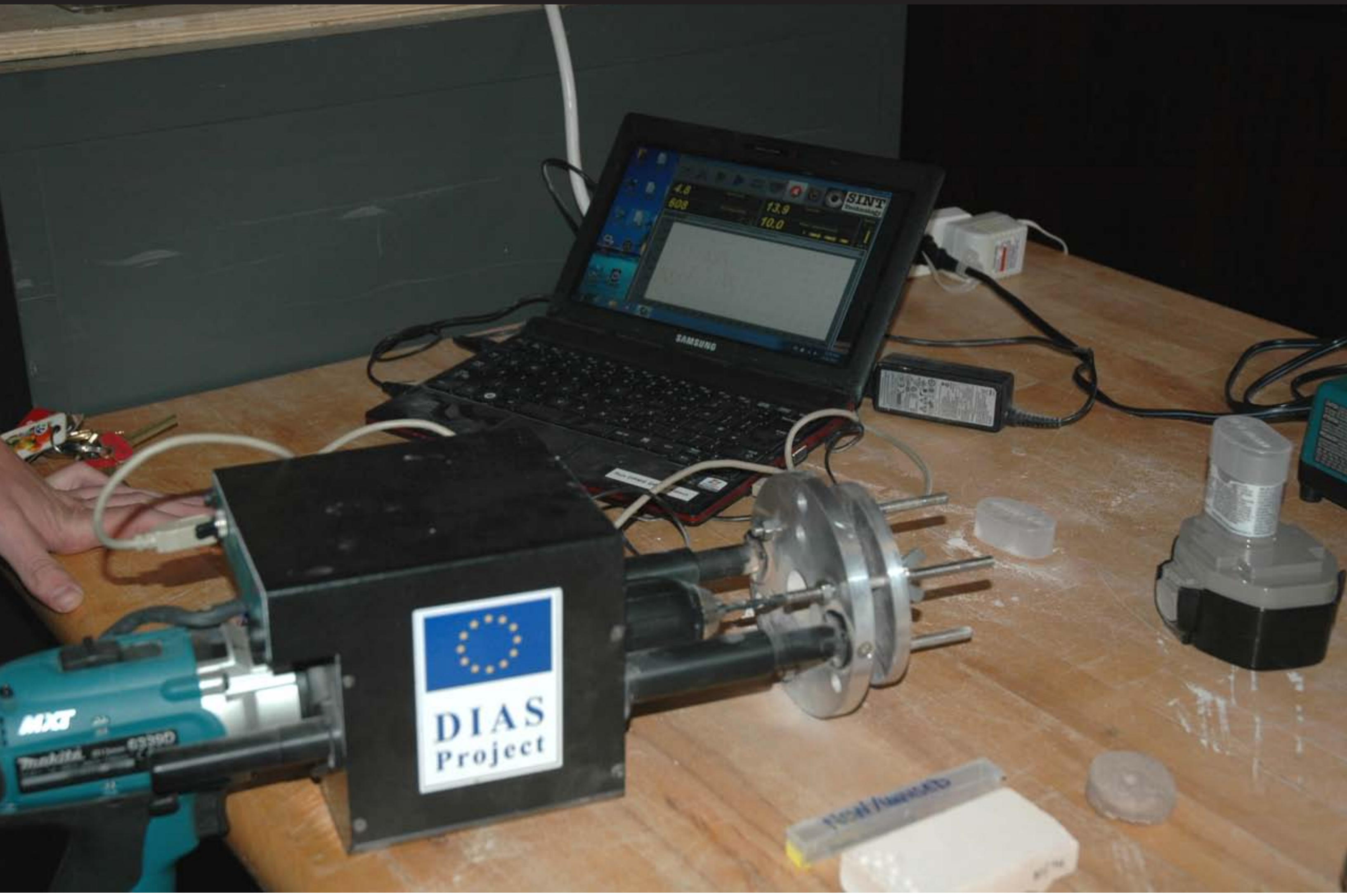
DRMS CORDLESS MANUAL



Created for the Architectural Conservation Laboratory at the University of Pennsylvania

By SINT Technology srl with additions by Kalen McNabb

SINT Technology

UNIVERSITY OF PENNSYLVANIA
Architectural Conservation Laboratory

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INTRODUCTION

This manual describes the main functions of the software program for operating the Drilling Resistance Measurement System, DRMS Cordless, and for management and processing of the data acquired by the system.

