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Cement Treated Bases for Development of Cost Effective Rural Roads

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Introduction

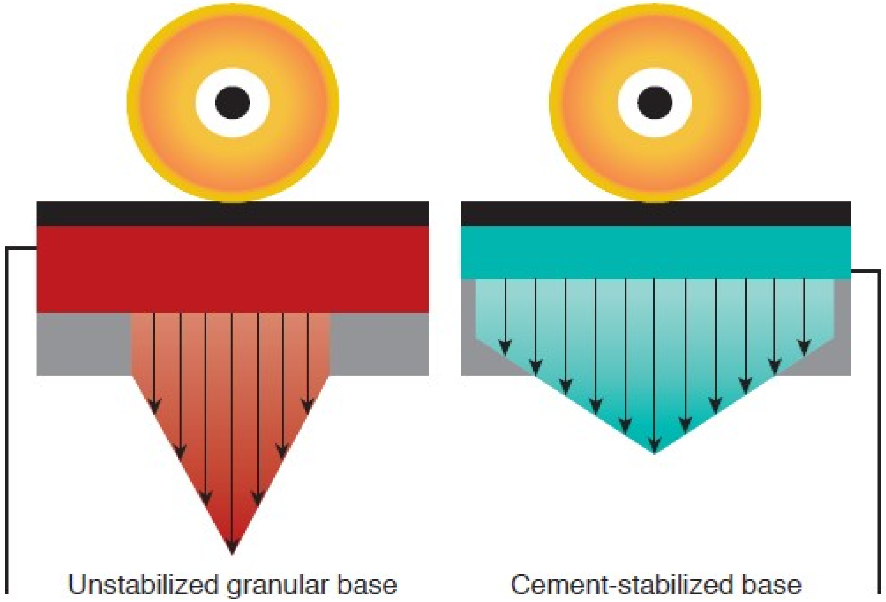
- Huge length of road network is being developed in India by NRIDA under PMGSY.
- Material scarcity for construction of roads have already been felt.
- Therefore, for sustainable development, we
  - Need to save the limited natural resources
  - Increase reuse, recycling and reprocessing
  - Need to use the locally available marginal materials

Need for Stabilized Layers

- Costly aggregates – High Transportation cost
- Soft subgrades
- Use marginal aggregates available locally
- Sites with drainage problem
- High Water Table

Advantages of Stabilized Bases

- With stabilization, the unbound material is hardened into a rigid/ semi-rigid layer that which will develop sufficient strength to spread the loads over a larger area of the subgrade.



Un-stablized granular base versus soil-cement base

Soil-Cement

- There are two primary types of soil-and-cement mixtures
  - Cement-modified soil (CMS)
  - Soil-cement
- When relatively small quantities of Portland cement and moisture are added to a soil material, the chemical and physical properties of that soil are improved. This is known as cement modified soil (CMS).
- Soil-cement is a mixture of pulverized soil material and measured amounts of Portland cement and water, compacted to high density. As the cement hydrates, the mixture becomes a hard, durable paving material.

Soil-Cement

- Cement-treated base (CTB), cement-stabilized soil, and cement-stabilized aggregate base are alternative terms used to represent soil-cement.
- The soil material in soil-cement can be almost any combination of sand, silt, clay, and gravel or crushed stone.
- Local granular materials (such as moorum, kankar and gravel etc.) plus a wide variety of waste materials (such as fly ash, slag and quarry waste etc.) can be used to make soil-cement.
- Also, old granular-base roads, with or without their bituminous surfaces, can be recycled to make good soil-cement, which is known as full depth recycling (FDR).

Stabilizers (Cementitious and Non-Cementitious)

- Lime
- Lime-Pozzolana (Flyash or Slag etc.)
- Cement
- Other commercial stabilizers/ Additives

Cement Treated Bases- Strength & Stiffness

- For Low volume rural roads, soil-cement can be effectively used to economise the construction.
- All types of soil-granular materials mixes having PI<20 for sub-base and PI<10 for base can be used.
- The mix design shall be done on the basis of 7 day UCS and/or durability test under 12 cycles of wet-dry conditions.
- For Rural Roads, IRC recommends a minimum 7-day UCS is 3.0 MPa for base course and 1.7 MPa for sub-base.
- NCHRP recommends an UCS value of 5.17 MPa for CTB after 28 days of curing.

