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AN ASSESSMENT OF MATERIALS THAT INTERFERE WITH STABILIZATION/SOLIDIFICATION PROCESSES

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ABSTRACT

Stabilization/solidification of hazardous waste involves mixing the waste with a binder material to enhance the physical properties of the waste and to immobilize contaminants that may be detrimental to the environment. Many hazardous wastes contain materials that are known to inhibit the setting and strength development properties of commonly used stabilization/solidification binder materials. This paper describes the initial results of an evaluation into the affect of ten interfering agents: oil, grease, lead nitrate, copper nitrate, zinc nitrate, sodium hydroxide, sodium sulfite, phenol, trichloroethylene, and hexachlorobenzene on the setting and strength development properties of a metal hydroxide sludge stabilized/solidified with three binder materials (Portland cement, lime/flyash, and cement/flyash).

The setting and strength development properties of the waste-binder-interfering agent mixture were evaluated using the unconfined compressive strength (UCS) test. UCS data indicated that relatively low levels (less than 8 percent) of phenols, lead nitrate, oil, and grease can result in an 80 percent reduction in the 28-day UCS developed by the waste-binder-interfering agent mixture as compared to control specimens. Trichloroethylene and hexachlorobenzene where shown to have little effect on strength development.

The results of this research confirm the need for waste-binder specific studies prior to the selection of a chemical stabilization/solidification process for the treatment of hazardous wastes.

INTRODUCTION

Background

The Environmental Protection Agency (USEPA) is responsible for evaluating the suitability of hazardous waste and materials for land disposal. Chemical stabilization/solidification (S/S) is one technique that has been proposed as a means of controlling the release of contaminants from landfilled wastes to surface and ground waters. Indeed, S/S of hazardous wastes is recognized in regulations implementing both the Superfund Amendments and Reauthorization Act of 1986 (SARA) and the Hazardous and Solid Waste Act Amendments of 1984 (RCRA).

A variety of S/S technologies have been proposed for treating hazardous wastes. The most commonly applied technologies use cement, pozzolan, or cement-pozzolan combinations as the primary mean of contaminant immobilization (U. S. EPA 1980, Cullinane et al. 1986). A potentia problem with using S/S technology involve chemical interferences with the hydration reactions typical of the cement and pozzolan processes. Experience in the cement and construction industry has demonstrated that small amounts of some chemicals can significantly affect the setting and strength development characteristics of concrete. Consequently, the cement industry has developed fairly stringent criteria for the quality of

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cement, aggregate, water, and additives (accelerators or retarders) that are allowed in concrete (Jones et al. 1986).

Of particular concern to S/S technology is the affect of organic compounds on the strength and contaminant immobilization characteristics of the final product. It is well documented that small concentrations of organic compounds (Young 1972, Young 1973), sugars (Ashworth 1965) formaldehydes (Rosskopf 1975) and various chemical contaminants typically found in hazardous waste affect the setting mechanisms of pozzolan cements and lime flyash pozzolans. Roberts (1978) and Smith (1979) reported on the affects of methanol, xylene, benzene, adipic acid, and an oil and grease mixture on the strength and leaching characteristics of a typical lime/flyash S/S formulation. Smith (1979) concludes that there was a good correlation between the effects of organic compounds on lime/flyash pozzolanic systems and the reported effects on the hydration of Portland cement. More recently, Chalasani, et al. (1986) and Walsh, et al. (1986), using x-ray diffraction and scanning electron microscopy techniques, reported on the affects of ethylene glycol and p-bromophenol on the microstructure of Portland cement hydration products. Ethylene glycol was found to produce significant changes in the microstructure up to at least a year of curing time.

Purpose and Scope

The purpose of the research described by this paper is to develop data on the compatibility of ten waste constituents with three binding agents - Portland cement, Portland cement/flyash, and lime/flyash pozzolan cement. Only the results of the unconfined compressive strength (UCS) test are presented in this paper. The remainder of the data will be presented in a comprehensive report scheduled for publication in 1988, after completion of the project.

MATERIALS AND METHODS

Jones et al. (1985) described the basic research program to evaluate the effects of interfering compounds on S/S processes at a previous conference. The study reported on herein was conducted in three phases: (1) preparation of a synthetic wastewater and sludge; (2) addition of a binder and interfering material to the sludge; and (3) UCS testing of cured specimens containing sludge, binder, and interference chemicals.