This program was developed by SINT Technology using National Instruments Labview environment. SINT Technology also designed and constructed the mechanical part and the electrical and electronic parts of the system.

The manufacturer shall not be held liable for any damages arising from the improper use of the system or failure to follow these operating instructions.

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Additions to the original manual provided by SINT were provided by Kalen McNabb of the Architectural Conservation Laboratory (ACL) at the University of Pennsylvania and were based upon numerous trails with the DRMS. The purpose of the additional information is to easily describe the set up, operation, and care of the DRMS to new users and ensure proper usage of this equipment.

1.0 MATERIALS

- Mechanical drilling instrument with onboard electronic controlled system
- Tablet PC with pre installed software
- CD-ROM with DRMS-Cordless software version 4
- Monopod
- USB Connection lead
- No. 02 Rechargeable batteries
- Nakita batter charger 110V
- Specimen holder
    - 1 plate
    - 3 threaded bars
    - 3 wing nuts
    - 3 nuts
    - 3 wall push rods
- ARS Specimen
- Marble Specimen
- Five 5mm drill bits
- Five 3 mm drill bits
- Calibration certificates, calibration declarations, CE marking conformity certificate

Figure 1.0: DRMS Drill

2.0 PRELIMINARY OPERATING INSTRUCTIONS

The procedure listed below must be followed for the measurement system to operate correctly. Each operation must be carried out in the correct order to ensure successful operation:

1. Remove the mechanical instrument and battery from the protective case. Ensure the ON/OFF switch is on OFF
2. Check the charge of a battery by placing it in the battery charger and checking the charge LED, following the instructions on the battery charger. When fully charged, the LED light on the charger should be a solid green.
3. Insert the battery into the heel of the handle of the DRMS (figure 2.1)
4. After the PC is started, connect the USB lead to the parts on the PC and mechanical instrument. On the provided laptop, ensure that the USB lead is connected to computer to the port on the right side of the instrument. (This is important as the USB port on the left side of the computer does not function properly)
5. When connected, the acquisition yellow LED initially flashes and then stays alight as a solid yellow.
6. Move the ON/OFF switch to ON, and the green LED will light up. **Remember to always turn on the DRMS on BEFORE opening the program, or an error message will appear when the program is finally opened.**

Figure 2.1: Inserting the battery (SINT 2007)

Figure 2.2: Main panel on the mechanical instrument including yellow "Acquisition" light and green "ON" light (SINT 2007)

Figure 2.3: USB lead connecting to PC (left) with correct displays lighting up. Machine is ready to use (SINT 2007)

2.1 Starting the Program:

1. Find the DRMS_Cordless icon on the desktop of the computer. If one does not exist, create a shortcut by finding the program in the "Start" menu.
2. Right click on the icon and select the command "Run as Administrator". **This program MUST be run as an administrator or an error message will appear when the program opens.**
3. When opened correctly, the control panel will open up containing a single bar of eight buttons. (Figure 2.5)

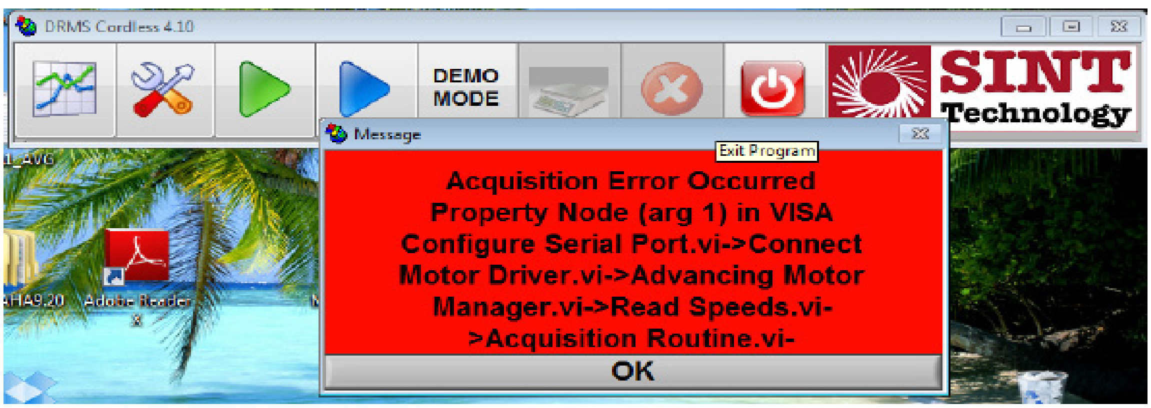

Figure 2.4: Error message displayed when program is opened without running as an administrator. NOTE: Same error message may appear for several different issues. See section 7.0 for further information.

