Parametric Evaluation of Admixture Effects on Soil

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Soil Stabilization

Benefits:

- Very substantial increases in resilient modulus values (by a factor of 10 or more in some cases)
- Very substantial improvements in shear strength (by a factor of 20 or more in some cases)
- Continued strength gain with time, even after periods of environmental or load damage (autogenous healing)
- Long-term durability over decades of service even under severe environmental conditions

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Soil Modification

Benefits:

- Plasticity reduction (depending on mineralogy)
- Reduction in moisture-holding capacity (drying)
- Swell reduction
- Improved stability
- The ability to construct a solid working platform

Sampling

Samples are taken from the actual jobsite in order to evaluate the depth profile, particle size distribution, optimum moisture determination, and strength properties.

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Strength and Durability Testing

Specimens are made with admixtures to confirm the strength and durability of the cementitious reactions.

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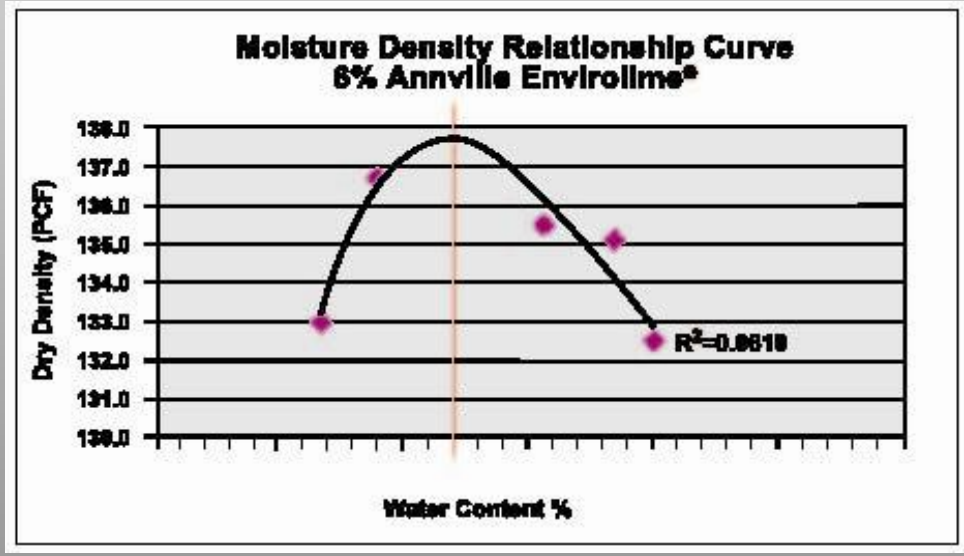
Analysis of Data

The Optimum Moisture Content (Proctor analysis) determines the moisture content needed for maximum density.



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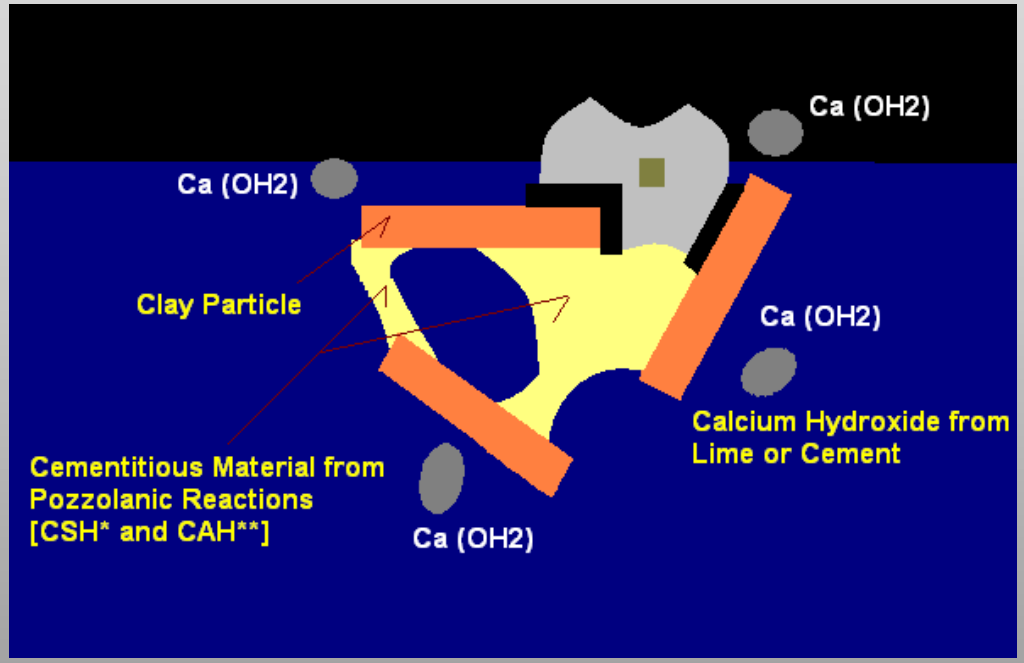
Pozzolanic Reaction



*Ca^{++} + OH^{-} + Soluble Clay Silica →Calcium Silicate Hydrate (CSH)

**Ca^{++} + OH^{-} + Soluble Clay Alumina →Calcium Aluminate Hydrate (CAH)

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Baseline Soil Classification Test Results

Table 1: Baseline Soil Classification Test Results						
Soil Type	Atterberg Limits			Percent Passing No. 200 Sieve	Maximum Standard Proctor Dry Unit Weight	Standard Proctor Optimum Moisture Content
	LL	PL	PI			
Silt/Clay (CL)	36	20	16	79.2%	114.2 pcf	14.4%
Clay/Sand (SC)	33	23	10	30.6%	113.3 pcf	14.1%
Silt (ML)	34	23	11	80.9%	113.3 pcf	10.7%

- Used three types of soil for parametric evaluation from numerous project site.