Synthetic Wastewater and Sludge Production

Initial laboratory tests revealed that a synthetic wastewater containing nitrate salts of cadmium, chromium, nickel, and mercury at 600 times the EPA extraction procedure limit could be treated with calcium hydroxide to produce a hydroxide sludge with typical metal concentrations of 86.2, 84.1, 18.8, and 0.137 mg/g (dry weight basis) of nickel, chromium, cadmium, and mercury respectively. Ni 3,000 Cr 3,000 Cd 600 Hg 12 600x EP level

Typically, the raw sludge contained 8 percent solids and was very fluid. The sludge was dewatered to approximately 30 percent solids using a rotary drum vacuum filter. A constant moisture content between sludge batches was maintained by adjusting the solids content of the dewatered sludge to 25 percent using the supernatant liquid from the sludge production process as a dilution liquid.

Specimen Preparation

The 25 percent solids content sludge was divided into three 150 gallon samples and binder material was added to each at the following ratios.

Binder	Binder/Sludge Ratio
Portland Cement (Type I)	0.3:1 Cement:Sludge
Portland Cement (Type I)/Flyash (Type F)	0.2:1 Cement:Sludge 0.5:1 Flyash:Sludge
Lime/Flyash (Type C)	0.3:1 Lime:Sludge 0.5:1 Flyash:Sludge

After mixing the sludge with the binder, each binder/sludge sample was subdivided into four equal parts. One of the ten interfering chemicals was added to each of the subsamples at ratios of 0, 0.02, 0.05 and 0.08 (by weight) interference chemical to binder/sludge material. The subsample to which no interference chemical was added was used as a control specimen. A control specimen was prepared each time an interference chemical was processed, thus

accounting for variability between batches, so that the UCS results between batches could be compared.

The interference/binder/sludge mixture (I/B/S) was then molded into two inch cubes in accordance with ASTM Method C-109-77/86 (ASTM 1986). Because the I/B/S mixture was usually viscous and could not be tamped into the molds, the ASTM method was modified to include vibration of the I/B/S mixture to remove any air pockets that developed during the molding process.

The specimens were cured in the molds at 23° C and 98 percent relative humidity for a minimum of 24 hours and removed from the molds whenever they developed sufficient strength to be free standing. After removal from the molds, the specimens were cured under the same conditions for periods of 4, 11, and 28 days. At the end of each curing period, the UCS of the specimens was determined in accordance with ASTM C 109-77/86.

DISCUSSION OF RESULTS

Space limitations do not allow presentation of all the study results. Typical results for selected interferences are discussed below.

Table 1 presents the results, reported as the percent increase or decrease in 28-day UCS from the control specimen. Figures 1 through 5 present a graphical representation of the results of the study. Figure 1 presents the UCS versus curing time for the cement binder-sodium hydroxide interference. Each curve represents the strength development curve for one interference concentration. Figure 2 presents the 28-day UCS versus interference concentration for each of the three binders for the sodium hydroxide. Figures 3, 4, and 5 present a graphical representation of the relative effects of interference concentration on the 28-day UCS of the three binders.

The data for the 28 day UCS are an indicator of the UCS trends observed at the earlier curing periods. This is clearly illustrated in Figure 1 which is a plot of cure time versus UCS for one interference material. Although the slope of the curves varies between binder and interference treatments, in most cases, the lines of constant interference concentration do not cross.

Portland Cement Binder

The data presented in Table 1 clearly indicate that the interference effects may be positive or negative, depending on the concentration of the interfering material. The addition of oil or grease at a 0.08 ratio resulted in a 44 percent decrease in the 28-day UCS. The addition of copper nitrate, resulted in an increase in UCS for all concentrations. The addition of copper nitrate at a 0.05 ratio resulted in a 181 percent increase in the 28-day UCS. The addition of zinc nitrate resulted in the an increase in UCS for the 0.02 ratio; however, when added at a 0.08 ratio, it resulted in the largest UCS decrease, 85.5 percent, observed for any of the interference compounds. For cement, most specimens exhibited a decrease in UCS with increasing interference concentration.