2.2 Elaboration of Test Control Functions on Control Panel:

1. **Test Elaboration:** this button allows the operator to process and analyze data acquired during previous tests. Further explanation of this function will be explained in a later section.
2. **Test Configuration:** This function allows an operator to set all the test parameters, from speeds to the operator's name.
3. **Signal Monitor:** This button enables real-time monitoring of all parameters (cell-reading, penetration speed, and speed of rotation) without any data being saved.
4. **Start Drilling Test:** This enables the procedure for acquisition and recording of test data. Once clicked, the test sequence starts as the "Test Configuration"
5. **Enable Demo Mode:** When this button is activated and then "Start Drilling Test" is clicked, a video demonstration of a sample hole will begin. The mechanical system will not be activated. Click "Abort/Exit acquisition mode" button to dis-enable this mode.
6. **Set zero reference**: Sets all readings to zero enabling the "Signal Monitor" function
7. **Abort/Exit acquisition mode**: exits "Signal monitor", "Start drilling test", and "Enable demo mode" procedures
8. **Exit Program**: Exits entire control program.

Figure 2.5: Main Control Panel

Figure 2.6: System ready for testing (SINT 2007)

3.0 DESCRIPTION OF OPERATING PROCEDURES

3.1 Test Configuration

Clicking on this button opens the panel where all the data can be entered for the drilling test you are about to carry out. The panel opens in the simplified configuration and the Automatic Name function (Figure 3.1) is enabled by default.

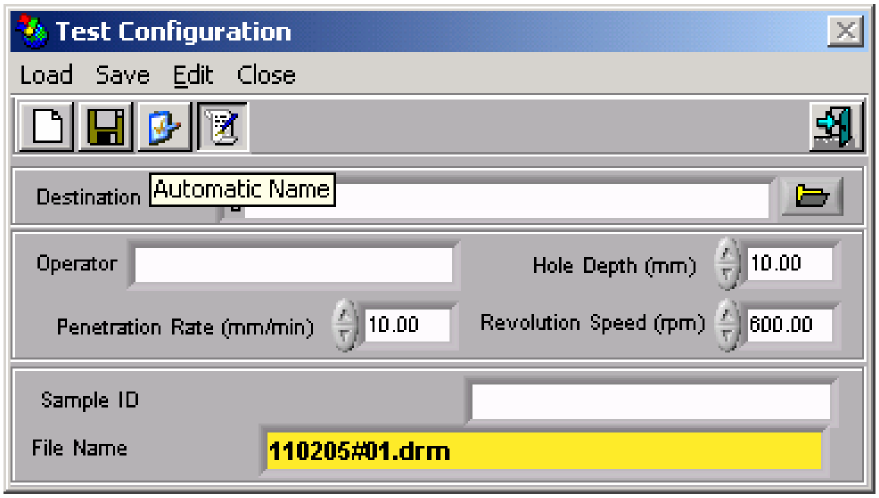

Figure 3.1: Simplified test configuration (SINT 2007)

This allows information to be entered in the following fields:

1. Destination Path: Allow you to select the directory where acquired files are to be saved. This is a required field. If the "Start drilling test" procedure is enabled without having filled this field, an error message appears. NOTE: Remember to have two different locations for your saved "Sets" and your destination folder. It is recommended you make a folder for each sample, save your destination to that current folder, and then create a separate set folder to save your parameters. **SAVING YOUR DRILL DATA AND YOUR SETS TOGETHER IN THE SAME FOLDER WILL NOT RECORD YOUR DATA**
2. Operator: the name of the operator carrying out the tests can be entered in this field.
3. Hole Depth (mm): the depth of the hole is set here in millimeters
4. Penetration Rate (mm/min): the penetration rate of the bit is set in millimeters per minute.
5. Revolution Speed (rpm): the speed of rotation of the bit is set in revolutions per minute.
6. Sample ID: allows input of additional information on the type of material that you are drilling. The characters entered in this field automatically form the "File name" field.