Standard Proctor Test Results for CL Soil

Table 2: Standard Proctor Test Results for CL Soil Admixture (% by Dry Unit Weight)					
Admixture	0% Admixture Content	2% Admixture Content	4% Admixture Content	6% Admixture Content	8% Admixture Content
Portland Cement	N/A	N/A	111.3 pcf @ 11.5%	112.9 pcf @ 12.1%	114.0 pcf @ 11.7%
High Cal	N/A	N/A	116.1 pcf @ 12.6%	113.4 pcf @ 10.2%	117.4 pcf @ 10.2%
Dolo	N/A	N/A	114.4 pcf @ 12.3%	115.5 pcf @ 12.5%	114.4 pcf @ 12.3%
No Admixture	114.2 pcf @ 14.4%	N/A	N/A	N/A	N/A

Table 3: Unconfined Compression Test Results for CL Soils in (psi) – No Admixture (% by Dry Unit Weight)

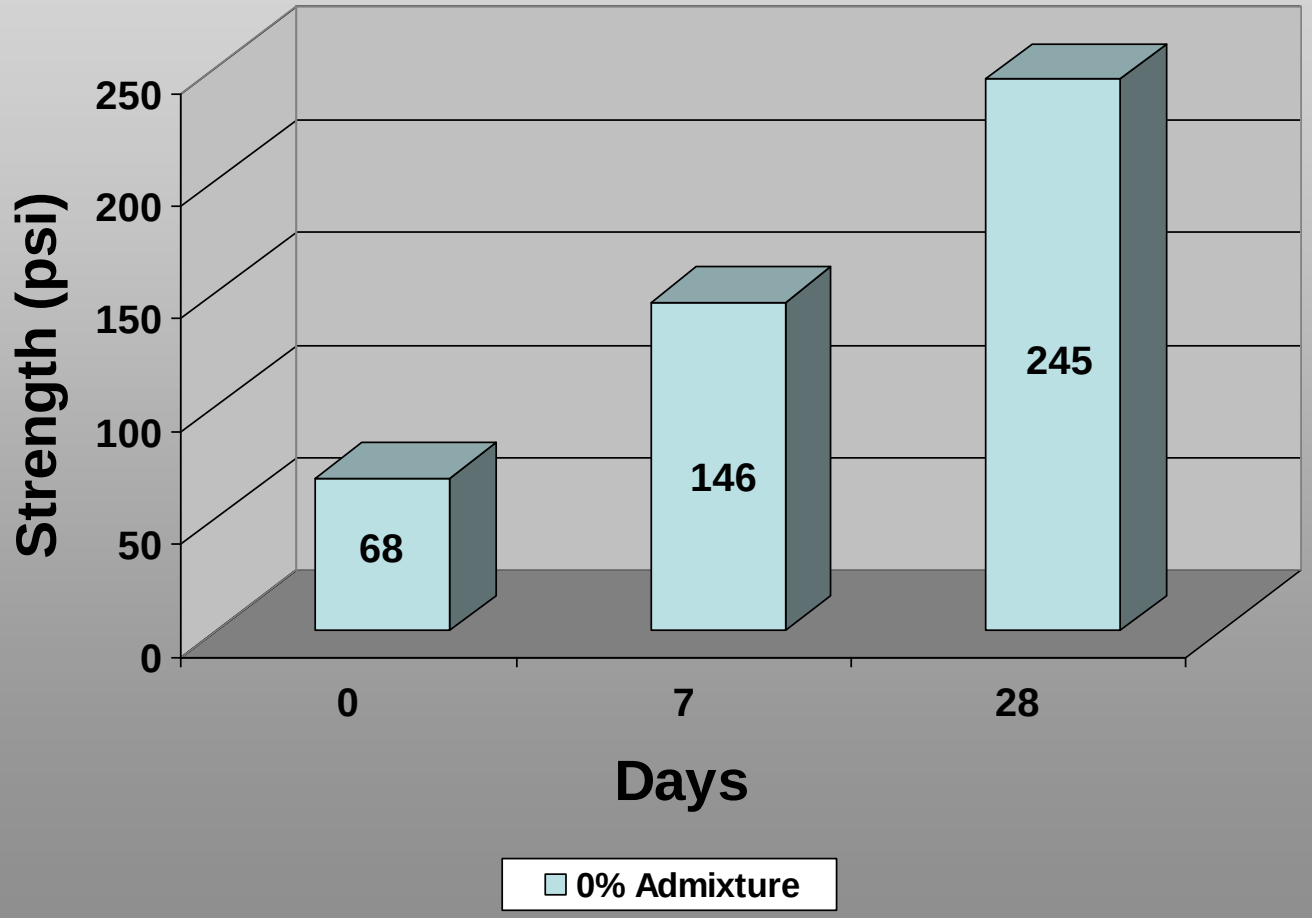


Table 4: Unconfined Compression Test Results for CL Soils in (psi) – Dolo Admixture (% by Dry Unit Weight)

