NEW STABILISATION STANDARDS AND GUIDANCE

Steve Dunn
Britpave Soil Stabilization
New Stabilisation Standards and Guidance

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Documents Covered

- European Standard PrEN16907
- Britpave Guidance BP62
EN16907 - Earthworks

- Part 1 – Principles and Design
- Part 2 – Classification
- Part 3 – Construction Procedures
- Part 4 – Soil Treatment
- Part 5 – Quality Control
- Part 6 – Land Reclamation with dredged hydraulic fill
- Part 7 – Hydraulic Placement of Mineral Waste
Normative Sections

Contains 10 Normative Sections

0  Introduction
1  Scope
2  Normative References
3  Terms and Definitions
4  Symbols and Abbreviated Terms
5  Constituents
6  Mixtures
7  Laboratory Testing Methodology
8  Performance Classification
9  Execution and Control
Normative Sections

- Parts 0 to 4 Self explanatory
- Part 5 Constituents
  - Material
    - Soils
    - Weak and intermediate rocks
    - Recycled Materials
    - Artificial Materials
  - Binders
    - Cement EN197-1
    - Fly Ash EN 450-1 or EN 14227-4
    - Slag EN 15167-1 or EN 14227-2
    - HRB EN 13282-1 or EN13282-2
    - Lime EN 459-1
  - Water
  - Other Constituents
Normative Sections

- Part 6 Mixtures
- Part 7 Laboratory Testing Methodology
  - Feasibility
  - Workability
  - Characteristics for Improvement and Stabilisation
- Mechanical Performance
- Sample Preparation
Normative Sections

- Part 8 Performance Classification
  - Improvement
    - Immediate Bearing Index (IBI), French IPI (indice portant immediat)
    - MCV
    - Degree of Compaction
    - Swelling
  - Stabilisation
    - Site Based
      - Water Content
      - Pulverisation
      - IBI
      - MCV
  - Laboratory
    - CBR
    - Compressive Strength Rc
    - Tensile Strength Rt and Modulus of elasticity E
    - Other Characteristics, loss on immersion, swelling, frost resistance etc
Normative Sections

- Part 9 Execution and Control
  - Preliminary Engineering Check
  - Binders
  - Soil Treatment Plant types
  - Improvement
  - Stabilisation
  - Testing and Compliance
  - Climatic and Environmental
Informative Annexes

- Contains 15 Informative Annexes
- A Production of test specimens for treated materials
- B Loading Speed for strength and modulus tests
- C Non destructive seismic test method for mechanical performance
- D Example of evaluation of performance sensitivity of treated materials to laying dispersion
- E Examples of age of classification and curing regimes for mechanical performance of treated materials for earthworks
- F Additional performance characteristics for treated materials
- G Field and laboratory identifications of common sulfide and sulfate minerals
Informative Annexes

- **H** Soil Treatment Plant Types
- **I** Treatment Sequence and Processes
- **J** Other Applications for Stabilised materials
- **K** Soil Stabilisation Checklist
- **L** Safety Considerations
- **M** Climatic and environmental conditions
- **N** Examples of local guidelines of best practice
- **O** Method and charts to determine the quantity of lime needed to reach a targeted IPI value
EN16907

- Due for final approval and publication early 2018
Britpave Document BP62
Document BP/62

- Outline
- Scope
- What and Why?
- Where to Use?
- How
- Conclusion
Document BP/62

- A new technical and best practice guide
- Prompted by possible future withdrawal of HA74 Treatment of Fill and Capping Materials using either Lime or Cement of Both
- However, not a HA74 replacement as in addition to highway works it covers a wide scope of soil stabilisation
- Has been industry reviewed by the Britpave working group, Britpave soil stabilisation task group and members of BS 1924 BSI committee
Scope

- Concentrates on the use of binders to improve and stabilise clays and fine-grained soils

- Provides guidance on 3 main areas: What and Why? Where to Use? and How?
What and Why

- Explains what is soil improvement and soil stabilisation
- Typical Binders and Binder Standards
- Benefits
  - Engineered Material
  - Reduced Costs
  - Reduced Programme
  - Improved Sustainability
## Binders

<table>
<thead>
<tr>
<th>Binder</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime only</td>
<td>Used to dry out soils or to improve strength sufficiently to form capping layers. It is best suited to higher plasticity soils although it can be helpful on some granular soils. Additional strength development can be achieved using lime content in excess of a parameter called the initial consumption of lime (ICL). This is traditional ‘lime stabilisation’ and is now seldom used because it is less easy to control in the field compared with lime + cement. In soil improvement the lime content is below ICL.</td>
</tr>
<tr>
<td>Cement only</td>
<td>Suited to lower plasticity and granular soils to form higher strength mixtures. It does not dry out soils as well as lime.</td>
</tr>
<tr>
<td>Lime + cement</td>
<td>Commonly used to stabilise clays to a form higher strength and frost resistant mixes. Used where soils, principally clays, are unsuitable for treatment with cement only or need to be dried before stabilising.</td>
</tr>
<tr>
<td>Lime + ggbs</td>
<td>The strength development compared to lime + cement is slower but is suited to treating sulfate bearing soils to reduce the expansion risk. Ggbs needs additional lime content to act as an activator.</td>
</tr>
<tr>
<td>Lime + fly ash</td>
<td>This is a slower curing mixture and as such relies on the soil grading for stability under early trafficking. Siliceous fly ash is a pozzolanic material and requires a source of available calcium oxide, lime or cement to produce a hydraulic reaction.</td>
</tr>
</tbody>
</table>
Where to Use

