 (8% kaolinite)	1	5	37	0	4350	4850	5570	6520	102%	145.2	3.5	5.3%	4:49
Sandy clay + limestone	53 (10% kaolinite)	15	8	19	5	4130	4920	5740	6670	107%	146.4	4.25	5.2%	NA

Given the excellent performance, when using a clay-based feedstock, it is often possible to increase cement replacement while maintaining performance. An example is given in Table 2 where shale overburden (52% clay of which 9% kaolinite) was used as starting material. Concrete mixes similar to the above mixes were made but using Type II cement. As such, clinker substitution was as high as 55% (40% OPUS SCM, 10% limestone, 5% gypsum) while

maintaining performance (87% of reference strength at 28 days). This is a similar substitution as for a limestone calcined clay LC<sup>3</sup> blend (typically 30% calcined clay, 15% limestone, 5% gypsum). However, since OPUS SCM has spherical particles, it behaves similarly to a fly ash and does not have the workability issues associated with calcined clays.

**Table 2: Performance of OPUS SCM made from low-kaolinite clay at different replacement levels.**

Sample	Concrete Compressive Strength (psi)				Concrete Properties		
	day 7	day 14	day 28	% of 100% OPC Strength (@28d)	Unit weight (pcf)	Slump (")	Air Content
100% Portland Limestone Cement	5880	6390	6950	-	142	4.0	6.4%
20% OPUS SCM	5250	6030	7090	102%	143	4.3	6.2%
40% OPUS SCM	4150	5160	6020	87%	142	5.0	5.5%



For additional information, please contact us:

TERRA CO2 TECHNOLOGY HOLDINGS INC | info@terraCO2.com | (303) 339-0867 | [www.terraCO2.com](http://www.terraCO2.com)