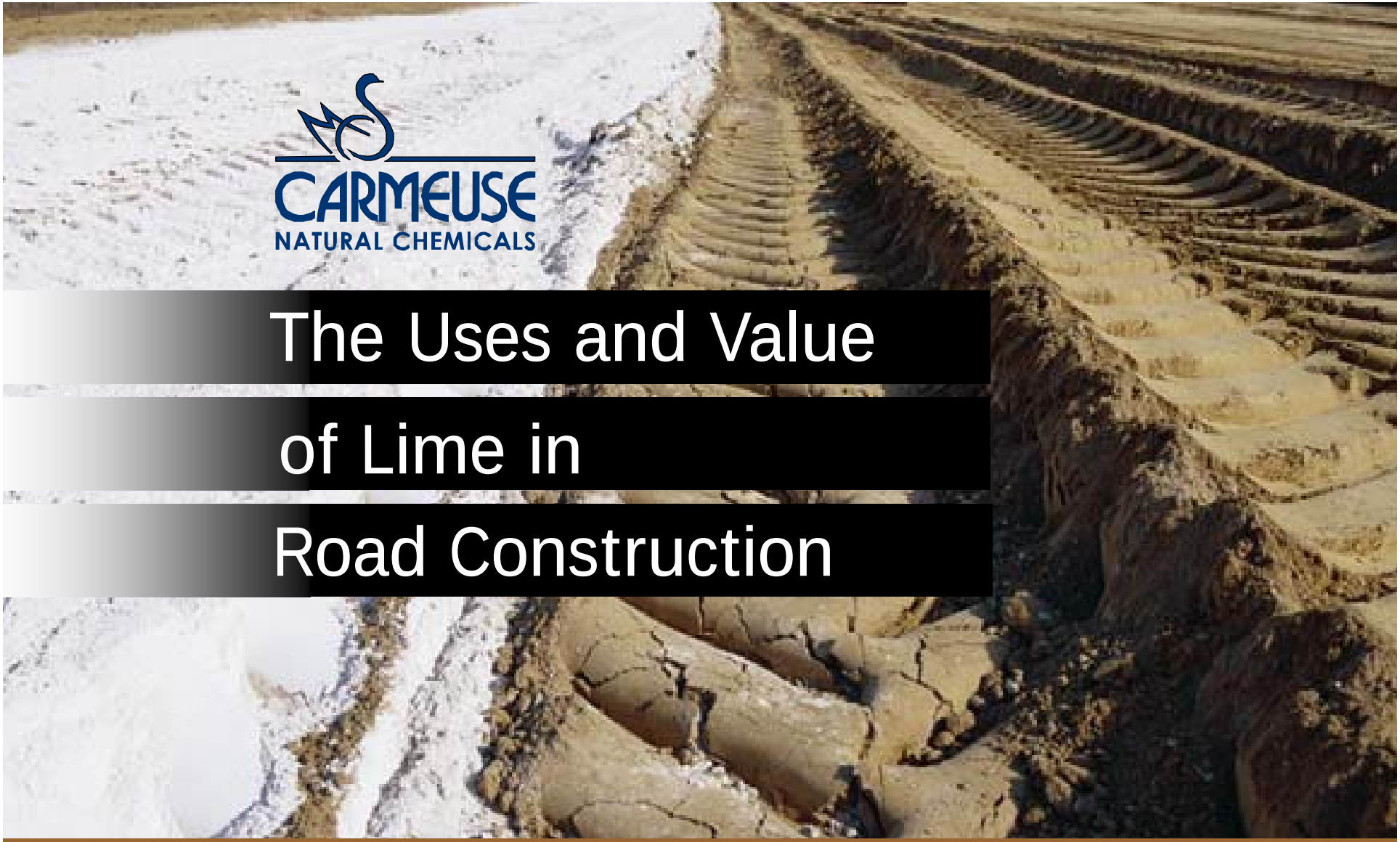

The Uses and Value of Lime in Road Construction

Presented by

Carmeuse North America

Added Value Applications

- Lime meets the challenges facing both the road designer, and the contractor in the areas of:
  - Soil Stabilization and Modification
  - Asphalt treatment and recycling

Lime in Soil Modification

- Soil Modification –
  Short term and immediate benefits:
  - Plasticity reduction
  - Drying
  - Swell reduction
  - Improved Stability and Compaction
  - Solid Working Platform
- Saves time and money!

