Materials Testing and Quality Assurance

The Role of the Resident Engineer

Liam Geoghegan MSc
Introduction

- Liam Geoghegan, RPS Consulting Engineers
- Experience in Road Construction Projects since 1991
- I have worked for Local Authorities, Consulting Engineers & Contractors
- Managed Material Testing laboratories on Motorway Construction Projects
- Since 2005 I have been employed mainly as a Senior Designer’s Site Representative on D&B & DBFO Projects in the ROI and Northern Ireland
The Aims of this Presentation

- Provide an overview of the testing and QA regime for Road Construction Materials
- Highlight the importance of Quality & Testing
- Identify testing normally carried out on site
- Responsibilities of the Resident Engineer
- Typical issues that may arise on site
- Suggest things we could do better
Parts of the Specification that are relevant to the talk

- NRA MCDRW Volume 1 - Series 100
- Clause 104 - Standards, Quality Assurance Schemes, Agreement Certificates and Other Approvals
- Clause 105 - Goods, Materials, Sampling and Testing
- NRA MCDRW Volume 2
- Appendix 1/5 – Testing to be Carried out by the Contractor
- Appendix 1/24 – Quality Management Schemes
- Appendix 1/25 – Product Certification Schemes
Quality Management System

Key Elements of ISO 9001

- ISO 9001 is based on the PDCA cycle – Plan-Do-Check-Act and its key elements are:
  - Establishing the quality management system
  - Documenting the system
  - Implementing the system
  - Reviewing the results
  - Maintaining the system
  - Improving the system.
Sometimes the Test Method used on Site is not the most scientific.
Components of Site Quality Management System put in place by a contractor

- Quality Management System
- Quality Management Plan
- Process and Procedures manual
- Inspection and Test Plan
- Method Statements
- Material Testing
- Supervision & Monitoring
- Records
- Checks and balances that will be in place
- Safety File and Operation manuals
Material Testing - General

Design Requirements are detailed in the specification and rates of testing required are detailed in the relevant appendices.

Testing carried out in suitably accredited laboratories (INAB, UKAS)

Testing will be carried out by competent and suitably trained personnel.

Are the materials the subject of a contractor submission or subject to a product certification scheme. (Supplied at least 4 weeks before use).

Test reports will be provided to the resident engineer (within 24hrs of completion).
Common Issues that arise

- Materials fail to comply with the specification requirements
- Tests are not carried out to specified frequencies
- Test results are not available in a timely manner
- Damage occurs to materials after they have been placed on site
- Incomplete QA Records
- Inspections on site do not support test results
- The material is not performing correctly on site
- Test certificates are incomplete
- Commercially Sensitive Issues
Roadbuilding Materials

Earthworks Materials (Soils, Rockfill)
Drainage (Filter Materials, Beddings)
Pre Cast Elements
Pavement Materials
Structural Concrete & Reinforcement
Imported and Site Won Aggregates (Cl. 804)
Questions the Resident Engineer needs to consider

1. Who carries out the Testing
2. The Frequency of Testing required
3. Is an INAB certificate required
4. What are the appropriate limits for acceptability
5. Storage of samples
6. Curing of samples
7. Interpretation of test results
8. Reporting
9. What is the appropriate action if test failures are recorded
   • Retesting
   • Remedial action
   • Reworking of materials
   • Removal of non compliant materials
Common Materials with Product Certification or Quality management Systems

Manhole Chambers and Covers
Drainage Pipes
Gullies
Road studs
Road marking products
Deck waterproofing
Safety Barriers
Drainage pipes
Concrete repair products
Waterproofing materials
Fencing materials
Parapet Systems

If not provided by the contractor the resident engineer should request copies of the appropriate documentation to show compliance
Material Testing & Monitoring

**Testing**
- Site Testing
- Source Approval
- Testing to the required frequencies
- Representative Sampling
- Test results reported in a timely manner
- Suitably qualified staff and laboratory

**Supervision**
- Inspections
- Trafficking of the works
- Weather Protection
- Management of materials
- Compliance to the specification requirements
- Locations being recorded accurately, date, time, source etc.
Earthworks Requirements

- Series 600 of the Specification for Roadworks
- Table 6/1 shows required properties
- Table 6/2 shows required properties
- Table 6/4 shows the required compaction method
- Appendix 1/5 – Testing to be carried out by the Contractor
- Appendices to Series 600
Table 6/1 (Continued): Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes)