By comparing the UCS results for the control specimens for different binders, it is evident that the cement specimens developed less strength than the lime/flyash or the cement/flyash specimens. Figure 2 however illustrates that increasing the concentrations of the interference chemical does not necessarily affect the different binders to the same degree.

Portland Cement/Flyash

The addition of a 0.08 ratio of lead nitrate, copper nitrate, zinc nitrate, and phenol resulted over a 90 percent decrease in 28-day UCS. The effect of sodium hydroxide, sodium sulfate, and copper nitrate addition was interesting because of the increase in UCS at the lower concentrations and decreases in UCS at the higher concentrations. The addition of a 0.02 ratio of sodium hydroxide resulted in a 22.8 percent increase in 28-day UCS while the addition of a 0.08 ratio caused a 19.5 percent decrease in 28-day UCS. The effect of hexachlorobenzene was not concentration dependent and resulted in a consistent 9 percent decrease in 28-day UCS, regardless of concentration.

Lime/Flyash

The addition of a 0.08 ratio of lead nitrate, copper nitrate, zinc nitrate, sodium sulfate, and phenol resulted in an 80 percent decrease in 28-day UCS. The addition of trichloroethlene, hexachlorobenzene, sodium hydroxide, and sodium sulfate resulted in a gain in 28-day UCS (51.0, 6.2, 71.1, 65.2 percent respectively) at the 0.02 ratio; however, these same compounds resulted in a decrease in strength (34.4, 1.2, 3.6, and 81.8 percent respectively) at a 0.08 ratio. The addition of oil or grease at a 0.08 ratio resulted in a 32 and 54 percent decrease respectively, in 28- day UCS.

CONCLUSIONS

Several conclusions can be drawn that characterize the effects of the interference materials investigated in this project on the UCS of stabilized/solidified waste materials.

1. The interference chemicals tested had a measurable effect on the setting and strength development properties of the stabilized/solidified waste. The magnitude of the effect depended on the type of binder, the curing time, and the type and concentration of the interfering compound.

2. Stabilized/solidified waste will show decreases in UCS development with increasing oil or grease concentrations.

3. Although the waste stabilized with Portland cement resulted in lower 28-day strength development, it appears that the concentration of interference material had less of an effect on the UCS development properties for the Portland cement binder than for the Portland cement/flyash or lime/flyash binders.

4. Zinc and phenol concentrations above 5 percent resulted in marked decreases in 28-day UCS development for all the binders tested.

5. Sodium hydroxide tends to increase the UCS at lower concentrations and decreases the UCS at higher concentrations for all binders.

6. The chlorinated hydrocarbons evaluated in this study had little effect on the UCS development properties.

ACKNOWLEDGEMENTS

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TABLE 1. 28-DAY UNCONFINED COMPRESSIVE STRENGTH AS A PERCENT OF CONTROL SPECIMEN[1]

Interference Chemical	Portland Cement Binder I/B/S[2] Ratio			Cement/Flyash I/B/S Ratio			Lime/Flyash I/B/S Ratio		
	0.02	0.05	0.08	0.02	0.05	0.08	0.02	0.05	0.08
Oil	-20	-38	-44	-8	-28	-42	-7	-27	-32
Grease	-12	-25	-45	-48	-40	-20	-7	-27	-54
Lead Nitrate	- 2	+18	+10	-51	-75	-97	-40	-77	-90
Copper Nitrate	+91	+181	+4	+17	-84	-98	-48	-48	-98
Zinc Nitrate	+3	-73	-86	-47	-93	-95	-53	-77	-88
Trichloroethylene	-28	-36	-27	-7	-33	-29	+51	-20	-34
Hexachlorobenzene	-5	-6	+15	-10	-9	-10	+6	+9	-1
Sodium Hydroxide	+14	-33	-52	+23	+5	-20	+1	-7	-4
Sodium Sulfate	-7	-13	-53	+23	+16	-64	+65	+38	-82
Phenol	-22	-26	-54	-49	-82	-92	-65	-88	-96

