Full Depth Reclamation Symposium
Full Depth Reclamation with Cement Equipment and Process

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**Reclamation:**
the act or process of reclaiming restoration to use; recovery

**Recycling:**
to make something new from something that has been used before
to make ready for reuse
Cold Recycling Handbook

- Investigation of Roadway
- Design Process
- Types of Recycling
  - In Place
  - In Plant
- Stabilization agents
  - Bitumen
  - Cement
The WIRTGEN Cold Recycling Manual

With the Cold Recycling Technology Manual, WIRTGEN provides a comprehensive compendium on everything to do with the economically efficient and environmentally friendly rehabilitation method. The manual describes the methods and options of cold recycling, methods for analyzing existing pavement structures, as well as procedures for selecting suitable binding agents. The authors have also included many suggestions for practical implementation.

Cold recycling clearly explained from A to Z with practical application examples. Includes the newest research results on the use of bitumen for cold recycling with 80 new illustrations of cold recycling technology.

Please click here to open the hands-on manual as PDF file:

DOWNLOAD
4.2 Stabilising with cement

4.2.1 General

Cement is the most commonly used stabilising agent; its use worldwide far exceeds all other stabilising agents combined. The main reasons for this are cost and availability; cement is manufactured in most countries throughout the world and is relatively inexpensive. Another reason is its proven track record as a construction material. There is a plethora of standards, test methods and specifications available and cement stabilised layers have provided excellent service on thousands of kilometres of roads.

Cement stabilisation, however, requires a proper design approach. The primary function of cement addition is strength gain and the Unconfined Compressive Strength (UCS) has achieved global acceptance as the principal design criterion. However, several factors other than UCS need to be considered, such as the rate of strength gain, the Indirect Tensile Strength (ITS), cracking potential and durability issues. These are addressed in the following sections.

4.2.2 Factors affecting strength

The compressive and tensile strength achieved in a cement stabilised material is largely determined by the amount of cement that is added, the material type, the density of the compacted material and extent of curing. Strength generally increases in a linear relationship with cement content, but at different rates for different materials and cement type. Density plays a major role in determining the ultimate strength whilst ambient temperature directly affects the rate of strength gain; the higher the ambient temperature, the faster the rate of gain of strength.

Crystalline bonds start forming between particles as soon as cement comes into contact with water in the mixing process. Some of these bonds are destroyed when the material is compacted, thereby reducing the strength that can be achieved. In addition, such bonding has the effect of reducing the maximum density achievable. It is therefore important to expedite the placing and compaction operations and complete them as soon as possible after mixing, in order to achieve maximum density as well as obtaining the anticipated strengths from the compacted material.

This is particularly important where ambient temperatures exceed 40°C and where the material is prone to rapid strength gain (e.g. amorphous silica reaction). Under such conditions, an alternative stabilising agent to ordinary Portland cement should be investigated, such as blends of slag cement and/or lime, with a slower rate of strength gain. It should also be noted that the finer the cement powder, the faster the rate of cementation.

4.2.3 Cracking of cement stabilised layers

All cement-treated materials, including concrete, are prone to cracking. The rate of gain of compressive and tensile strength in cement stabilised material is a function of time, as shown in the sketch.

Tensile stresses develop within a cement treated material as a result of shrinkage and/or traffic and, if these exceed the tensile strength at that time, cracks occur.

\[ \text{Strength} = \frac{\text{time}}{\text{days, log scale}} \]

Note:
- The strength of cemented material generally increases linearly with cement content.

Strength/time relationship for cemented material

Such cracks can be controlled and are not necessarily detrimental. However, it is important to recognise that cement treated material tends to crack for two very different reasons. The first is caused by shrinkage that is a function of the chemical reaction that takes place when cement hydrates in the presence of water and is therefore not traffic induced. The second is caused by the repeated loading of traffic over a period of time. Crack initiation and subsequent propagation are entirely different processes, warranting that they be considered separately.
Recommended Construction Guidelines
For
Full Depth Reclamation (FDR)
Using Cementitious Stabilization
FDR102

01/27/2015

ARRA
Pre Construction Process

Evaluation
- Present conditions and use
- Future expected use

Investigation
- Current structure
- Materials present

Design Options
- Lab work
- Economic analysis

Process takes resources
Design = Construction Plan

- Design needs to be practical and obtainable in the field
- Design is the Benchmark
- Construction should mimic the design otherwise why have the design?
Consistent Inconsistencies