Cement Treated Bases- Strength & Stiffness

- As per NCHRP, the modulus of rupture (MOR) for CTB may be taken as 0.69MPa, which corresponds to a minimum 28 days UCS value of 5.17MPa.
- The elastic modulus (in MPa) has been found to be 1000 to 1250 times the UCS value (in MPa) after 28 days of curing.
- However these multiplying factors are more appropriate for cement stabilized aggregates and not valid for all types of stabilized soil. For soils, it will be less depending on the type of soil and amount of cement added.

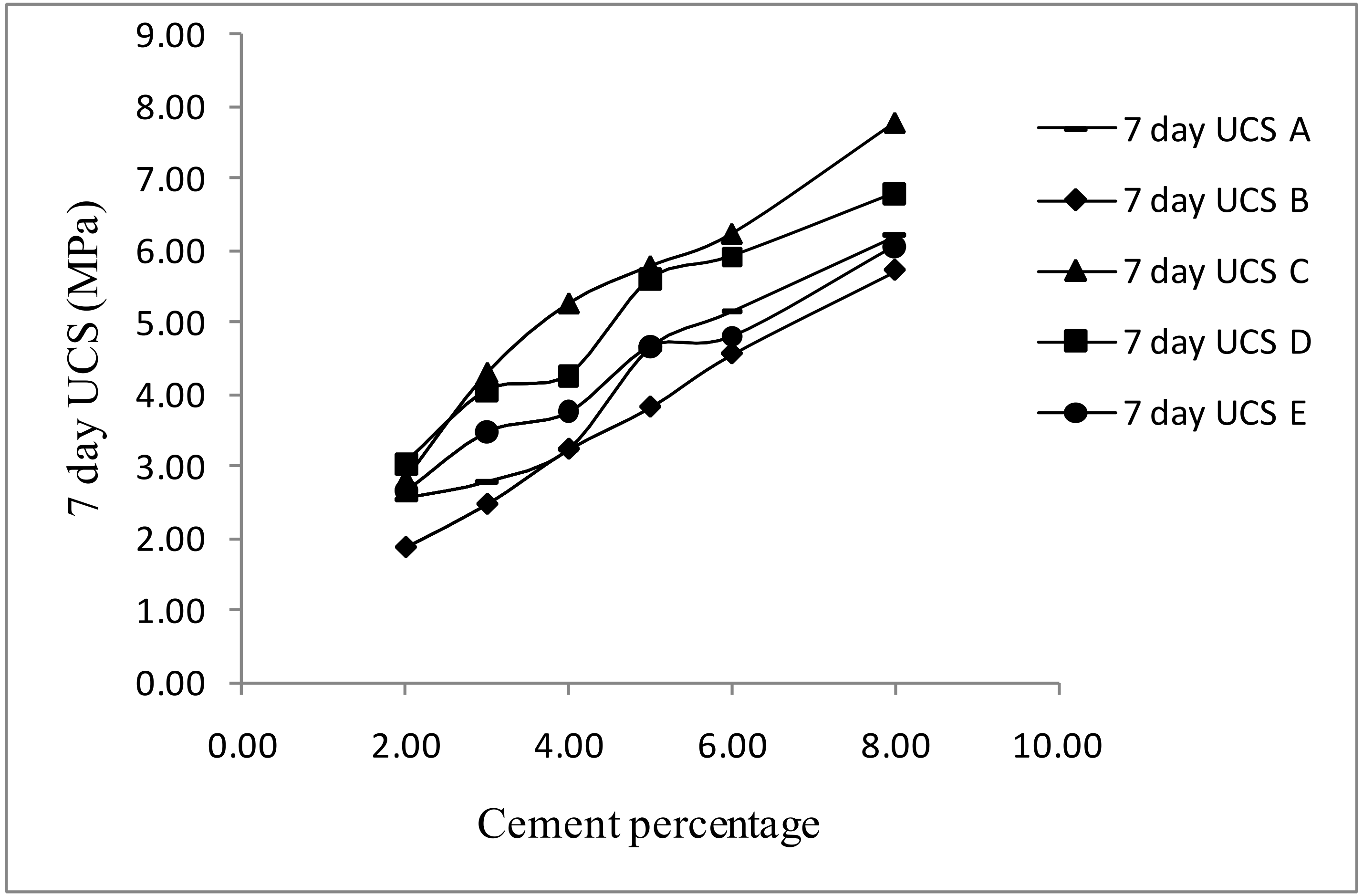
Mix Design- Cement Content

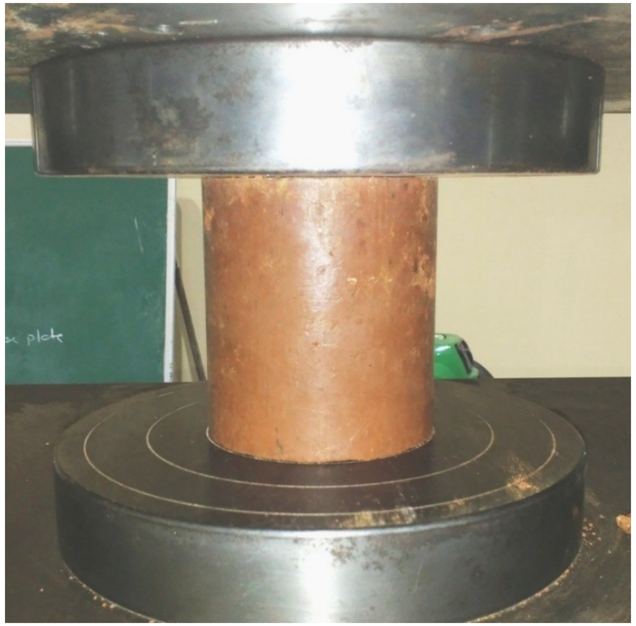
AASHTO soil classification	ASTM soil classification	Typical range of cement requirement, *percent by weight	Typical cement content for moisture-density test (ASTM D558), percent by weight	Typical cement contents for durability tests (ASTM D559 and D560), percent by weight