1 All results reported as percent increase (+) or decrease from the control specimen rounded to nearest whole percent.

2 Interference to binder/sludge ratio.

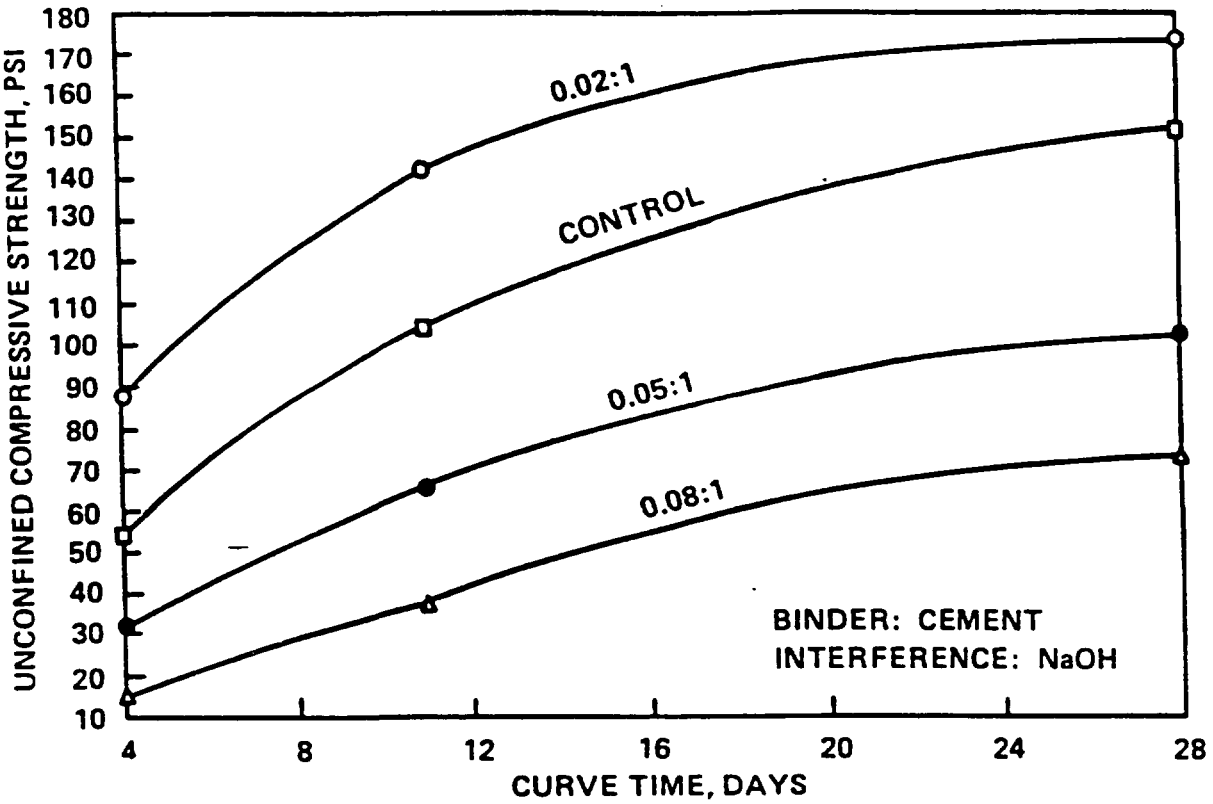

Figure 1. Unconfined Compressive Strength as a Function of Curing Time and Interference Concentration