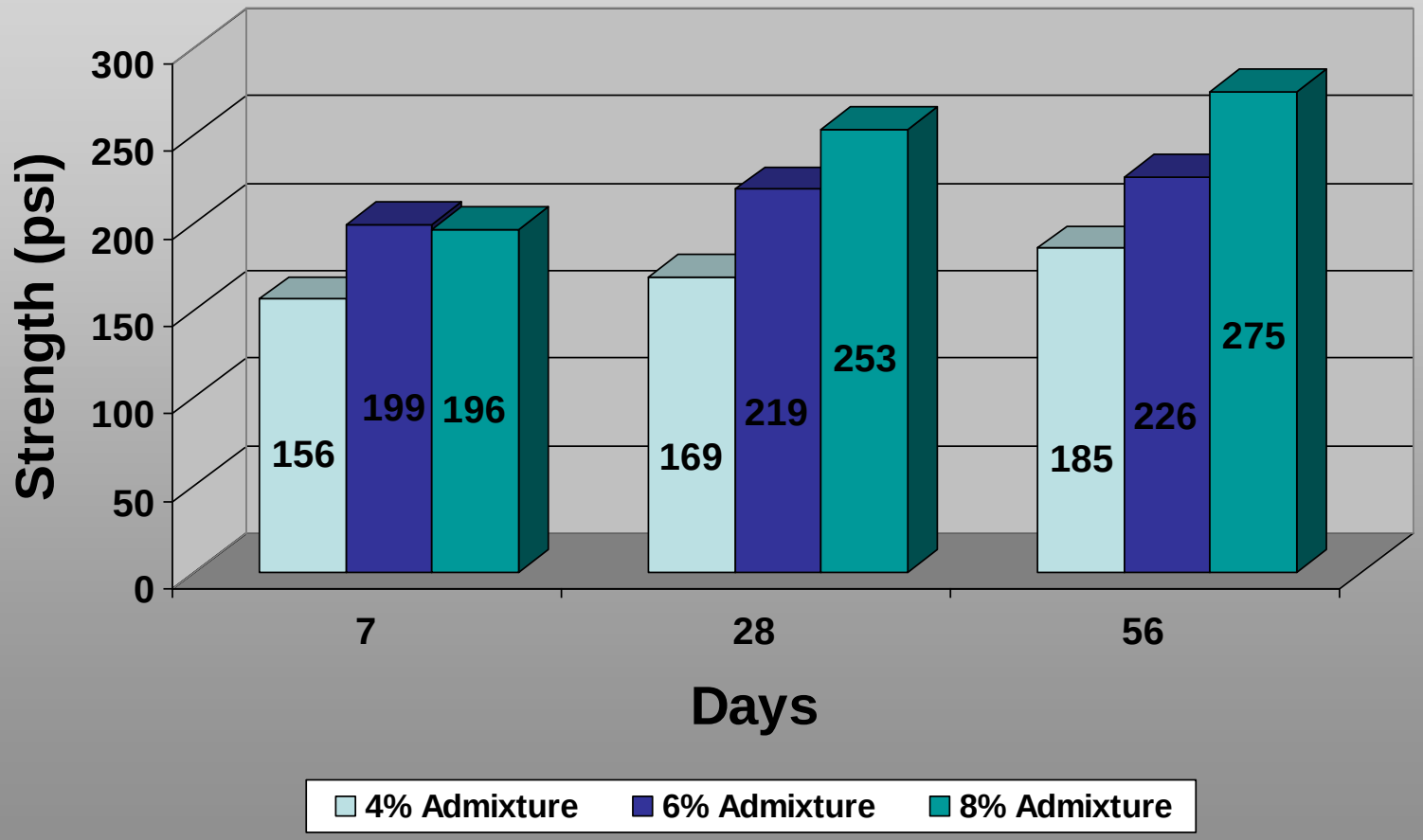


Table 5: Unconfined Compression Test Results for CL Soils in (psi) – Hi Cal Admixture (% by Dry Unit Weight)

