

Materials Testing and Quality Assurance

The Role of the Resident Engineer

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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

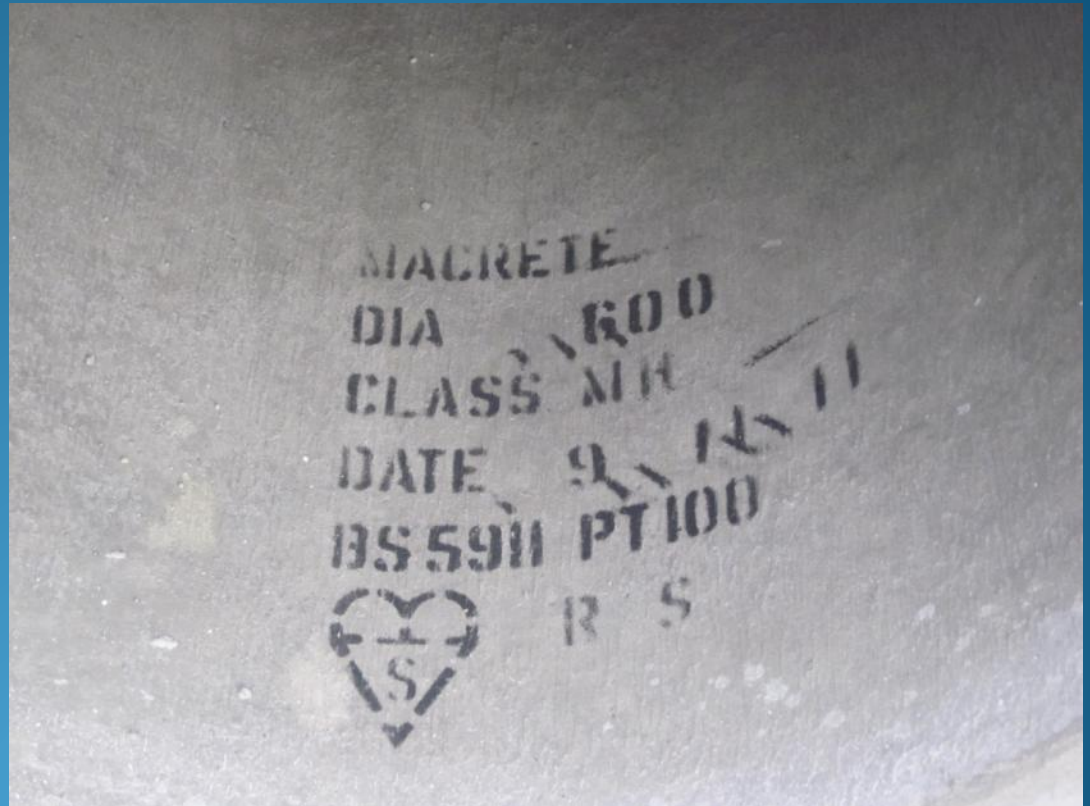
Concrete repair products

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)

Class	General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class		
				Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:					
						Lower	Upper				
G E N E R A L C O H E S I V E F I L L	2 B - Dry cohesive Material	General Fill	Any material or combination of materials.	(i) grading	BS 1377: Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 2	2	B	-
				(ii) plastic limit (PL)	BS 1377: Part 2	-	-				
				(iii) mc	BS 1377: Part 2	App 6/1	PL -4%				
				(iv) MCV	Clause 632	App 6/1	App 6/1				
				(v) undrained shear strength of remoulded material	Clause 633	App 6/1	App 6/1				
2 C - Stony cohesive material	General Fill	Any material or combination of materials.	(i) grading	BS 1377: Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 2	2	C	-	
			(ii) mc	BS 1377: Part 2	App 6/1	App 6/1					
			(iii) MCV	Clause 632	App 6/1	-					
			(iv) Undrained shear strength of remoulded material	Clause 633	App 6/1	-					

Table 6/2: Grading Requirements for Acceptable Earthworks Materials

Class	Percentage by Mass Passing the Size Shown																				Class	
	Size (mm)		Size (mm) BS Series													Size (microns) BS Series				Size (microns)		
	500	300	125	100	75	37.5	28	20	14	10	6.3	5	3.35	2	1.18	600	300	150	63	2		
1A		100	100																	0-15	1A	
1B			100																	0-15	1B	
1C	100		10-95																0-25	0-15	1C	
2A & 2B			100											80-100						15-100	2A & 2B	
2C			100											15-80						15-80	2C	
2D			100																	80-100	0-20	2D
6A	100									15-85										0-30	0-5	6A
6B	100		0-10																			6B
6C			100							15-85										0-30	0-10	6C
6F1			100		65-100	45-100				15-75	10-60									0-30	0-15	6F1
6F2				100	65-100	45-100				15-75	10-60									0-30	0-10	6F2
6F3			100		65-100	45-100				15-95	10-70									0-45	0-15	6F3
6H								100						60-100		15-45			0-25	0-5		6H
6I & 6J			100		85-100					25-100						15-100			9-100		0-15	6I & 6J
6K								100													0-10	6K
6L											100		89-100		60-100	30-100	15-100	5-70	0-15 except 0-20 for crushed rock			6L
6M					100																0-10	6M
6N				100	65-100	45-100				15-75	10-60									0-30	0-15	6N
6P			100		65-100	45-100				15-75	10-60									0-30	0-15	6P
7I			100											15-80							15-80	7I

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

Clause	Work, Goods or Material	Test	Frequency of Testing	Test Certificate	Comments
Series 600					
601 631 to 633 635 to 637 640	Acceptable material	Class	General Description		
		1	General granular fill	Grading/uniformity coefficient	Twice a week*
			1C only	10% fines value (IL)	Weekly*
	2	General cohesive fill	Grading	Twice a week*	
			mc/MCV/PL Undrained Shear Strength	2 per 1000 m ³ up to max of 5 per day*	<i>[Cross-reference should be made to any requirements in Appendix 6/1]</i>
	4	Landscape fill	Grading/mc/MCV (IL)	Daily*	
	5	Topsoil	Grading	Daily*	
	601 631 to 633	6	Selected granular fill	Grading/uniformity coefficient	1 per 400 tonnes*
				PI (IL)	Daily*
				10% fines value (IL)	Weekly*
OMC/mc/MCV (IL)				1 per 400 tonnes*	
		Organic matter/water soluble sulphate content (IL)	Weekly*		

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



Reinforced Concrete Materials

Concrete

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



Contractor Submission

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



Main Blacktop Tests

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!!!!**