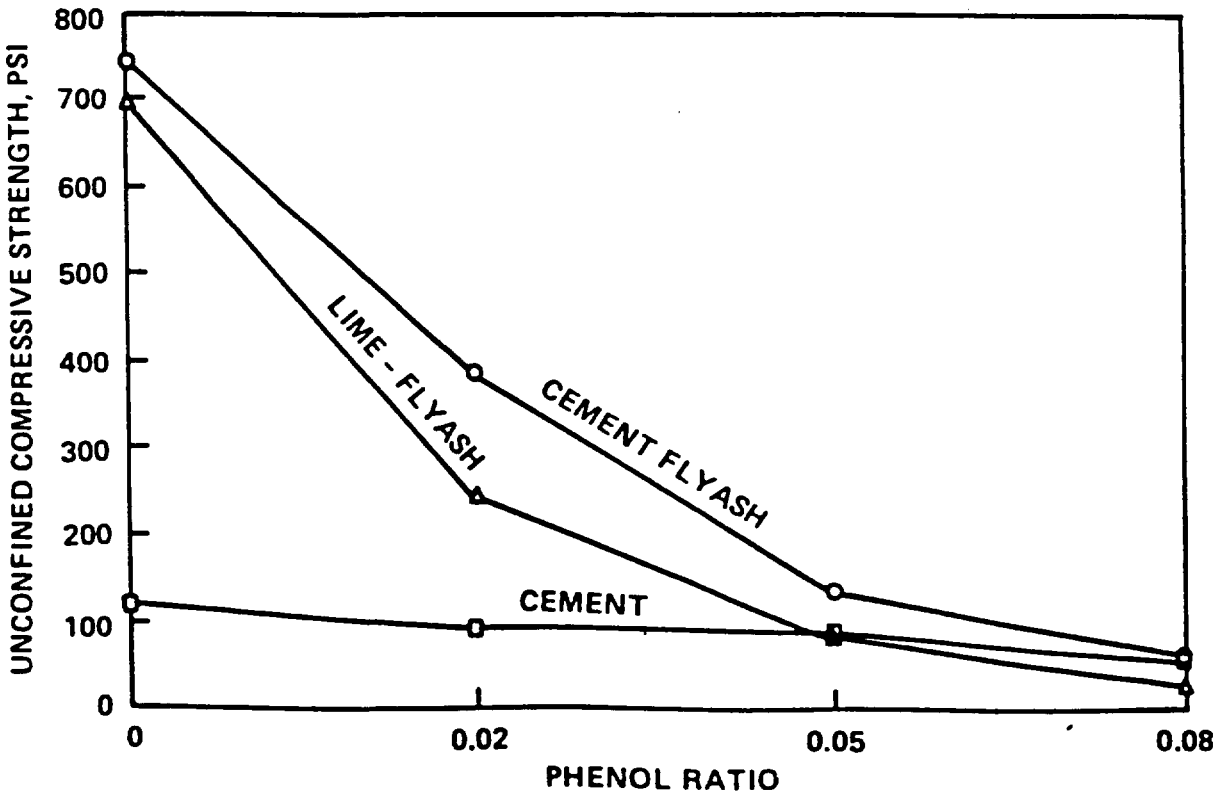

Figure 2. Unconfined Compressive Strength for Three Binders as a Function of Interference Concentration