- Wide Range of Construction Projects
- Earthworks
- Pavement Foundations
- Pavement Base
## Where to Use

**Fig 1:** Typical pavement cross section options showing where in-situ stabilisation could be used.

<table>
<thead>
<tr>
<th>Surface Course</th>
<th>Asphalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder Course</td>
<td>Asphalt</td>
</tr>
<tr>
<td>Base</td>
<td>Asphalt</td>
</tr>
<tr>
<td>Foundation</td>
<td>Unbound sub-base, or, Hydraulically bound mixtures such as CBGM, FABGM, SBGM or soil cement</td>
</tr>
<tr>
<td>Earthworks</td>
<td>Soil improvement (if required)</td>
</tr>
</tbody>
</table>

**Notes:**
1) Options for in-situ stabilisation highlighted in orange
2) CBGM = cement bound granular mixture.
3) FABGM = Fly ash bound granular mixture.
4) SBGM = Slag bound granular mixture.
5) RCC = Reinforced cementitious concrete.
How

- Ground investigation and its procurement
- Sampling on site for stabilisation design mix
- Site quality control procedure
- Plant
- Health and safety
- Environment
- Flow Charts
Ground Investigation & Sampling

Soil testing for organic matter, sulfates, sulphides and total potential sulfate (TPS) should be in accordance with the following:

<table>
<thead>
<tr>
<th>Organic matter</th>
<th>BS1377: Part 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water soluble (WS) sulfate content</td>
<td>TRL Report 447, Test No. 1</td>
</tr>
<tr>
<td>Oxidisable sulfides (OS) content</td>
<td>TRL Report 447, Test No. 2 and 4</td>
</tr>
<tr>
<td>Total potential sulfate (TPS) content</td>
<td>TRL Report 447, Test No. 4</td>
</tr>
</tbody>
</table>

Table 4: Soil testing

While the MCHW1 specifies test methods to EN 1744 for sulfates, TRL Report 447 methods are recommended as they are more effective at identifying TPS.

Limiting values of swelling due to the presence of sulfide and sulfate are defined through the swelling measured in accordance with the following soaked CBR tests:

<table>
<thead>
<tr>
<th>CBR</th>
<th>BS EN 13286-47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swelling</td>
<td>BS EN 13286-47</td>
</tr>
</tbody>
</table>

Table 5: CBR tests
Site Quality Control

- Recommended Quality Control procedure for stabilised materials. Extract below

Recommended quality control procedure for stabilised materials

1. Confirm soil properties before treatment are the same as assumed in the design. If changes are found then refer back to the designer.

2. Assess moisture content of material before treatment to adjust binder or water content if required

3. Check rate of spread of binder and adjust rate of spread if required or re-spread if insufficient binder has been added

4. Check mixing depth by hand dug trial holes and adjust and re-mix to the correct depth if necessary

5. Assess moisture content of mix after mixing – the mix should bind together and be homogeneous when moulded into a ball by hand. NDG gauge readings will provide a guide to moisture content. Take samples for laboratory moisture content testing to correlate with gauge readings. Where practical consider rapid methods for moisture content testing such as microwave oven for granular materials or MCV for cohesive materials and adjust water addition accordingly.

6. Check the pulverisation after mixing. This is important for cohesive materials, especially heavy clays, to ensure that the binder is well mixed. Multiple passes or a mellowing period can be required for some materials to break down. This should be determined from initial trials and replicated in the main works. Remix if satisfactory pulverisation is not achieved
Plant

- Advice is given on the type of plant that can be utilised
- Mixers, Binder Delivery, Storage, Spreading, Water Bowsers, Trimming and Compaction are all included.

britpave
The British Cementitious Paving Association
Flow Charts

A1 Phased project progress

- **Ground Investigation**
  - Desk study of known geology / site history
  - Identify opportunity & risks for stabilisation of material expected
  - Scope up ground investigation to include specific sulfate & contamination tests for each material (STDS Ref) – guide on sample frequency
  - Note presence of gypsum crystals / sulfate crystals and/or contamination (experienced geotechnical / materials engineer required)

