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Metakaolin for High Performance Concrete

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Sinoma Research Institute

Limestone Calcined Clay Cement LC3

Content

- Effect of burning temp on reactivity of MK
- Performance of Cement + MK/SF
- Performance Comparison of Concrete with addition of MK/SF

Raw Materials

Chemical composition of Kaolinite from different regions of China

No.	Chemical analysis (%)						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	LOI
A	47.29	36.34	0.85	0.10	0.49	0.83	13.56
B	51.96	30.14	2.37	0.25	0.52	4.46	13.58
C	41.78	38.79	1.99	0.72	0.90	0.71	14.18
D	39.18	26.51	5.13	1.08	0.26	0.92	18.16
E	47.16	34.50	1.06	0.24	0.56	0.93	14.28
F	57.38	24.40	1.67	0.84	0.47	0.79	13.21

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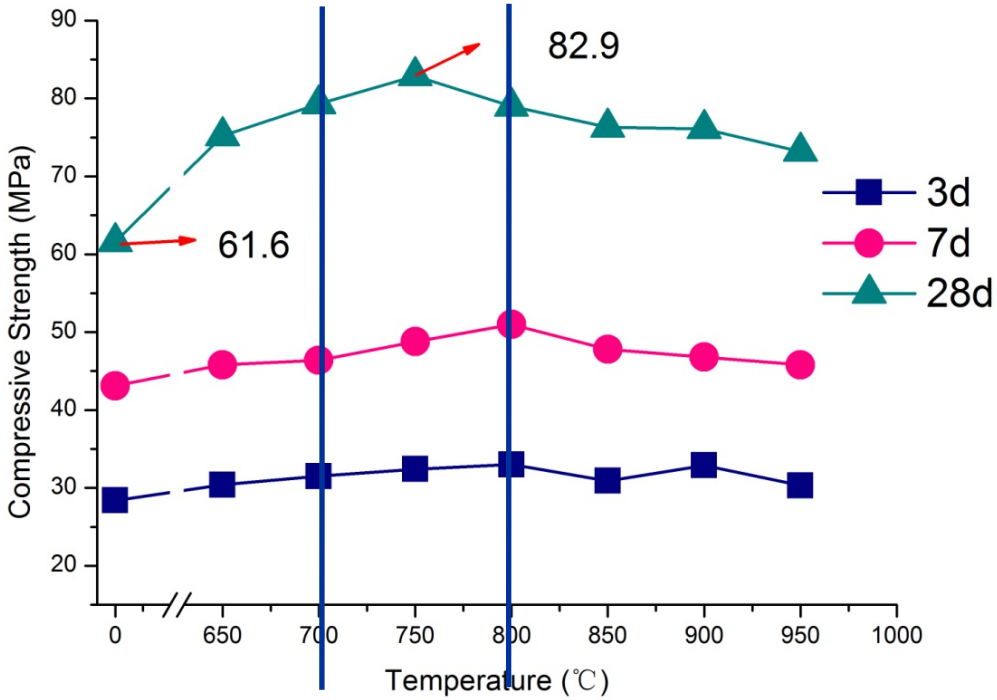
➢ Burning Temperature vs Strength

MK-A



Strength increase for all MKs, the best ranging from 700-800℃ with MK dosage: 10%

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➢ Burning Time vs Strength

Compressive strength of cement with MK-A from calcination time

No.	Calcination temperature (° C)	Calcination time (h)	Compressive Strength (MPa)		
			3d	7d	28d
Control	/	/	28.4	43.1	61.6
A31	750	2	30.4	47.8	82.9
A32	750	4	32.0	47.8	78.3
A33	750	6	31.6	47.3	76.7

Strength decrease with time, the best duration is about 2 hours, with MK dosage: 10%

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Types of MK vs Strength

Compressive strength of cement with MK of different composition

No.	SiO_2 (%)	Al_2O_3 (%)	$SiO_2+Al_2O_3$ (%)	Compressive Strength (MPa)		
				3d	7d	28d
Control	/			28.4	43.1	61.6
A	47.29	36.34	**83.63**	30.4	47.8	**82.9**
C	41.78	38.79	80.57	30.9	47.8	77.9
D	39.18	26.51	65.69	29.1	43.7	68.9

Strength increase with $SiO_2+Al_2O_3$, with MK dosage: 10%

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Mortar Performance Comparison vs MK/SF Dosage