A-1-a	GW, GP, GM, SW, SP, SM	3 to 5	5	3-5-7
A-1-b	GM, GP, SM, SP	5 to 8	6	4-6-8
A-2	GM, GC, SM, SC	5 to 9	7	5-7-9
A-3	SP	7 to 11	9	7-9-11
A-4	CL, ML	7 to 12	10	8-10-12
A-5	ML, MH, CH	8 to 13	10	8-10-12
A-6	CL, CH	9 to 15	12	10-12-14
A-7	MH, CH	10 to 16	13	11-13-15

* Does not include organic or poorly reacting soils. Also, additional cement may be required for severe exposure conditions such as slope protection

(Source: ACI 230, 2009)

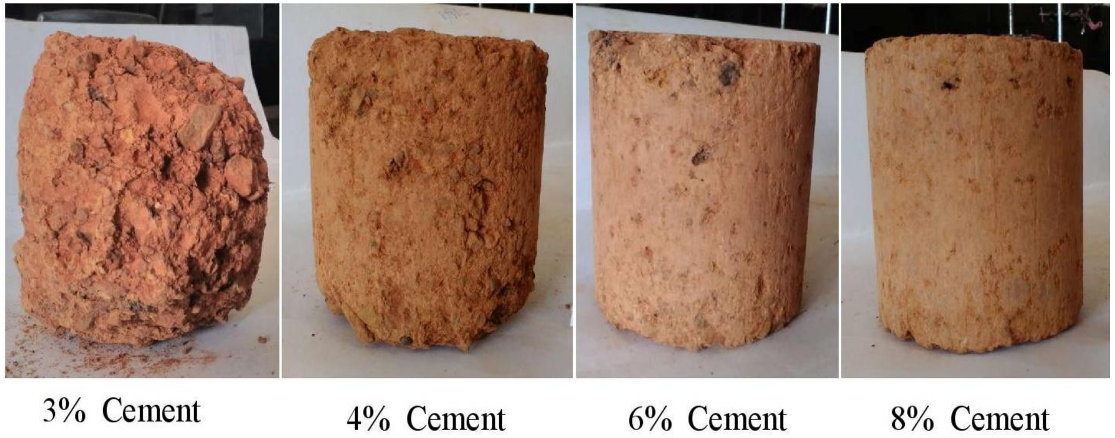
Unconfined Compressive Strength Test





Durability Test

- ASTM D 559 or AASHTO T135 :- Wetting and Drying (12 cycles of wetting and drying).
- Each cycle immersion in water for 5 hours followed by drying at 71 ^{0}C for 42 hours.
- After each cycle, the specimens are brushed with a wire brush. Loss in weight determined