- **Pavement / Platform Design / Materials Improvement**
  - Purpose / load / sequence / programme / trafficking during construction & permanent use
  - Single layer (subbase) versus two layers (capping & subbase)
  - Utilising site arising materials & imported aggregates
  - Highways IAN 73 Foundation Class (STDS Ref)

- **Mix Design**
  - Each geology / material type – type test
  - Target worst case geology / sulfate / organic levels for robust mixture design
  - Consider material / Layer Strength / Stiffness required
  - Binder choice slow / fast cure
  - Sulfates
  - Programme / sequence / cost
  - PI >10 normally required
  - PI <10 suitable for treatment without lime
  - PI >20 consider lime + cement combination where higher strength required for sulfate bearing soils consider lime + GGBS
Flow Charts

A1 Phased project progress

- **Laboratory Trials**
  - Improvement/Modification
    - MC/MCV before
    - Add binder – mellowing period
    - MC/MCV after
    - Check swell – soak for 28 days where risk of sulfates is identified
  - Binder content range
    - Minimum of three binders
    - Contents to plot performance
  - Simulate mellowing periods / time between two binders & assess pulverisation
  - Early age strengths to establish trends
  - Correlate simple site tests e.g. cube strength or CBR to stiffness to enable routine monitoring during main works

- **Site Trials**
  - Repeat chosen mixture from laboratory trials
  - Assess mixing & pulverisation of material methodology (single paste? / type of plant / mellowing period)
  - Assess compaction plant size / type of output
    - Check compaction/insitu air voids & verify compaction regime
    - Consider PTR for surface finish & early trafficking
  - Where imported aggregate treated over clay allow extra depth of aggregate as buffer to avoid contamination from below

- **Compliance Monitoring**
  - Methodology approved from site trials, repeat if anything changes
  - Feedstock checks where required:
    - PI, PSD, sulfates
  - Protection of the works from:
    - Weather, trafficking, interface with follow on activities
    - Sequencing / temperature protection
    - Possibly build a stronger layer if required
  - Compliance testing:
    - LWD or FWD for pavement
    - Layer strength/stiffness or bearing ratio for mixed material
    - Wet density – target
## A2 Design testing requirements for material sourced off-site

### Lime Modified and Stabilised

<table>
<thead>
<tr>
<th>Test at Hydraulic Binder Addition</th>
<th>Test Reference</th>
<th>Modified / Improved</th>
<th>Stabilised</th>
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<tbody>
<tr>
<td>MCV</td>
<td>EN13286-46</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Moisture Content</td>
<td>EN 13286-2</td>
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<td>x</td>
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<tr>
<td>Pulverisation</td>
<td>EN 13286-48</td>
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<td>x</td>
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<tr>
<td>Bearing Ratio (CBR)</td>
<td>EN 13286-47</td>
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<td>x</td>
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<tr>
<td>Swell</td>
<td>EN 13286-48</td>
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<tr>
<td>Moisture Content</td>
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<td>x</td>
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<tr>
<td>Insitu Density</td>
<td>BS1924-2 or BS1377 Part 9</td>
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<tr>
<td>Frost Heave Test</td>
<td>BS1924 Part 2</td>
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<td>*x</td>
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* If in the frost zone normally 450mm
# Flow Charts

## A2 Design testing requirements for material sourced off-site

<table>
<thead>
<tr>
<th>Hydraulically Bound Materials</th>
<th>HBM</th>
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<tr>
<td><strong>Test</strong></td>
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<td>Water Content</td>
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<td>Grading Aggregates</td>
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<td>Grading Soils</td>
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<td>Plasticity</td>
<td>EN 13286-47</td>
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<td>Mixture Grading incl Binder</td>
<td>EN933-1</td>
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<td>Water Content at Final Compaction</td>
<td>BS1924-2</td>
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<td>*MCV at mixing and final Compaction</td>
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<td>Pulverisation</td>
<td>EN13286-48</td>
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<tr>
<td>Spread Checks</td>
<td>Sub-Clause 870.3</td>
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<tr>
<td>Depth of Mixing for 'Mix in Place' at each stage of the mixing process</td>
<td>Sub-Clause 870.4</td>
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<tr>
<td>In-situ Wet Density</td>
<td>Sub-Clause 870.5</td>
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<td>Laboratory Mechanical Performance</td>
<td>As Required by Table 8/15</td>
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<td>Strength After Immersion</td>
<td>Subclause 880.4</td>
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<td>LWD</td>
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* Cohesive Mixtures Only
### A3 Design testing for site won materials treated with lime and/or hydraulic binders

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<th>Standard</th>
<th>Lime Fill</th>
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</tbody>
</table>

* If Compressive Strength is less than C2.3/3 at 28 days

# Lime Only Capping (15% CBR Max)
Conclusion

With its full set of project progress flowcharts, data on testing requirements and comprehensive further reading bibliography, this new guide aims to be what one member of the Britpave Working Group described:

“The type of guide that I wish was available when I first started out in this industry.”
Conclusion

Any Questions?