- Cement not spread accurately
- Water not spread accurately
- Materials mixed inconsistently
- Surface finished poorly
Cement
Cement

Start/Stops 18” depth
Cement

Application Higher than Design:

- Shrinkage Cracks
- During hydration process
- More rigid than desired
- Results in extra maintenance sooner
- Cracks larger at surface
Application lower than design:

Less strength for anticipated traffic

Structure will not bear traffic loads

Results in future base failures
XII. Construction Methods

- Spread uniformly length and width
- Calibrated, automated meters
- Application Rate within 0.20 percentage points of mix design

- 5% Design
  - Range of 4.8%--5.2%
Mounted and Towed “C” series

Streumaster Binding Agent Spreaders
Modern machinery for universal spreading applications
Streu Master Binding Agent Spreaders
Modern machinery for universal spreading applications

Dust separation filter

Electronic Regulation

Volumetric Dosing

Weightronic
Streumaster SW “C” series – Onboard Electronic

The high-precision binding agent spreaders

Sensor fitted to cardan shaft determines distance travelled

Radar unit determines distance travelled

PLC processes all information

Hydraulic valve for spreading quantity control

Spreading width

Distance travelled

Cardan shaft

Distance processed

Four load cells measure the weight
Streumaster SW “C” series – Onboard Electronic
The high-precision binding agent spreaders
Streumaster SW “C” series
The high-precision binding agent spreaders

3 x 2.67 ft

8 ft
Consistent Inconsistencies

- Cement not spread accurately
- **Water not spread accurately**
- Materials mixed inconsistently
- Surface finished poorly
XII. Construction Methods

- Water content will be monitored closely to ensure conformance within +/- 2% of optimum from design

- **Important to know in-situ material moisture**
  - Nuke gauge
  - Dry down
Water
Water Injection

- 16 injectors
- Microprocessor-controlled
- Precise accuracy
- Input desired %
- Ability to turn off individual nozzles
Consistent Inconsistencies

• Cement not spread accurately
• Water not spread accurately
• **Materials mixed inconsistently**
• Surface finished poorly
X. Equipment

- Ability to pulverize and mix to achieve 100% of reclaimed material mixture passes a 2” sieve
- Control depth of scarification
  - Depth of design is achieved
  - Sub-base materials are not disturbed
Recycler
Variable Volume Mixing Chamber

Larger Volume at High Depth
Variable Volume Mixing Chamber

Smaller Volume at Shallow Depth
Mixing Rotor

MILLING AND MIXING ROTOR FOR THE WR 250

Cutting tool arrangement precisely tailored to the performance of the WR 250

- Hard-wearing quick-change toolholder system
- Cutting tool arrangement at a tool spacing
  LA = 30x2 mm
- High, heavy-duty forged holder bases
- Large number of cutting tools for high mix quality at high advance rates
- Rotor especially suitable for tough cold recycling applications, such as pulverizing hard asphalt layers
- Interchangeable edge ring segments open at the sides
Mixing of materials

- Gradation in spec
- Materials thoroughly mixed
- Proper moisture content
Mixing of materials

Large gradation
Additive not mixed thoroughly
Low moisture level
Spread additive and recycle 8’ wide; same length in lane
Spread additive 4’ wide, recycle 8’ wide with 4’ overlap
Overlap Pass

Spreader half width

WR Injection System
Consistent Inconsistencies

- Cement not spread accurately
- Water not spread accurately
- Materials mixed inconsistently
- **Surface finished poorly**
Compact and Finish

- 15-20 ton pad foot compactor
- Vital for project success
- The greater the depth, the more critical
- Need growth curve--refusal
- Target >95% maximum lab density

- Complete within 2 hours of cement
- Do not over-work
- Remove loose wind row
Compaction

Double vibratory after blade
15 ton

Pneumatic 15-25 ton
Roll for smooth finish
Good Finish

- Maintain moisture
- Large material off the edge
- Pad foot dimples bladed out
- Slush roll completed with pneumatic
Finish

Materials not mixed uniformly
Poor Finish

Material dried out during finish

Pad foot dimples still present

Did not slush roll with pneumatic