Cement Stabilized Lateritic Soil Samples after 12 cycles of Wet-Dry & Brushing

Mix Design- Durability Requirement

AASHTO Soil Group	Unified Soil Group	Maximum Allowable Weight Loss (%)
A-1-a	GW, GP, GM, SW, SP, SM	14
A-1-b	GP, GM, SP, SM	14*
A-2	GP, GM, SC, SM	14
A-3	SP	14
A-4	CL, ML	10
A-5	ML, MH, CH	10
A-6	CL, CH	7
A-7	OH, MH, CH	7

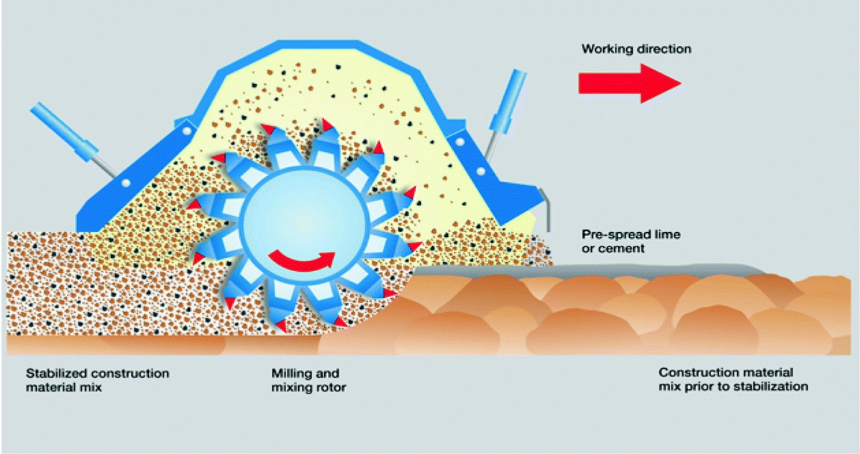
(Source: PCA, 1971)

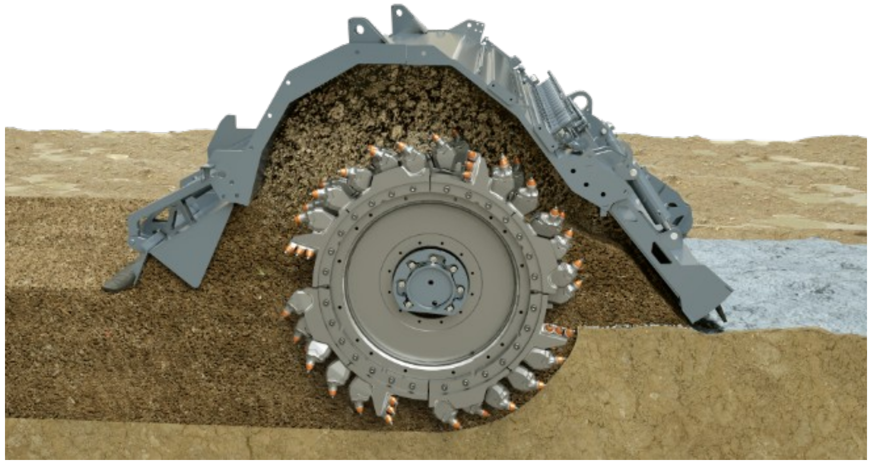
Construction Procedure

- The mixing procedures can be divided into two main groups:
  - Plant-mix stabilization
  - Mix-in-Place stabilization
- In-situ stabilization involves the following operations
  - Initial Preparation
  - Spreading of Stabilizer
  - Pulverisation and Mixing
  - Compaction and Finishing
  - Curing

Spreading of Stabilizer

In-situ mixing – Stabilizing Equipment





Compaction

Curing

Curing of the stabilised layers

Stabilized Surface after curing

Surface Dressing

- Two coat surface dressing is recommended as per the provisions given in IRC and MORD specification book as this works as a crack relief layer