The "File Name" field cannot be changed and is automatically created with the hole drilling date (the first 6 digits) and after the "#" symbol it is again automatically updated with the progressive hole number. If characters are entered in the "Sample ID" field, they are automatically added at the end in the "File Name" field.

"Hole Depth (mm)", "Penetration Rate (mm/min)" and "Revolution Speed (rpm)" are very important parameters and represent the corresponding values that the mechanical system will automatically operate with during hole drilling in the "Start Drilling Test" mode.

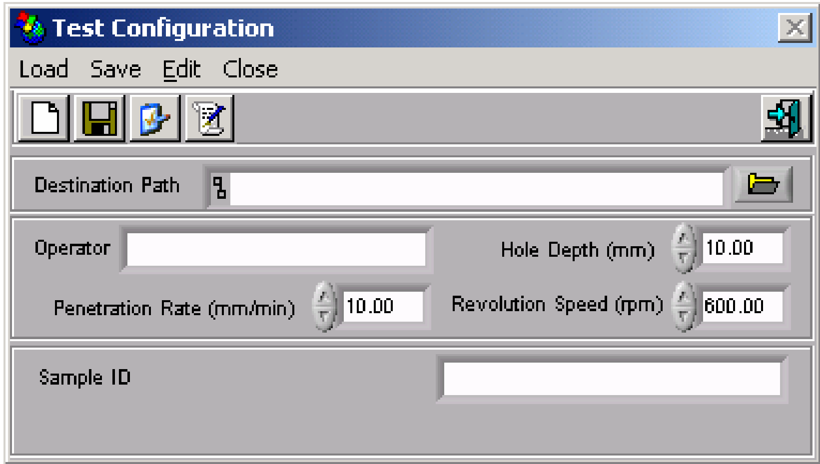

Figure 3.2: "Test Configuration" control panel with automatic name function disabled (SINT 2007)

When the Automatic Name function (Figure 3.2) is disenabled, on clicking on the "Start drilling test" button you are asked to name the file which will be saved in the previously selected directory.

By clicking on the Full Setting button the full control panel shown in Figure 3.3 opens. The first part of the configuration process is the same as for the simplified control panel in Figure 3.1. In addition, it is possible to enter the following additional fields:

1. Lithotype: additional field to characterize the type of material being tested.
2. Decay State: state of decay of the material being tested (Figure 3.4). You can
3. choose from SOUND (no decay), LIGHT decay, MEDIUM decay, HEAVY decay.
4. Treatment: any treatment of the material under testing. You can choose from NONE (NN) – Cleaning (CL) – Protection (PT) – Consolidation (CO) – Other (OT) – Artificial Ageing (AA) – Natural Ageing (NA).
5. Type: additional field for describing the type of treatment.
6. Water Porosity (%): water porosity of the material being tested
7. Compressive Strength (Mpa): resistance to compression.
8. Drill Bit Type: bit code.
9. N. Holes: number of holes drilled by the bit with a specified code
10. First Hole: number of the first drilled hole
11. File Name: name of the file, created automatically.

As for the simplified panel, the "File Name" field cannot be modified but is filled automatically based on the characters entered in the fields described above. The first five characters from the left are taken from the "Sample ID" field, 4 characters from the "Drill Bit Type" field, 3 represent the progressive number of holes made with the type of bit, and the last two indicate any treatment applied to the material. If the Automatic Name option is not selected, when you click on the "Start drilling test" button you are asked to enter the name of the file to be saved in the directory selected earlier.

Once all the required data is entered, the configuration can be saved in a file with extension .set by clicking on the Save button. It may then be called up by clicking on the Load button.