Physical property of cement with addition of MK and SF

No.	Dosage (%)	Water demand (%)	Setting time (h: min)		Mortar Flow (mm)	Compressive Strength (MPa)		
			Initial	Final		3d	7d	28d
Control	0	26.7	4:05	6:24	144	28.4	43.1	61.6
MK-1	5	28.0	3:55	5:29	136	29.4	45.7	70.1
MK-2	10	30.0	3:01	4:37	128	30.1	45.3	71.2
MK-3	15	32.0	2:40	4:19	122	29.8	46.4	76.0
MK-4	20	34.0	1:38	3:13	113	30.5	49.2	72.8
SF-1	5	26.0	3:42	5:17	135	31.4	48.0	71.1
SF-2	10	27.5	3:10	4:41	119	33.4	47.2	72.5
SF-3	15	29.0	2:42	4:01	115	31.8	44.8	70.2
SF-4	20	35.0	1:45	3:19	107	29.3	39.7	61.6

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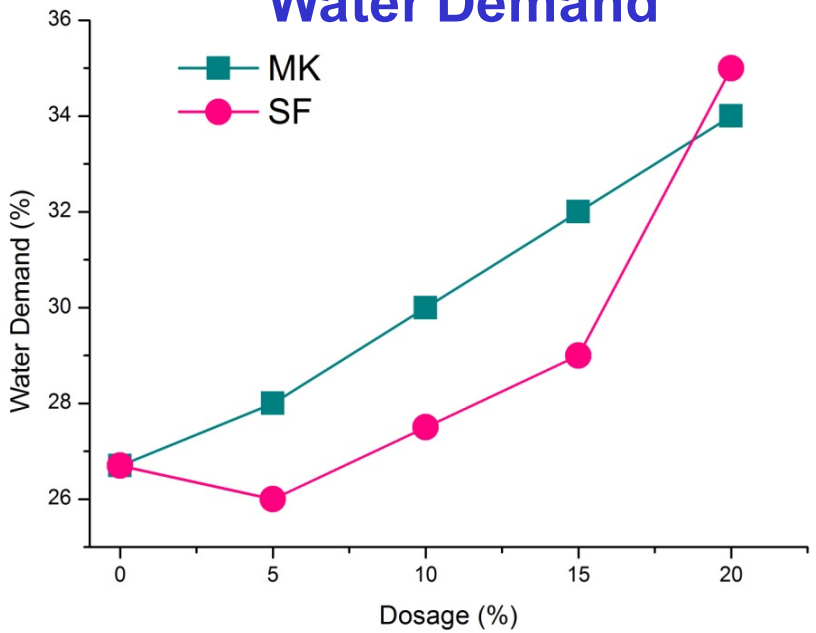
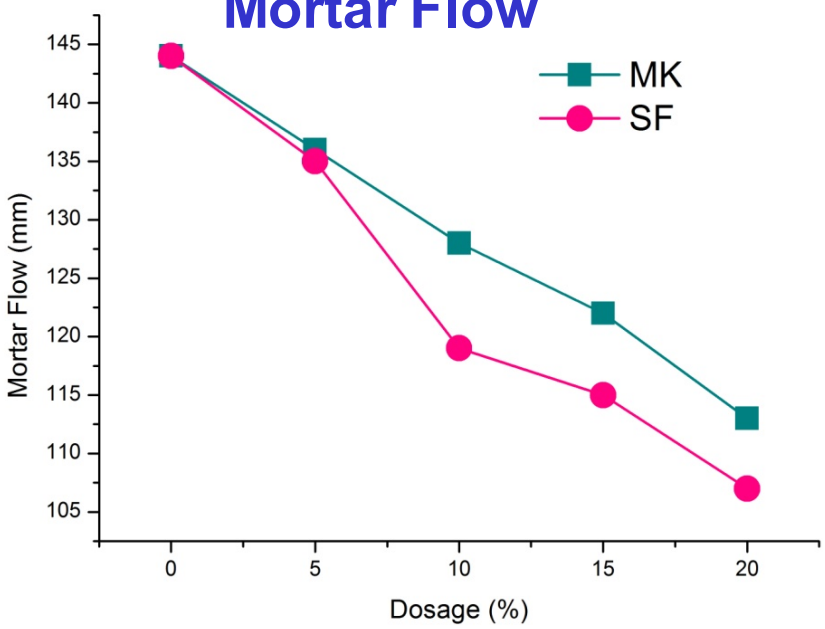
Mortar Performance Comparison vs MK/SF Dosage

