DRMS CORDLESS

Automatic system for determining the Drilling Resistance of stone materials and mortars
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DRMS Cordless – Main Features

- Developed for both **laboratory** tests and **outdoor** applications with integrated power battery for a good autonomy
- Measures the **Force** necessary to drill the material
- The mean value of the Drilling Resistance can be correlated with the Uniaxial Compression Strenght (UCS)
- Works at **constant operating conditions**: Rotation speed (20-1000 RPM) and Penetration rate (5-80 mm/min)
- **Records** the resistance profile of the first layer of a stone material (up to 50 mm depth)
- Enable quantification of the consolidating effect and the determination of the penetration depth of the consolidating product
DRMS Cordless – Additional Features

- **Fully portable** and stand-alone system for site measurements
- Battery operated (14 V)
- **USB** connection between the electronic microdrilling device and the laptop computer
- **Load cell** for the drilling force measurement (Max. Force 100N)
- Special **diamond drills** are used to minimize the wear effect. The standard drill diameter is 5 mm.
- Developed under the DIAS European Project
Story of Equipment

First prototype is dated 1994

Old version - Hardrock Project

On-site tests with old system

Mechanical Upgrade (Force and Torque)

Electronic Upgrade
Story of Equipment

Development under *DIAS European Project*
DRMS Cordless – Advantages & Key Features

✓ Allows **direct measurements** of the Drilling Force during the drilling operation
✓ Metrologic Traceability: the Drilling Force is calibrated against a Load Cell
✓ Allows **detailed information** about the variation of the material strength with **depth**
✓ Evaluation of consolidating treatments, in terms of depth and strength
✓ Possibility to perform drilling tests in **any direction**
✓ Abrasivity effect reduction with special diamond drills
✓ Abrasivity effect correction
✓ **Light** (5.5 kg), easy to use in scaffolding
## DRMS Cordless – Advantages & Key Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Unit</th>
<th>Min.</th>
<th>Max.</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotational speed</td>
<td>rpm</td>
<td>20</td>
<td>1000</td>
<td>Maintained constant during drilling</td>
</tr>
<tr>
<td>Penetration rate</td>
<td>mm/min</td>
<td>1</td>
<td>80</td>
<td>Maintained constant during drilling</td>
</tr>
<tr>
<td>Force</td>
<td>N</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>mm</td>
<td>0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Drill bit diameter</td>
<td>mm</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Drill bit type</td>
<td></td>
<td></td>
<td></td>
<td>Diamond</td>
</tr>
<tr>
<td>Monopod height</td>
<td>mm</td>
<td>800</td>
<td>1600</td>
<td></td>
</tr>
<tr>
<td>Battery power supply</td>
<td>Vdc</td>
<td></td>
<td>Typ 14,4</td>
<td></td>
</tr>
<tr>
<td>Tablet Pc</td>
<td></td>
<td></td>
<td>Optional</td>
<td></td>
</tr>
</tbody>
</table>

**Weight:** 5.5 kg
Evaluation of Consolidating Treatments

EVALUATION WITH DRMS

Operating conditions:
- Rotation Speed: 600 RPM
- Penetration Rate: 40 mm/min
- Depth: 10 mm
- Drill Bit: 5 mm - diamond

CONSOLIDATING TREATMENT

Product: FLUORMET CP - 2.5% Solution in Acetone (Blend of Fluoroelastomer and ethyl methacrylate -co-methyl acrylate)

Application: Brush

Time: Until refusal (50-80 g/m2)
# On-site Evaluation of Consolidating Treatments

<table>
<thead>
<tr>
<th>Material</th>
<th>Consolidating Product</th>
<th>Application mode</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decayed Marble</td>
<td>Lime water + Saturated solution of ammonium oxalate</td>
<td>Arbocel BC 200 pack 2 of Arbocel BC 1000 + 1 of Arbocel BC 200 pack</td>
<td>10 days 16 hours 2nd applicat. After 1 week</td>
</tr>
</tbody>
</table>

- Heavy decayed fragment of a marble column
- Abbey of Badia a Passignano - Italy
- Before treatment
- After treatment

Abbey of Badia a Passignano - Italy
Drilling Capability in Any Direction

Drilling Up

Drilling Down

Horizontal Drilling
Abrasivity Effect with Widia Drills

Source: DIAS web site: http:\server.icvbc.cnr.it/drilling/index.htm
Abrasivity Effect Reduction with Diamond Drills

Polycrystalline diamond plates inserted at the tip of end mills minimize the effect of abrasivity.

**Widia end mill**

**Diamond end mill**
Abrasivity Effect Correction

The proposed methodology is suitable to correct drilling data affected by progressive wear of the drill bit tip in abrasive stones.

Source: J. Delgado Rodriguez, D. Costa.

Original Data: BSCO (Snethlage & Kocher)
DRMS Cordless – Software Features

- The main graphical interface of the program is a large toolbar that makes easier its use with a tablet computer with touchpad screen.
- The toolbar contains few and essential buttons that are sufficient to completely manage the drilling resistance test.

TEST CONFIGURATION:
The user can choose between two setup types:

a) Partial Setup and
b) Full Setup
The **partial setup** format contains the lowest number of information needed to manage the test:

a) Destination Path, File Name and 
b) Nominal Hole Depth

The **full setup** format contains all the information needed for DRMS compatibility and for test storing.
Software – Test Configuration

File Name

Decay State

Treatment Choice

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**MONITOR**: starts off-line acquisition mode. This feature is useful to verify sensors signals before starting test procedure. The listed signal measurements are shown while monitor is on:

- Depth [mm]
- Force [N]
- Revolution Speed [RPM]
- Penetration Speed [mm/min]
Software – Additional Pushbuttons

**SET ZERO REFERENCE**, while ‘MONITOR’ is on: with this button it is possible to zeroing force and depth signal

**START DRILLING TEST**: this button allows user to start test. The user can follow the whole test on graphical interface where are placed real time acquired signals and drilling resistance curve (see below)

**DEMO MODE**: enable demo mode functionality. If demo mode is on (pressed) acquiring procedure are simulated and data readings are derived from a standard test on ARS specimen. (demo mode does not require drilling cordless system connection)

**ABORT / EXIT ACQUISITION MODE**: this button allows user to abort drilling test. It is also used to stop signal monitoring in off-line mode

**EXIT**: this button closes the program
Software – Control Panel

Control Panel during the test

Control Panel at the end of the test
Software – Test Elaboration

TEST ELABORATION:

- Pressing this button, the elaboration window is opened
- The user can retrieve, plot, compute and compare all data acquired during the drilling resistance tests
Software – Test Elaboration
Software – Averages

AVERAGE CURVES

Force [N]

0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00

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Test Results – ARS (Artificial Reference Stone)
Test Results – Mortars

[Graph showing test results for mortars, with force in Newtons plotted against depth in millimeters.]
Test Results – Before & After Treatment

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Test Results – Before & After Treatment
Test Results – On-site Tests

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THANK YOU FOR YOUR ATTENTION!
Via Delle Calandre, 63 - 50041 Calenzano (Florence) – Italy
Tel: +39.055.8826-302 – Fax: -303
www.sintechology.com
info@sintechology.com