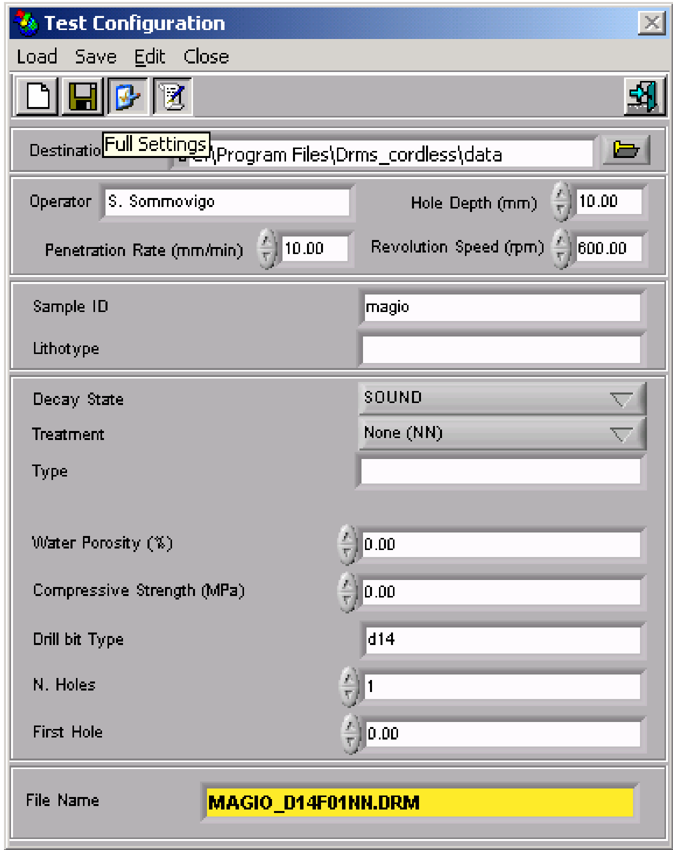

Figure 3.3: Full "Test Configuration" control panel with typical data input (SINT 2007)

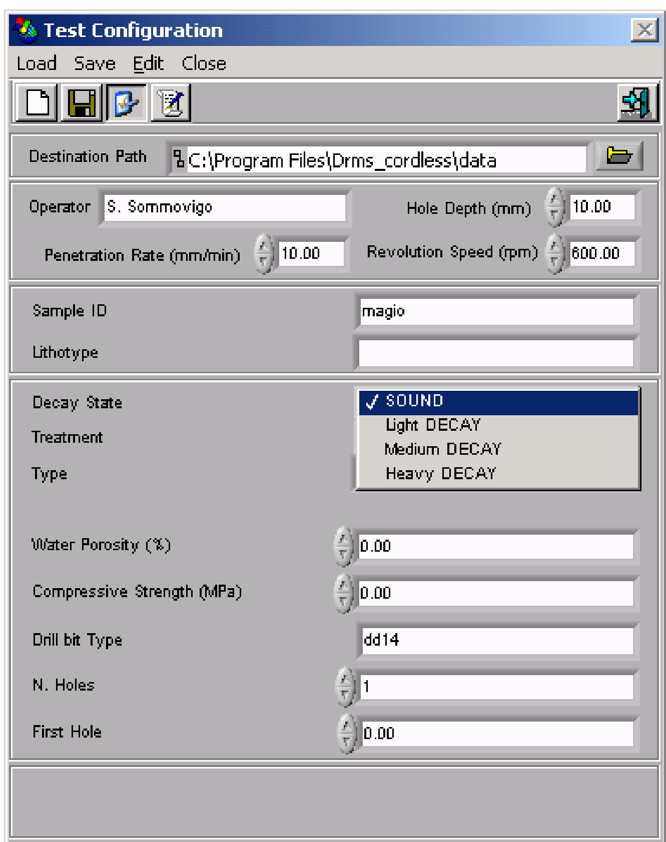

Figure 3.4: States of decay options (SINT 2007)

3.2 Signal Monitor

Pressing this button accesses the panel for real time monitoring of the drilling instrument movements and signals (Figure 3.5).

It gives you an instantaneous view of:

1. Depth (mm): hole depth in millimeters.
2. Rev. Speed (rpm): bit speed of rotation in revolutions per minute.
3. Force (N): force read by the load cell, corresponding to the penetration resistance, measured in Newtons.
4. Penetr. Speed (mm/min): penetration speed in millimeters per minute.
5. Battery: battery charge. As the charge runs down, the bar changes color going from green to yellow and finally to red. When the charge level gets too low to guarantee proper operation of the system, an alarm message appears telling you to change the battery (Figure 3.6).

The “Set zero reference” button for resetting the load cell reading and the “Abort/exit acquisition mode” button for going back to the main control panel are active on this panel.

With this procedure you can move the mechanical drilling instrument forward and backward by the start button on the handle and the direction selector. This allows you to set the bit as close as possible to the surface of the specimen and to cut working time to the minimum before starting with the automatic test procedure.