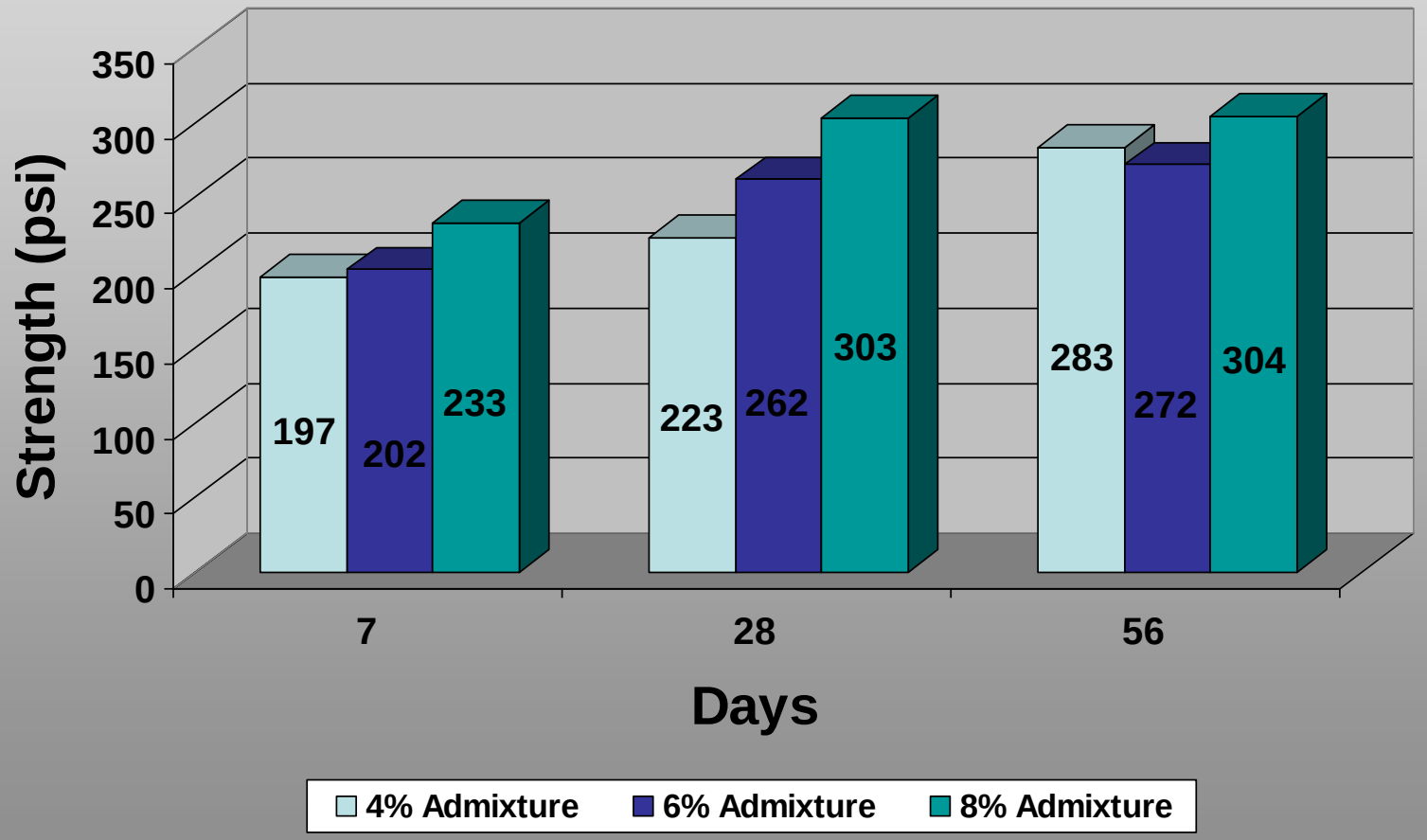
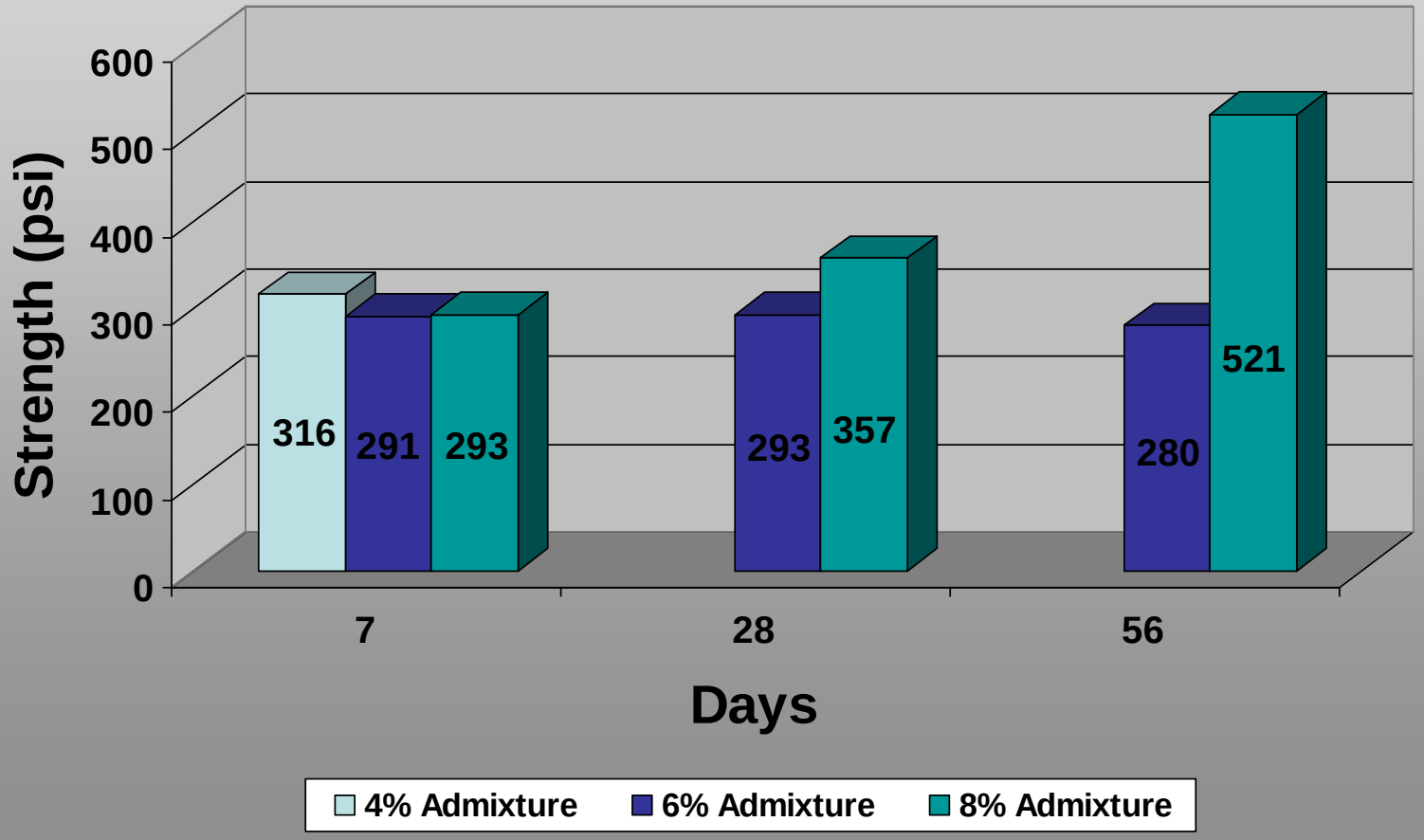


Table 6: Unconfined Compression Test Results for CL Soils in (psi) – Portland Cement Admixture (% by Dry Unit Weight)



Standard Proctor Test Results for SC Soil

Table 8: Standard Proctor Test Results for SC Soil Admixture (% by Dry Unit Weight)					
Admixture	0% Admixture Content	2% Admixture Content	4% Admixture Content	6% Admixture Content	8% Admixture Content
Portland Cement	N/A	N/A	N/A	N/A	N/A
High Cal	N/A	N/A	114.4 pcf @ 14.8%	113.4 pcf @ 14.3%	113.2 pcf @ 13.5%
Dolo	N/A	N/A	113.3 pcf @ 13.7%	111.7 pcf @ 14.1%	113.3 pcf @ 14.1%
No Admixture	112.9 pcf @ 12.3%	N/A	N/A	N/A	N/A