Water Demand



Mortar Flow



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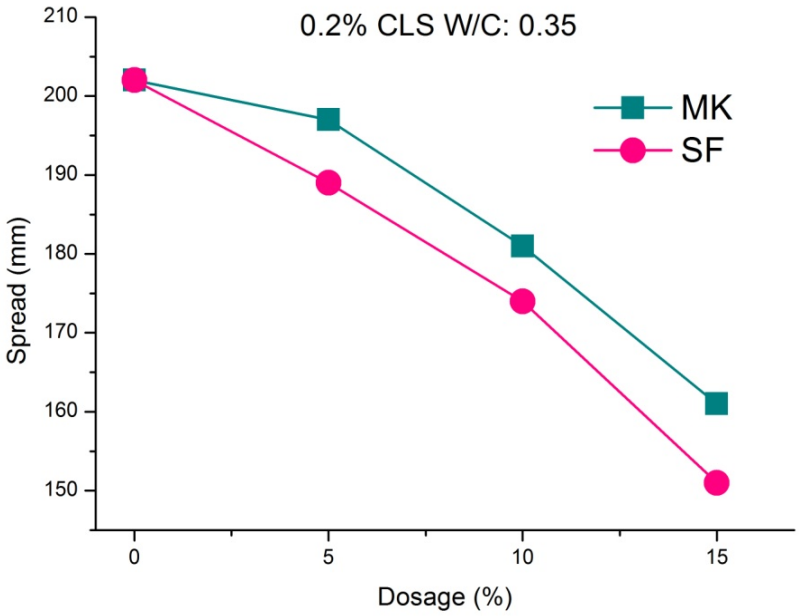
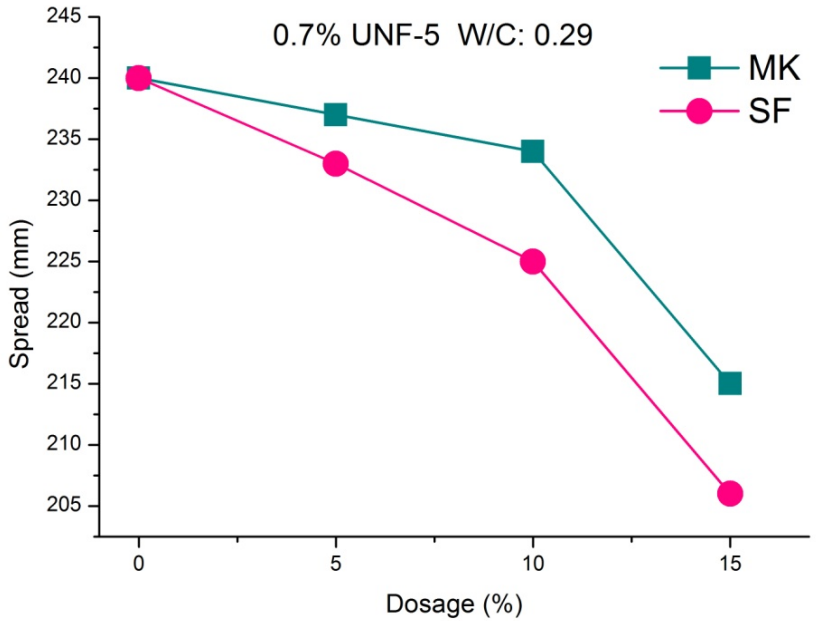
➢Workability of Cement & Concrete with MK & SF

Fresh pastes spread with PC + MK/SF





Flowability：MK > SF

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Performance comparison of concrete with addition of MK and SF combined with PFA

No.	W/(Cem+SCMs)	Cement (Kg/m3)	Addictive & dosage (Kg/m3)			Water (Kg/m3)	SP (C× %)	Slump (cm)	Compressive (MPa)			
			Pfa-I	MK	SF				3d	7d	28d	90d
MKP-1	0.32	360	130	25	-	165	1.0	23.0	55.4	60.1	72.1	90.2
MKP-2	0.30	376	134	27	-	160	1.1	22.5	59.3	63.2	76.0	93.9
MKP-3	0.28	385	137	28	-	155	1.2	23.0	62.5	67.9	83.3	97.1
MKP-4	0.26	393	142	28	-	145	1.4	23.5	66.8	72.5	93.7	101.1
MKP-5	0.24	406	145	30	-	140	1.5	21.5	72.1	76.3	96.7	107.2
SFP-1	0.32	360	130	-	25	165	1.0	22.5	57.1	61.0	72.4	90.7
SFP-2	0.30	376	134	-	27	160	1.1	23.0	60.7	64.1	77.1	94.1
SFP-3	0.28	385	137	-	28	155	1.2	23.0	63.1	69.1	83.9	98.0
SFP-4	0.26	393	142	-	28	145	1.4	23.5	65.1	74.1	94.3	101.3
SFP-5	0.24	406	145	-	30	140	1.5	21.5	72.4	77.1	96.8	111.3

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Same strength development

➢Conclusion

- MK optimal burning temperature 700～800℃, 2 h
- Decrease in setting and flow indicates need for water reducer
- MK and SF same performance， a little increase in early strength and 10～20% increase for 28d with 10% MK
- Both MK and SF work well for HPC

Thank you!

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