Lime in Soil Stabilization Mix Designs

- Fine Soils and Clays (typically PIs 15 and above)
  - Handling improvements as soil modification
  - Substantial Increase in CBR Resilient Modulus
  - Continued Strength Gain with Time
  - Long Term Durability in very adverse conditions
  - Very Cost Effective
  - Proven Approach
- Lime-Flyash treatment applicable for Sandy /Silty soils
- Lime use in asphalt recycling FDR (Full Depth Reclamation)

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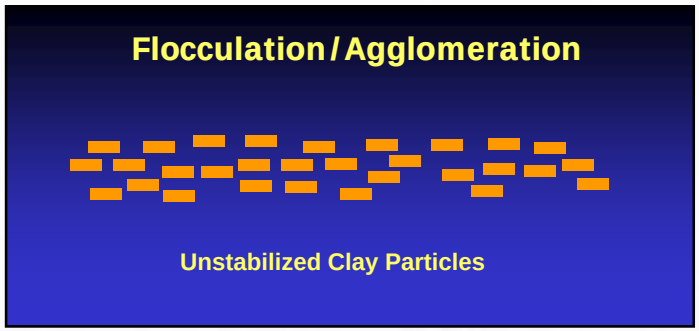
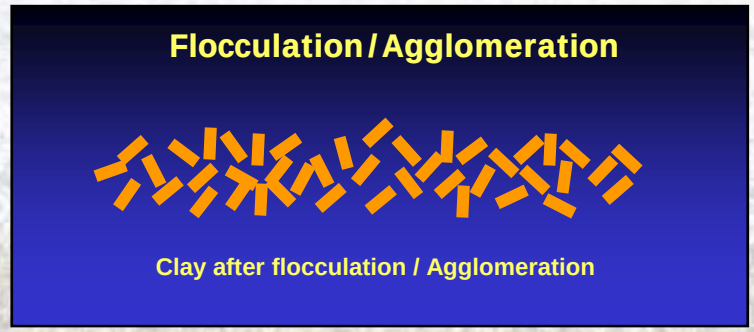
Lime Based Mix Designs for Different Soil Types

Soil Type	Well graded gravels and gravel sand mixtures, little or no fines	Poorly graded gravels and gravel sand mixtures, little or no fines	Silty gravels, gravel-sand-silt mixtures	Clayey gravels, gravel-sand-clay mixtures	Well-graded sands and gravelly sands, little or no fines	Poorly graded sands and gravelly sands, little or no fines	Silty sands, sand-silt mixtures	Clayey, sands, sand-clay mixtures	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Organic silts and organic silty clays of low plasticity	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	Inorganic clays of high plasticity, fat clays	Organic clays of medium to high plasticity	Peat, muck, and other highly organic soils
Unified Group Symbol	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH	OH	PT
AASHTO Group Classification	A-1-a	A-1-a	A-1-b	A-1-b	A-1-b	A-1-b or A-3	A-2-4 or A-2-5	A-2-6 or A-2-7	A-4	A-6	A-4	A-5	A-7-6	A-7-5	A-8
Recommended Additives	**LIME PLUS TYPE "F" Coal Fly Ash** (Stabilization)							**LIME** (Stabilization & Modification)							

Lime Reacts Chemically with Clays to Alter Molecular Interactions

Untreated clays have a molecular structure similar to some polymers, and give plastic properties. The structure can trap water between it's molecular layers, causing volume and density changes.