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Table 9: Unconfined Compression Test Results for SC Soils in (psi) – Dolo Admixture (% by Dry Unit Weight)

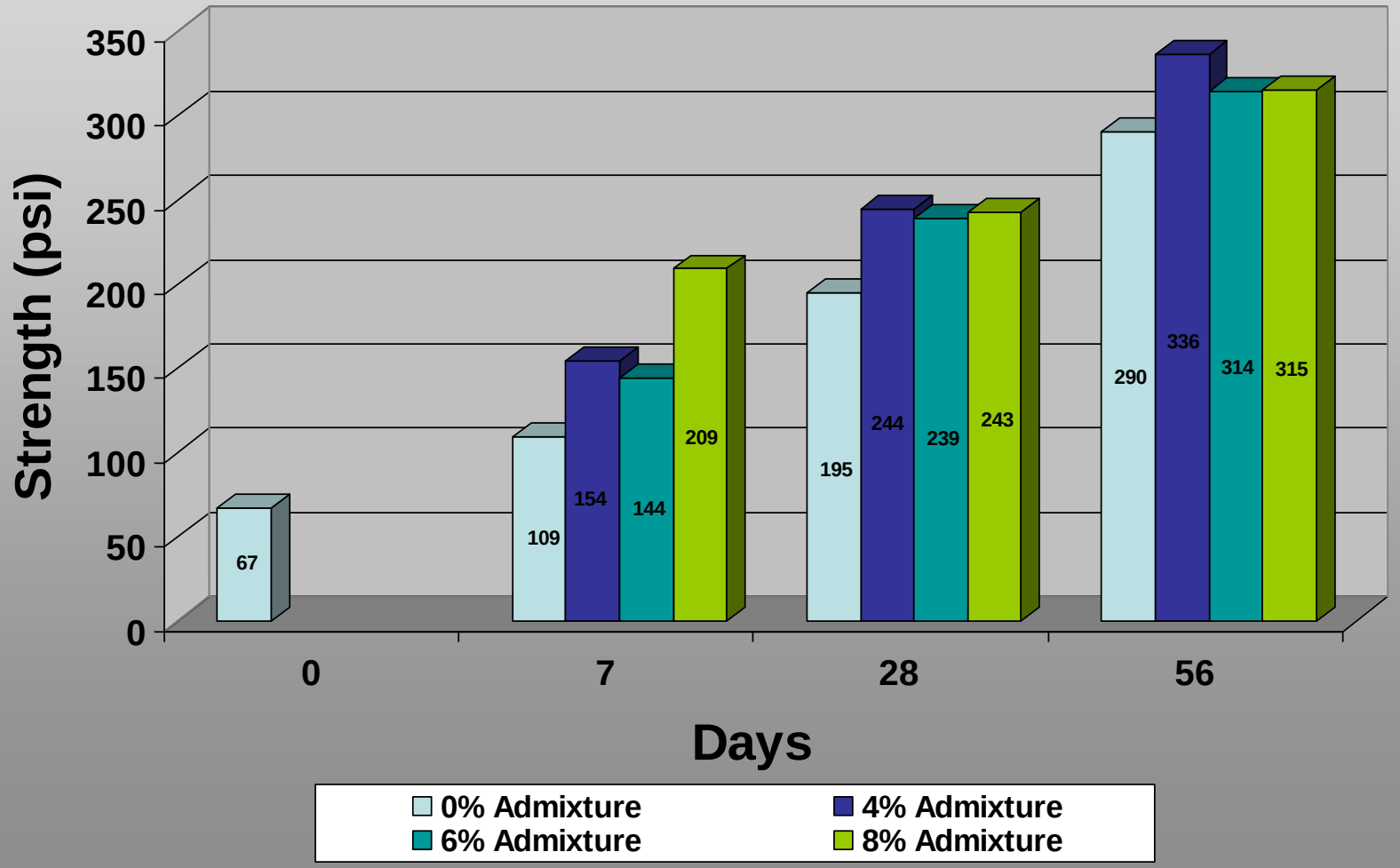
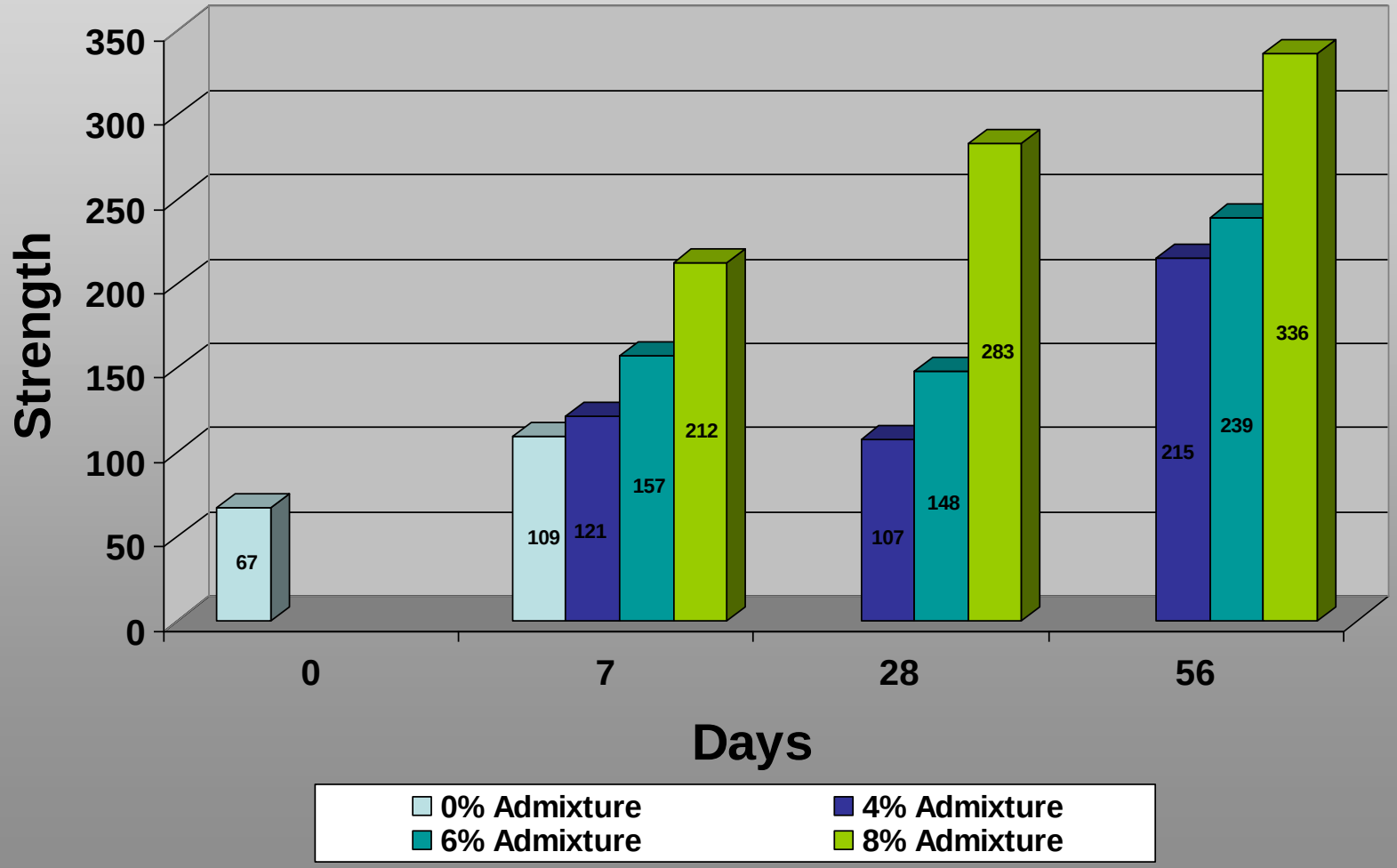


