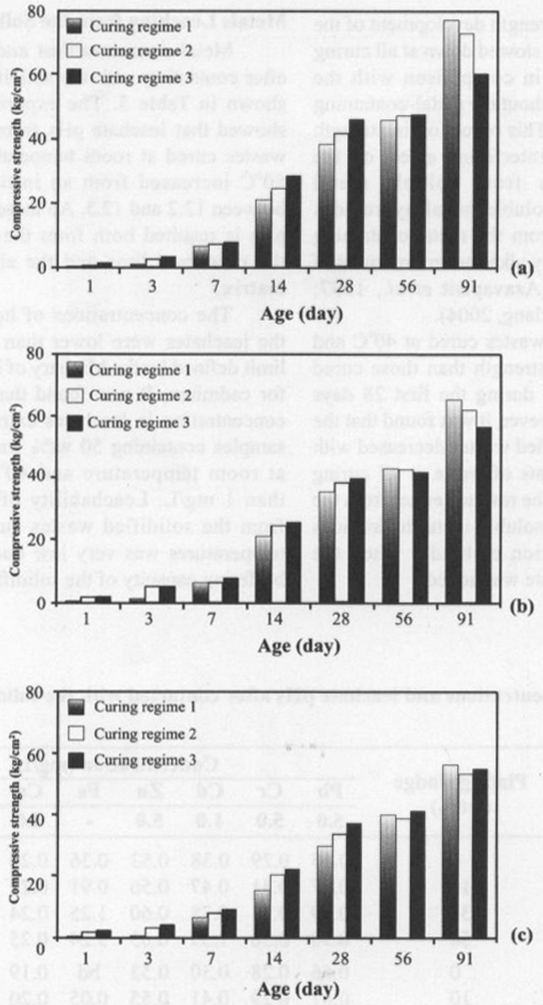

Figure 3. Strength development of lime-BHA cements containing metal-containing waste at (a) 10%, (b) 30%, and (c) 50%

rapid formation of hydration products which precipitate and cover the BHA particles. The rate of hydration at the later ages is therefore controlled by diffusion through the thick layer of precipitated hydration products. (Shi and Day, 2000a, 2000b)

Effect of Curing Temperatures on Strength of the Solidified Wastes

The Strength development of the solidified wastes at different waste concentrations and cured at room temperature, 40°C and 50°C is shown in Figures 3(a-c). At 10 wt% of waste loading, the rate of strength development of the solidified wastes was slowed down at all curing durations observed in comparison with the reference samples without the metal-containing waste (Figure 3(a)). This reduction in strength was caused by the interfering effect on the hydration reaction from soluble metal hydroxides. These soluble metal hydroxides were resolubilized from the metal-containing waste under the highly alkaline environment of lime-BHA cement (Asavapisit *et al.*, 1997; Asavapisit and Chotklang, 2004).

The solidified wastes cured at 40°C and 50°C gained higher strength than those cured at room temperature during the first 28 days (Figures 3(a-c)). However, it was found that the strength of the solidified wastes decreased with increasing the amounts of waste at all curing durations. This could be resulted either from the interfering effect of soluble metal hydroxides or the reduced portion of binder when the metal-containing waste was added.

Metals Leaching from the Solidified Wastes

Metal concentrations and leachate pHs after contacting with the solidified wastes are shown in Table 5. The experimental results showed that leachate pHs from the solidified wastes cured at room temperature, 40°C and 50°C increased from an initial pH of 5 to between 12.2 and 12.3. An increase of leachate pHs is resulted both from the dissolution of the unreacted lime and the alkali solidified matrix.

The concentrations of heavy metals in the leachates were lower than the regulatory limit defined by the Ministry of Industry except for cadmium. It was found that the cadmium concentration in leachates extracted from the samples containing 50 wt% wastes and cured at room temperature and 40°C was higher than 1 mg/L. Leachability of heavy metals from the solidified wastes cured at various temperatures was very low due to the strong buffering capacity of the solidified wastes. It is

Table 5. Metal concentrations and leachate pHs after contacted with the solidified plating wastes

BHA : Lime (55 : 45)	Plating sludge (wt%)	Concentration (mg/L)							pH
		Pb	Cr	Cd	Zn	Fe	Cu	Ni	
		5.0	5.0	1.0	5.0	-	2.0	-	
Curing regime I	0	0.65	0.29	0.38	0.53	0.36	0.20	0.26	12.3
	10	0.67	0.31	0.47	0.56	0.91	0.21	0.28	12.3
	30	0.69	0.31	0.78	0.60	1.25	0.24	0.28	12.2
	50	0.90	0.36	1.39	0.63	3.24	0.25	0.29	12.2
Curing regime II	0	0.66	0.28	0.30	0.53	bd	0.19	0.25	12.3
	10	0.67	0.29	0.41	0.55	0.05	0.20	0.26	12.3
	30	0.68	0.30	0.71	0.59	1.76	0.20	0.28	12.2
	50	0.83	0.34	1.31	0.60	2.70	0.23	0.28	12.2
Curing regime III	0	0.63	bd	0.28	0.50	bd	0.19	0.24	12.3
	10	0.63	bd	0.38	0.52	bd	0.18	0.26	12.3
	30	0.64	0.02	0.68	0.57	1.22	0.19	0.27	12.2
	50	0.78	0.05	0.83	0.57	2.39	0.21	0.28	12.2

Curing regime I : room temperature (30 - 32°C)
Curing regime II : 40°C for 1 day followed by room temperature
Curing regime III : 50°C for 1 day followed by room temperature
bd = Below analytical detection limit

therefore notpossible to assess the effect of the elevated temperature curing on leachability of heavy metals from the solidified wastes.

Conclusion

1. BHA consists of 94.5 wt% SiO_2 with a 28-day strength activity index of 95.4% of the control. The lime-BHA cement gained the highest rate of strength development when lime was added at 45 wt%.
2. Lime-BHA cements cured at the elevated temperatures (40°C and 50°C) have higher strength at the early age. This is due to an increase of the solubility of monosilicate ion $[SiO(OH)_3^-]$ from the surface of BHA and rapidly reacts with Ca^{2+} to form C-S-H gels.
3. The elevated temperature curing has a significant influence on the later age strength of lime-BHA cements. The experimental results showed that the 91-day strength of lime-BHA cements cured at 40°C and 50°C was 65% and 63% of the control.
4. Addition of metal-containing waste to lime-BHA cement matrices caused strength reduction of lime-BHA cements. The strength decreased with increasing the amounts of waste loading. This could be partly resulted from the interfering effects of heavy metals on hydration reactions and the dilution effect on binder. However, concentration of heavy metals in leachates contacted with the solidified wastes meets the regulatory limit defined by the Ministry of Industry except for cadmium.

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