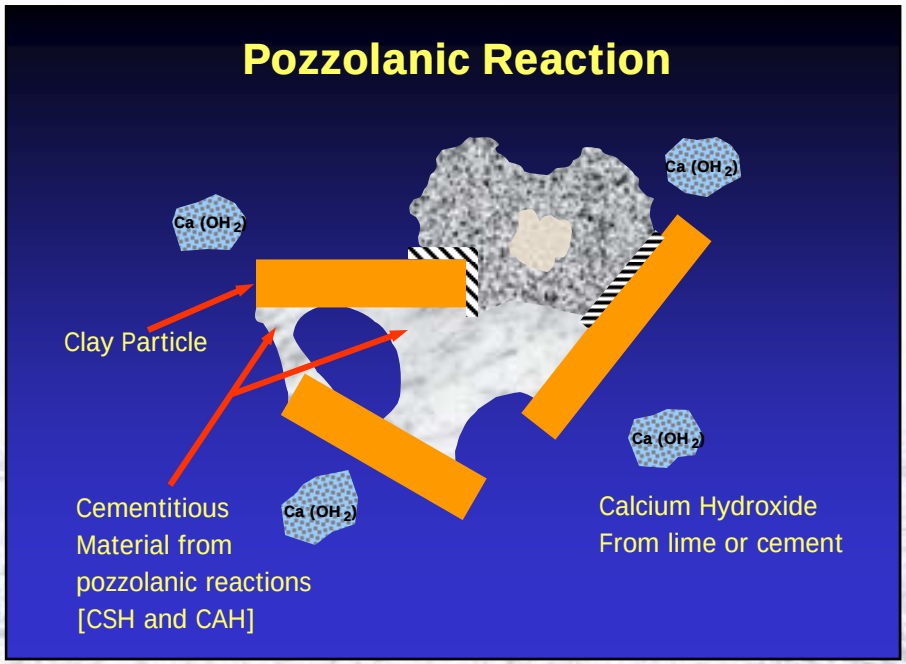
In treated clays Calcium atoms (from Lime) have replaced Sodium and Hydrogen atoms producing a soil with very friable characteristics

On-going reaction with available Silica and Alumina in the soil forms complex cementatious materials (the POZZALONIC effect.

Pozzolanic Reactions Using Lime

Essential to the treatment of clay soils

On-going reaction with available Silica and Alumina in the soil forms complex cementitious materials (the POZZOLANIC effect.)

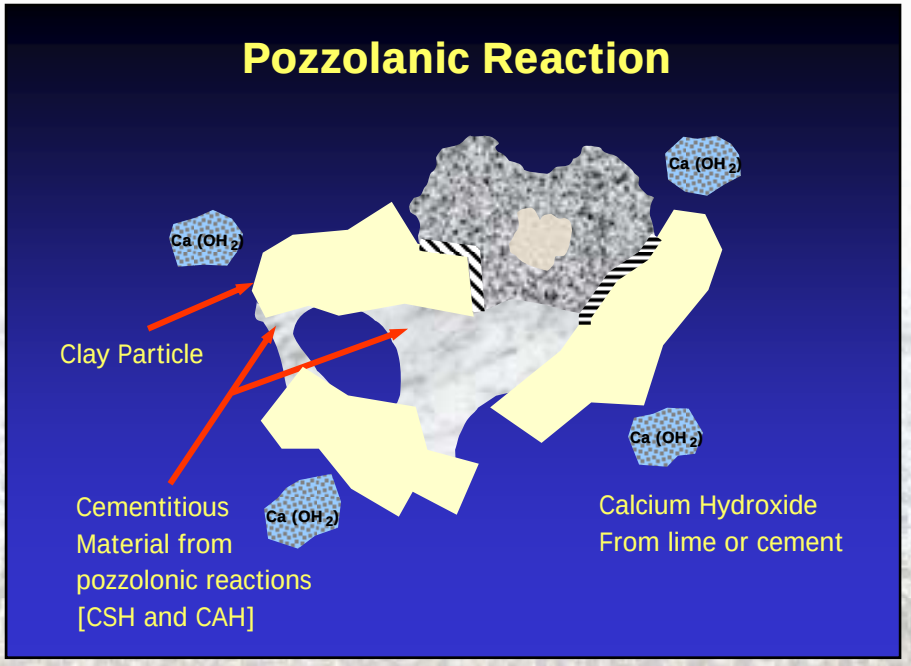


Lime Reacts Chemically with Flyash to provide Cementatious Result

Essential to the treatment of non-clay soils and aggregates

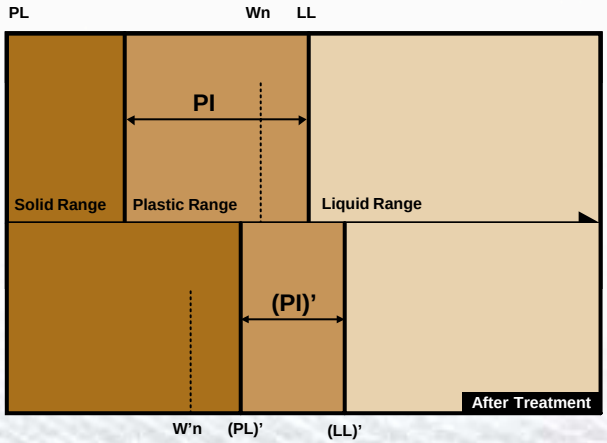
Reactions between lime and the Silica and Alumina in flyash form complex cementitious materials