Table 10: Unconfined Compression Test Results for SC Soils in (psi) – Hi-Cal Admixture (% by Dry Unit Weight)



Standard Proctor Test Results for ML Soil

Table 12: Standard Proctor Test Results for ML Soil
Admixture (% by Dry Unit Weight)

Admixture	0% Admixture Content	2% Admixture Content	4% Admixture Content	6% Admixture Content	8% Admixture Content
Portland Cement	N/A	N/A	N/A	N/A	N/A
High Cal	N/A	N/A	113.3 pcf @ 10.7%	113.7 pcf @ 11.6%	112.7 pcf @ 11.1%
Dolo	N/A	N/A	113.7 pcf @ 12.7%	113.8 pcf @ 12.7%	116.4 pcf @ 8.4%
No Admixture	113.3 pcf @ 15.4%	N/A	N/A	N/A	N/A

Table 13: Unconfined Compression Test Results for ML Soils in (psi) – Dolo Admixture (% by Dry Unit Weight)

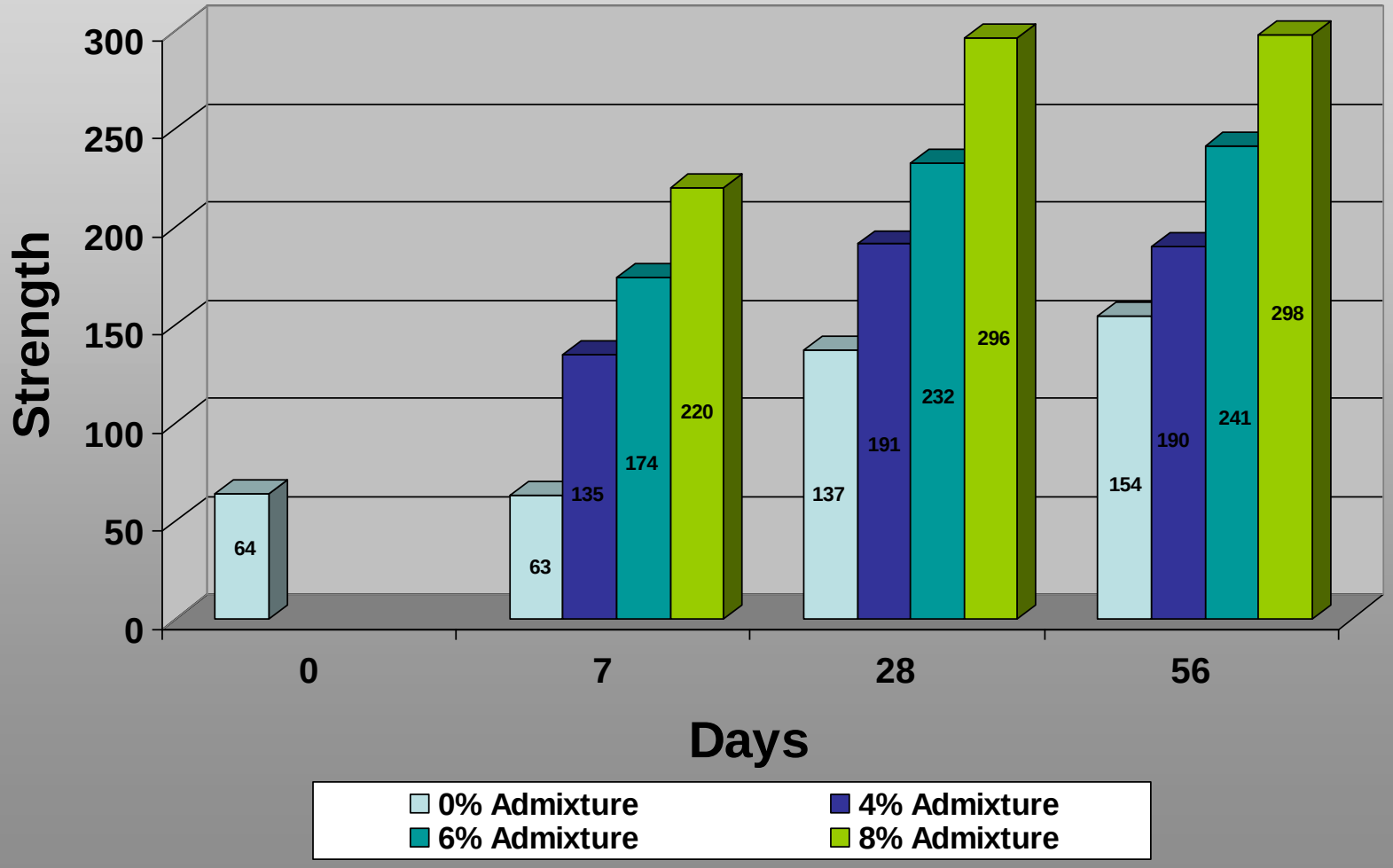
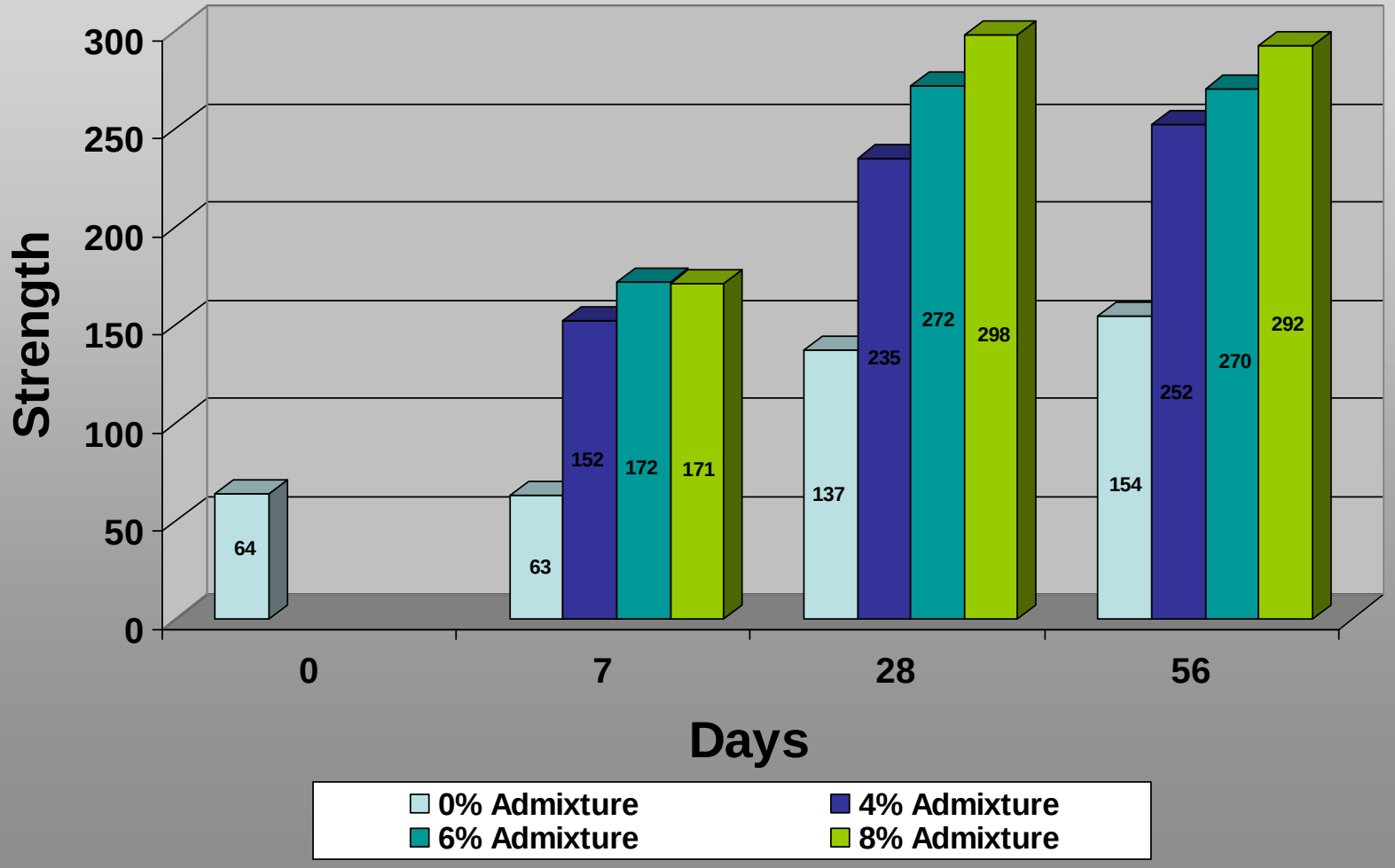
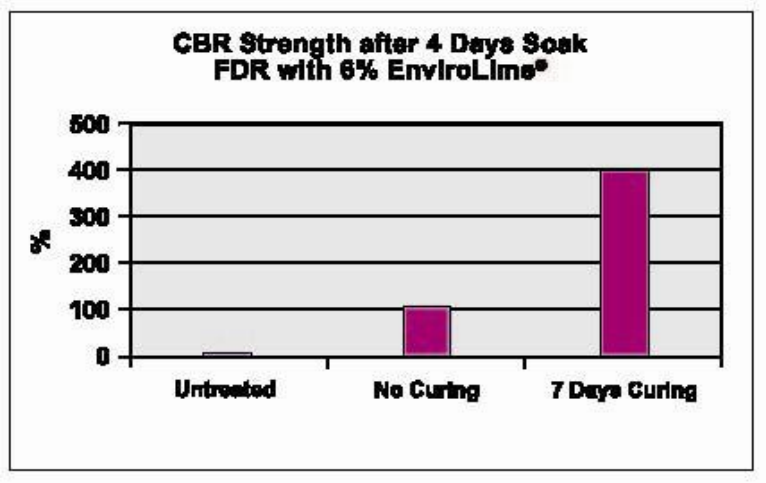


Table 14: Unconfined Compression Test Results for ML Soils in (psi) – Hi-Cal Admixture (% by Dry Unit Weight)



Load Bearing Capacity is Greatly Increased

California Bearing Ratio (CBR) improves after the 4 day soaking even without curing time. At the Xenia site, the CBR increased 400% with 7 days curing time, followed by the 4 day soak.