<table>
<thead>
<tr>
<th>Class</th>
<th>General Material Description</th>
<th>Typical Use</th>
<th>Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)</th>
<th>Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)</th>
<th>Compaction Requirements in Clause 612</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Property (See Exceptions in Previous Column) Defined and Tested in Accordance with Acceptable Limits Within:</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(g) grading BS 1377: Part 2 Tab 6/2 Tab 6/2 Tab 6/1 Method 2 z B *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dry cohesive Material</td>
<td>General Fill</td>
<td>Any material or combination of materials.</td>
<td>(ii) plastic limit (PL) BS 1377: Part 2 - -</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(iii) mc BS 1377: Part 2 App 6/1 PL - 4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Stony cohesive material</td>
<td>General Fill</td>
<td>Any material or combination of materials.</td>
<td>(iv) MCV Clause 632 App 6/1 App 6/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>(v) undrained shear strength of remoulded material Clause 633 App 6/1 App 6/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(g) grading BS 1377: Part 2 Tab 6/2 Tab 6/2 Tab 6/1 Method 2 z C *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(ii) mc BS 1377: Part 2 App 6/1 App 6/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(iii) MCV Clause 632 App 6/1 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(iv) Undrained shear strength of remoulded material Clause 633 App 6/1 -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6/2: Grading Requirements for Acceptable Earthworks Materials

<table>
<thead>
<tr>
<th>Class</th>
<th>Size (mm)</th>
<th>Percentage by Mass Passing the Size Shown</th>
<th>Size (microns) BS Series</th>
<th>Size (microns) BS Series</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500</td>
<td>300</td>
<td>125</td>
<td>100</td>
</tr>
<tr>
<td>1A</td>
<td>100</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>100</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1C</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>2A &amp;</td>
<td>2100</td>
<td>40</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2C</td>
<td>100</td>
<td>15</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>2D</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>6A</td>
<td>100</td>
<td>15</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>6B</td>
<td>100</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6C</td>
<td>100</td>
<td>15</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>6F1</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>6F2</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>6F3</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>6H</td>
<td>100</td>
<td>60</td>
<td>100</td>
<td>15</td>
</tr>
<tr>
<td>6I &amp;</td>
<td>100</td>
<td>85</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>6J</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6K</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6L</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6M</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6N</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>6P</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>7I</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Footnote to Table 6/2:

For the purposes of classifying materials, the gradings specified in this table, with the exception of 1C, 6A and 6B materials, apply to the portion of the material passing the 125 mm BS Sieve.
# Table NG 1/1 Typical Testing Details

<table>
<thead>
<tr>
<th>Clause</th>
<th>Work, Goods or Material</th>
<th>Test</th>
<th>Frequency of Testing</th>
<th>Test Certificate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series 600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>601</td>
<td>Acceptable material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>631 to 633</td>
<td>Class</td>
<td>General Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>635 to 637</td>
<td>1</td>
<td>General granular fill</td>
<td>Twice a week*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>640</td>
<td>1C only</td>
<td>10% fines value (IL)</td>
<td>Weekly*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>General cohesive fill</td>
<td>Twice a week*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>mc/MCV/PL</td>
<td>2 per 1000 m³ up to max of 5 per day*</td>
<td></td>
<td>[Cross reference should be made to any requirements in Appendix 6/1]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undrained Shear Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Landscape fill</td>
<td>Grading/me/MCV (IL)</td>
<td>Daily*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Topsoil</td>
<td>Grading</td>
<td>Daily*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Selected granular fill</td>
<td>Grading/uniformity coefficient</td>
<td>1 per 400 tonnes*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PI (IL)</td>
<td>Daily*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% fines value (IL)</td>
<td>Weekly*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OMC/me/MCV (IL)</td>
<td>1 per 400 tonnes*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>601</td>
<td></td>
<td>Organic matter/water soluble sulphate content (IL)</td>
<td>Weekly*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>631 to 633</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Earthworks

Material Classification
- Site Investigation Data
- Trial Pits

On going Site Testing
Frequencies stated in Appendix 1/5
Tests in accordance with BS 1377

Compaction testing
- Method Compaction or End Product Compaction
- Nuclear Density Testing

Visual Assessment and Records
- Setting Out Data
- Monitoring Data
- Settlement Data
Earthworks Classification Testing

Criteria set out in table 6/1 if the SRW

Class 1 - General Granular Fill
Class 2 – General Cohesive fill
Class 4 – Landscape Fill
Class 5 – Topsoil, turf
Class 6 – Selected Granular Fill
Class 7 - Selected Granular Fill

Compaction requirements

Grading requirements are stated in Table 6/2 of SRW
Common On Site Testing

- Moisture Condition Value (MCV)
- California Bearing Ratio (CBR)
- OMC v MDD
- Gradings (PSD)
- Liquid and Plastic Limits
- Plate Bearing Tests
- Shear Strengths
Common Problems Associated with Earthworks