Lime and Flyash provide a filler for larger particles of sand or gravel based soils



Results of Lime Treatment:

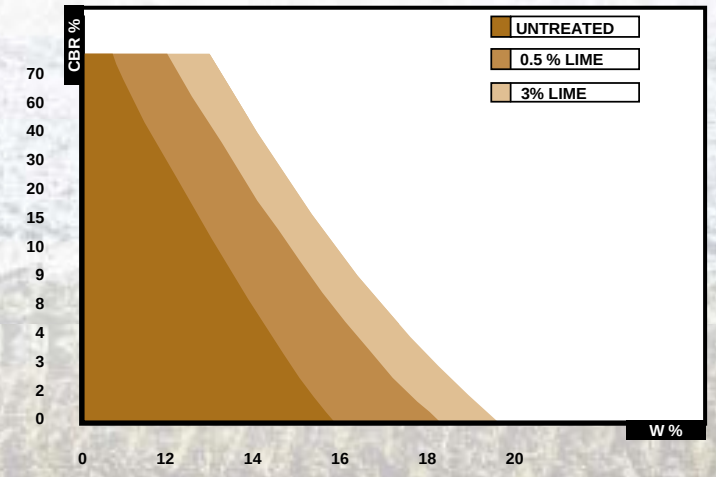
Immediate Impact on Plasticity, Workability, and Load Bearing Capacity



Drying: The water content is reduced from Wn to W'n

Plasticity: Treatment with lime displaces the solid range to the right. This enables the soil to accept a higher water content while remaining solid. The plasticity index PI = LL-PL is reduced.

Increase in carrying capacity after liming: After 2 hours with an initial water content of 14% the CBR index increased from 9 to 30 (0.5% lime added) and 70 (3% lime added) respectively



Lime in Soil Modification: Preparing the site

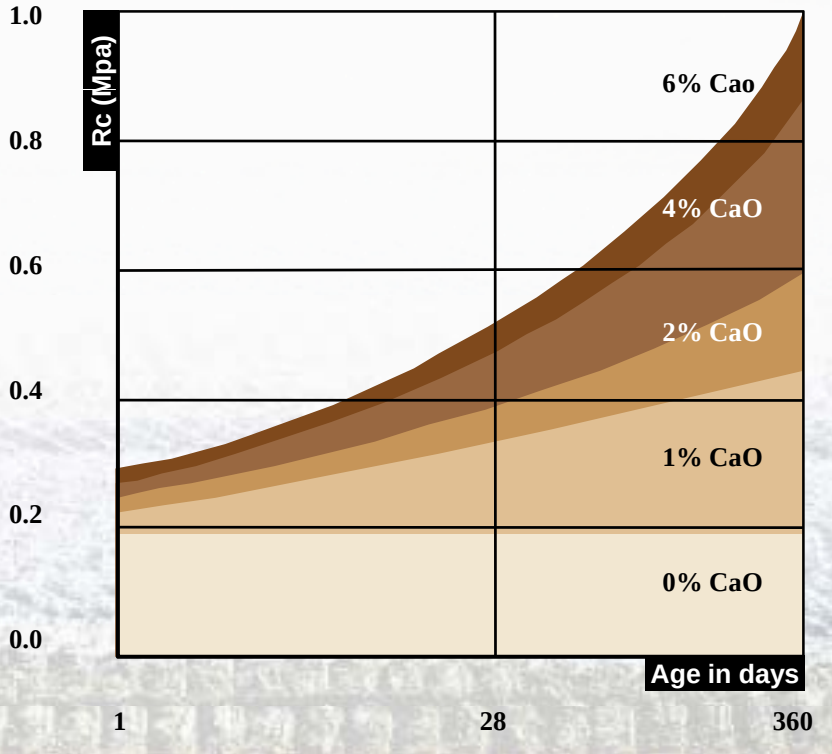
- Dry up the site and keep on working
- Great working platform for heavy machinery
- Makes non-workable clays into workable soils in minutes

Lime in Soil Stabilization

Compressability from initial curing continue

The Pozzolanic reactions from Lime treatment continue, allowing the base to gains strength and reduce compressability.