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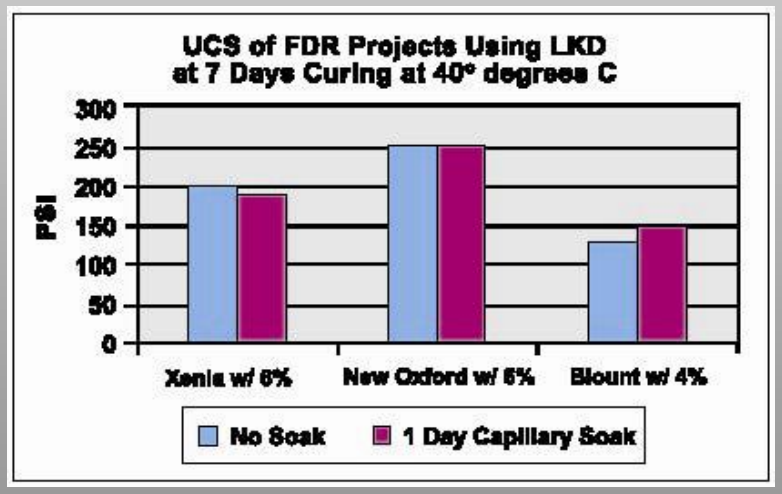
High Resistance to Moisture Damage

Unconfined compressive strengths using admixtures gain enough strength to resist moisture damage. Subjecting the cylinders to 1 day of capillary soaking did not impair their strength.



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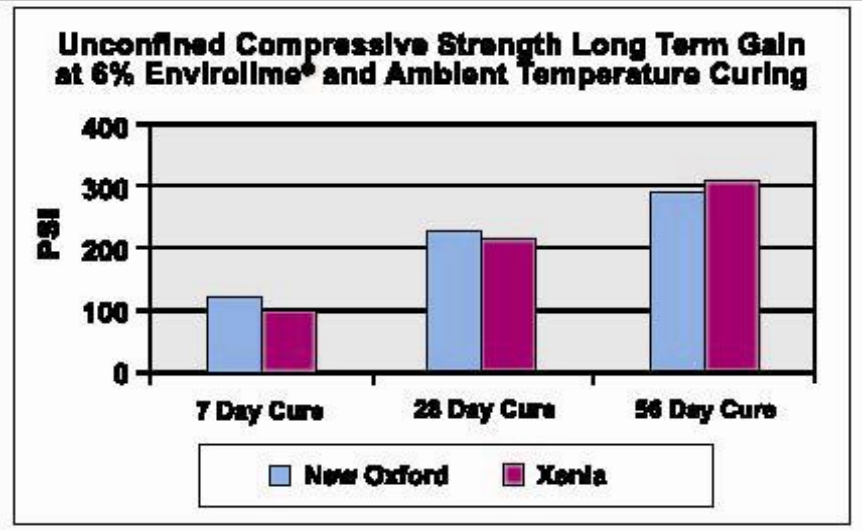
Long-Term Strength Gain

Unconfined compressive strengths using 6% lime/kiln dust show a significant 300% gain from 7 to 28 to 56 days, cured at ambient room temperature.



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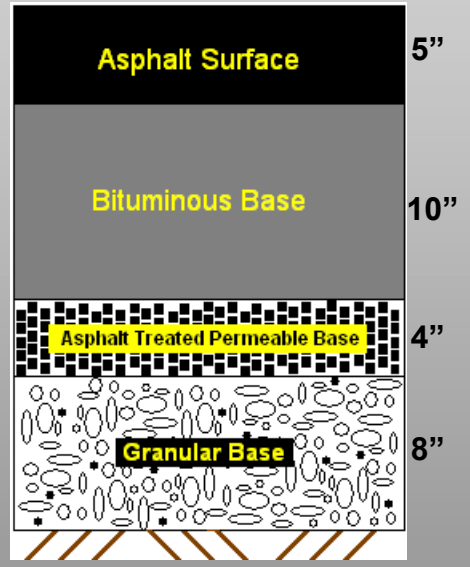
Lime Stabilization Lowers Pavement Cost

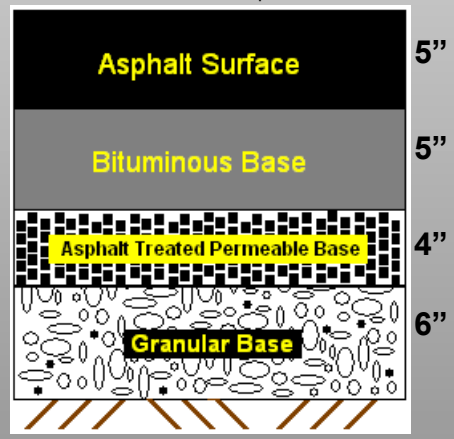
Lime Stabilization Yields Over 20% Initial Cost Savings

Estimated Cost = $26.1 Million



Untreated Subgrade CBR = 8

Estimated Cost = $22.1 Million



Lime Stabilized Subgrade CBR = 15

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Questions/Comments