1. Moisture
2. Trafficking
3. Rutting
4. Drainage Issues
5. Compaction
6. Soft Areas
Things to look out for

- Is there adequate Compaction Plant Available
- Layer Thicknesses
- Oversize materials
- Is the underlying Material Suitable to receive Fill
- Compaction Monitoring
- Weather Conditions
- Profiled to shed water
- Supervision Levels
- Record Keeping
- Samples Taken
- Lab on site
Granular Materials

- Source Approval
- PSD Testing
- Plasticity Testing
- Sub-formation Testing
- Compaction Testing
- Site Inspections
- Moisture Control
- Level and Profile Checking
- Proof Rolling
- Soft Area Identification
- Protection Measures
Concrete shall conform to the requirements of I.S. EN 206 – 1

Tested to BS EN 12390-3:2009
Cured to BS EN 12390-2:2009
Density to BS EN 12390-7:2009

Details of the design mixes required are contained in Appendices to Series 1700 of the Specification

- Location
- Strength Class
- Types of Aggregates
- Sulphate Class
- Cement Type
- Exposure Class
- Chloride Class
- Min Cement Content
- Max Water Cement Ratio
- Rate of Sampling (Appendix 1/5)
- Slump Class
- Any other Requirements
Certification of the Concrete Plant Quality Management System to produce compliant concrete to BS EN 206 Part 1 & BS 8500

Submission will include
Constituent Sources
Design Mix details
Aggregate tests
- Gradings
- Flakiness Index
- Particle Density
- Water Absorption
- Los Angelus Co-efficient
- Cement Type & Certs
- Water tests
- Historical Test results
Concrete Testing

- Concrete Cubes
- Slump Testing
- Pour Records
- Dockets
- Concrete Temperature
- Air temperature
- Delivery Times
- Vibration Plant
- Plant Records
Main Tests Carried out on Concrete

Concrete Cubes (Strength)  Slump Testing (Workability)
Common Problems Associated with Concrete

Concrete Finishes
Cracking
Voids
Cold Joints
Cube Strength Failure
Curing issues
Heat Loss / Frost
Protection
Sampling
Curing and storage of Cubes
Detailed Records
Vibration Issues
Steel Reinforcement

Steel shall be obtained from a firm holding a valid CARES certificate (or fully equivalent scheme)

- Storage on site
- Tying Wire
- Links
- Bar mark Inspections
- Surface Contamination
- Correct Cares mark
Pavement Materials
Bituminous bound materials

**Clause 901 - General**

Bituminous Mixtures shall be produced in plants that are independently accredited to ISEN 9001 or equivalent quality management system

Certificate of Factory Production Control
Contractor Submission and Method Statement

- Method Statement
- Inspection & test plan
- Source of Supply
- Certification
- Aggregate Tests
- Binder Certificates
- Compaction Plant to be used
- Laying records
- Joint Patterns
- Technical sheets for compaction plant
- Temperature Monitoring
Bituminous Pavement Materials

Pavement Design requirements are contained in Appendix 7/1

• Required materials
• Thicknesses

Series 900 of the Specification for Roadworks

Relevant British Standards

Method Statements

BBA Certificates
Tests on constituents of the bituminous mixtures are submitted prior to commencement of works on site

QMS to ISO 9001:2008 (NSAI)

Certificate of Factory Production Control Procedures.

Appendix 1/5 will specify the frequencies at which tests are to be carried out on site

Off Site - Binder Content & Grading, PRD, binder Penetration

On Site - Sand Patch, Rolling Straight Edge Testing, Coring, Temperature
Sand Patch Testing

Surface Texture Measurement

Rate of spread of chippings and temperature of the mix are important issues on HRA

Carried out over a 50m length with the average diameter of 10 determinations being used to calculate the surface texture

Requirements detailed in Clause 921 of SRW and Table 9/14

There are alternative methods available but this is the definitive test
Compaction Testing

- Percentage Refusal Density
- Cores or Nuclear Density Meter
- Cores taken on site to form a correlation
- Battery operated monitoring systems
- Rollers have inbuilt compaction management software
Rolling Straight Edge used to check surface regularity

Requirements are detailed in Series 700 of the Specification for Roadworks

Allowable Number of Deflections are detailed in Table 7/2
Things to look out for

- Inspection & Test Plan
- Detailed Laying Records
- Delivery Dockets
- Cleanliness
- Rolling temperatures
- Level Control – dipping Surveys
- Roller Marks
- Temperature Monitoring
- Compaction Testing
- Tack Coat / Bond Coat
- Layer Thickness
What can we do better

Ensure that the required tests are detailed in Appendix 1/5

Apply common sense approach to some testing frequencies. More is not always better

Ensure that Sampling / Testing is carried out by suitably trained personnel using the correct equipment

Highlight materials issues as soon as they become known.

Training is a key component and resident engineers should be provided with support mechanisms

Instruct additional testing where required

If in doubt............... ask!!!!