Surface Dressing work at Site

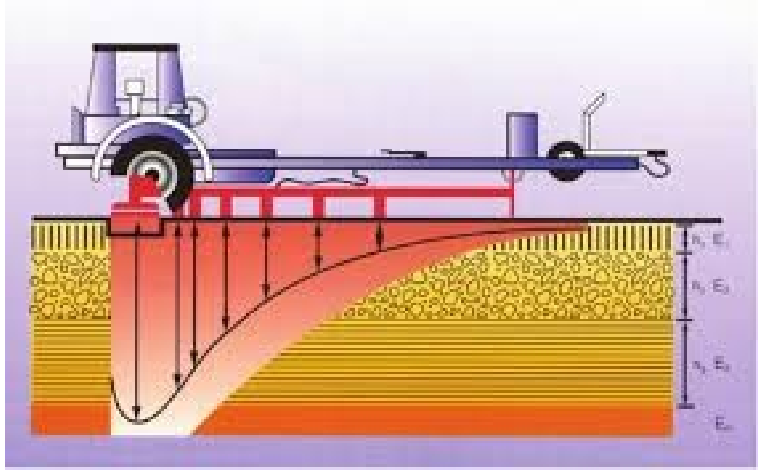
Quality control for Soil-cement base

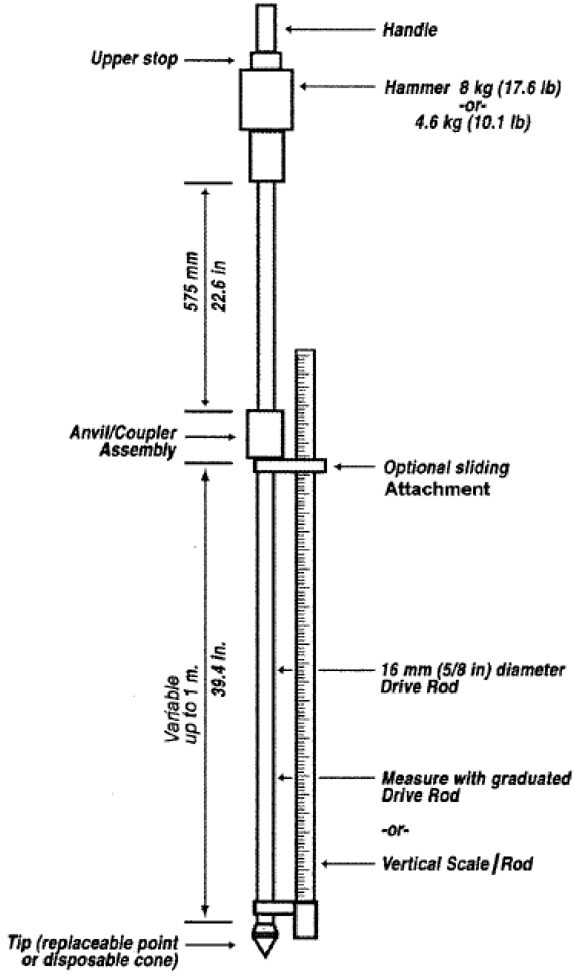
- Field Testing for quality checks during construction
  - Pulverization
  - Uniformity in mixing
  - Water content
  - Density
  - Cement content

Evaluation of Strength and Stiffness

- **Stiffness Evaluation**
  - Falling Weight Deflectometer (FWD)
  - Light Weight Deflectometer (LWD)
  - Soil Stiffness Gauge (SSG)
- **Field Testing for strength**
  - Dynamic Cone Penetrometer (DCP)
  - Mould casting
  - Core cutting

Evaluation of Strength and Stiffness





Reflection Cracking

- For controlling the reflection cracks, the following measures can be taken:
- Pre-cracking
- Provision of Stress Relief Layer
  - 50-100 mm Unbound Aggregate Layer
  - SAMI (Stress Absorbent Membrane Interlayer)
  - A geotextile fabric between the stabilized base and surfacing

Summary

- For sustainable development of Infrastructure there is a need to save the limited natural resources and increase reuse, recycling and reprocessing
- Stabilization of the soil and/or aggregates using cementitious materials for replacing the granular layers is a common ecofriendly practice in most of the countries to save the natural resources.
- Almost all types of soils/granular materials can be stabilized.
- Suitable Mix Design Should be carried out in the laboratory before application in the field.

Thank You