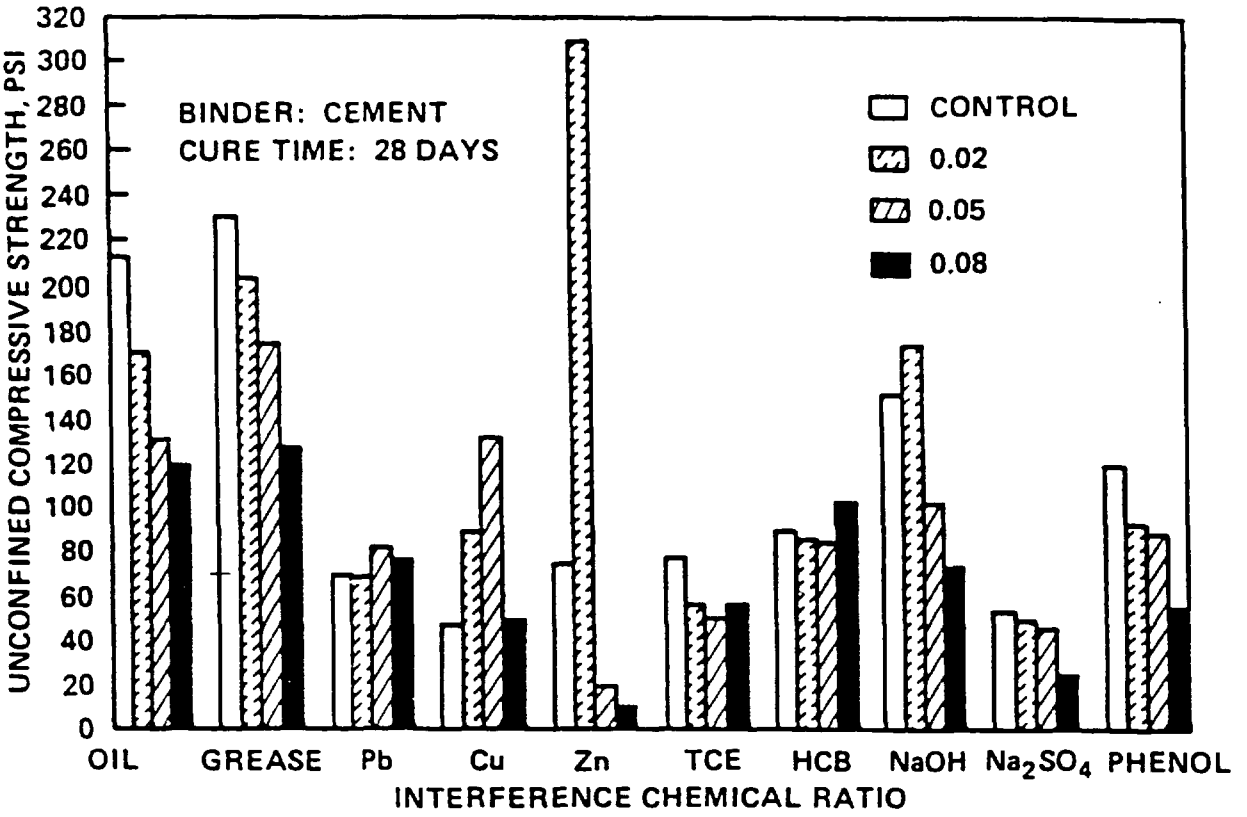

Figure 3. Effect of Interference Concentration on 28-day UCS for Type I Portland Cement Binder