The availability of small amounts of excess lime provide “self-healing” (or “Autogenous healing”) of cracks caused by repeated freeze-thaw cycles over time.



Cost Effective Solution to Stabilization

- Lower Construction Costs
  - Makes in-place materials usable
  - Eliminates costs to remove and dispose
  - Eliminates cost associated with re-fill materials
- Lower Lifetime Costs
  - Lower maintenance costs through better resistance to water and freeze-thaw effects
  - Extended lifetime before replacement required

Cost Effective Solution to Stabilization

Comparison of Lime to Alternative Materials
A case study* – PA Turnpike Somerset Section, 21km long, 23.6m wide.

(* Bashar, Seksinsky, Jianchao, TRB Presentation January 2000)

	Natural Sub-grade		Lime Stabilized Sub-grade	
Design Methodology	**Base Thickness* (mm)**	**Project Cost** (MM$)**	**Base Thickness* (mm)**	**Project Cost*** (MM$)**
Resilient Modulus Calculation	**730**	**28.2**	**490**	**21.6**
CBR Calculation	**680**	**26.1**	**510**	**22.1**
Layer Structural Coefficient	**680**	**-**	**550**	**23.7**

*Required Base Thickness to meet Design Requirements

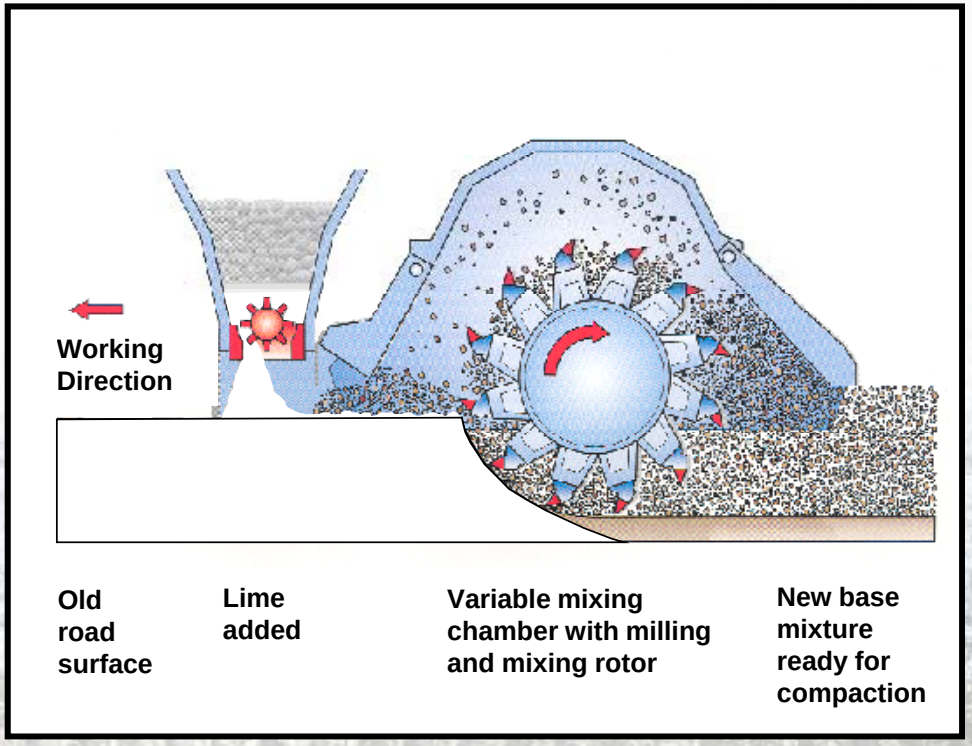
**Includes $2.3 MM for removal of existing pavement

***Includes $2.3 MM for removal of existing pavement plus $2.3 million for lime stabilization

20 % Cost Saving

Lime (or Lime-Flyash) in asphalt FDR (Full Depth Reclamation)

- Easy to apply in FDR process
- Provides Pozzolanic effect to provide strength to the reclaimed base material
- Water resistance
- Strength gain over time
- Autogenous healing of cracks



Summary – Areas of Application for Lime Stabilization

- Base Stabilization
  - Roads (all grades)
  - Parking lots / Public areas
  - Upgrades marginal base material making it usable
- Asphalt FDR
- Structural Fills and Embankments
- Site Preparation