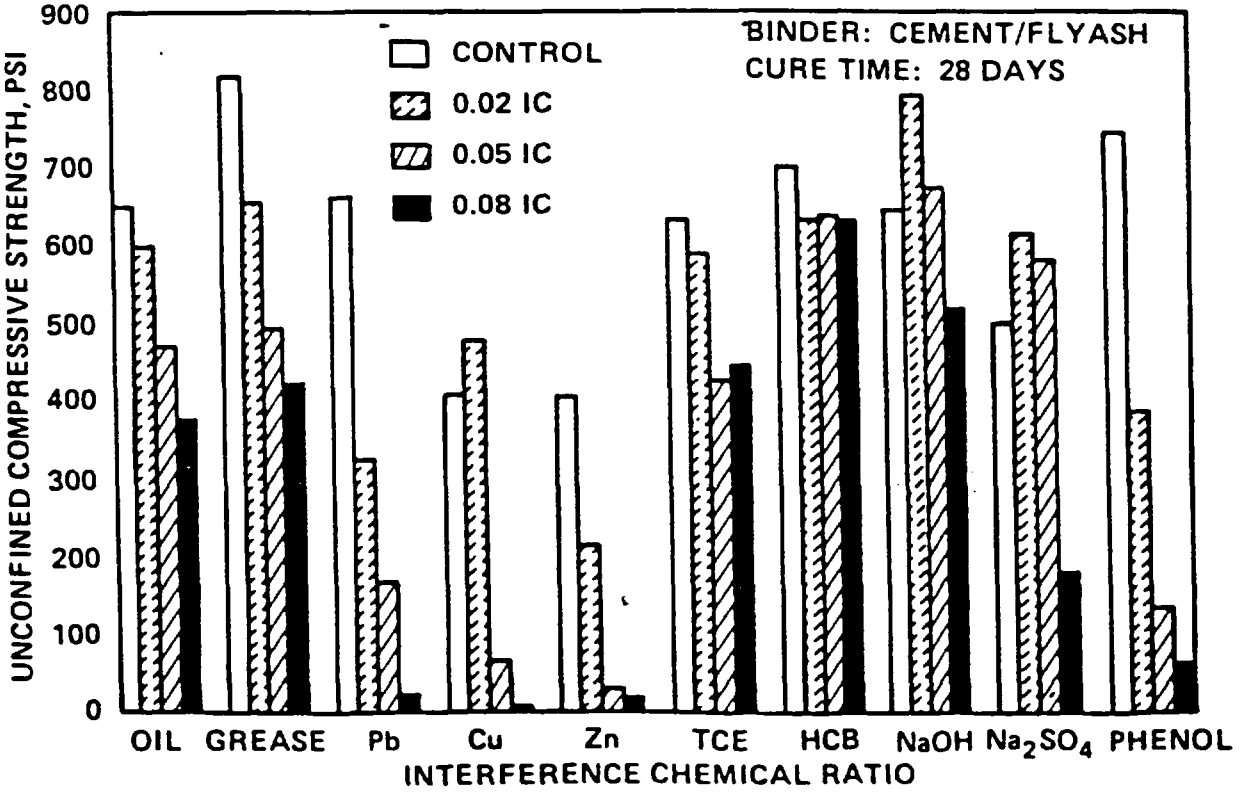

Figure 4. Effect of Interference Concentration on 28-day UCS for Cement/Flyash Binder.

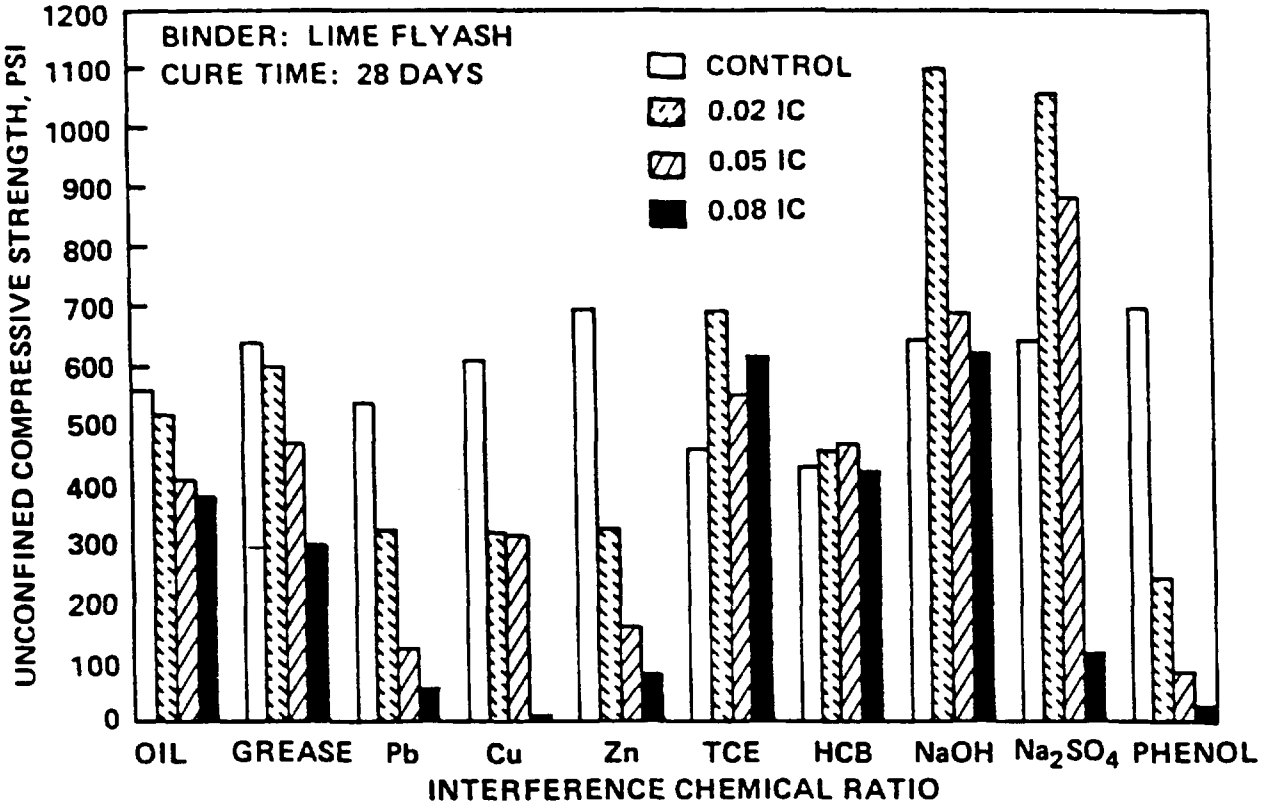

Figure 5. Effect of Interference Concentration on 28-day UCS for Lime/Flyash Binder.