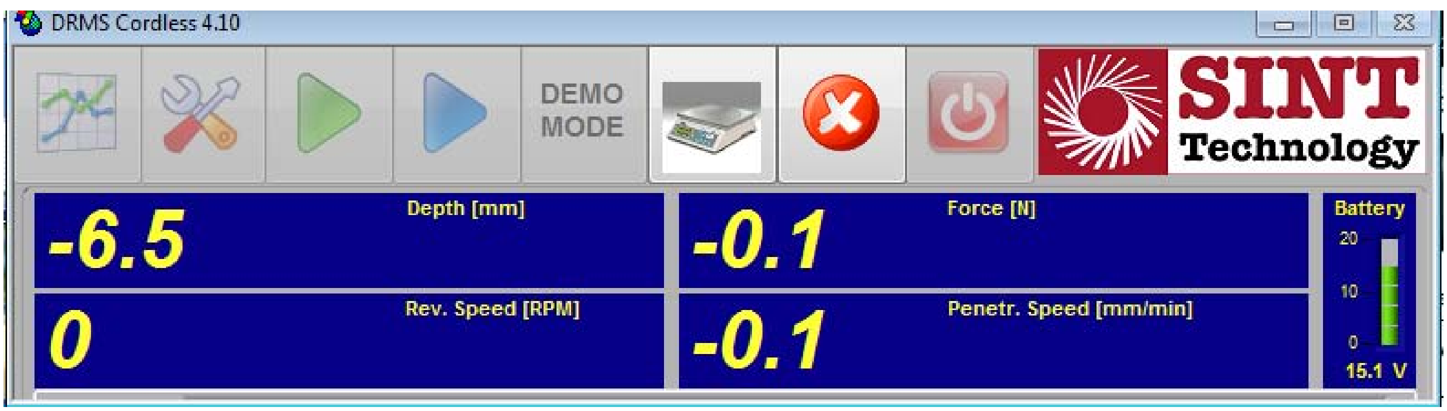

Figure 3.5: Signal Monitor. NOTE: Moving the drill by pulling the trigger will adjust the depth accordingly (SINT 2007)

3.3 Starting the Drilling Test

This button enables acquisition and saving of data in the file named in the “Test configuration” control panel. Unless the directory where it is to be saved is specified in the “Test configuration” panel, an error message is displayed (Figure 3.6) and the “Start drilling test” function cannot be enabled.

Figure 3.6: Error message showing the directory where the data is to be saved has not been designated (SINT 2007)

Once the directory is specified, when the “Start drilling test” button is pressed the red and white flashing window shown in Figure 3.7 immediately appears

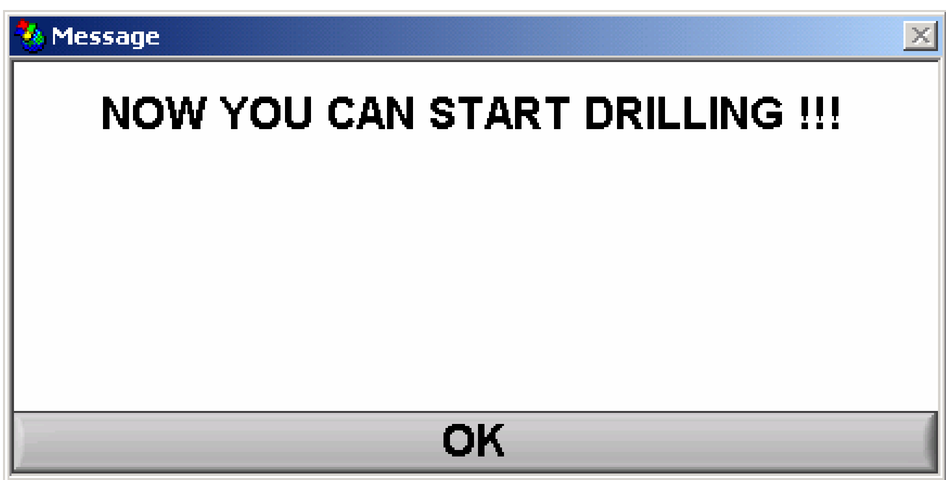

Figure 3.7: Message Indicating the “trigger” can be pressed to begin drilling (SINT 2007)

Now pressing the start button on the handle of the mechanical system starts the test. The bit will start to rotate to the speed of rotation set in the configuration and will then begin moving at the speed again set in the configuration.

When the bit reaches the surface, acquisition will commence automatically and the window containing the force vs penetration depth graph will open (Figure 3.8).

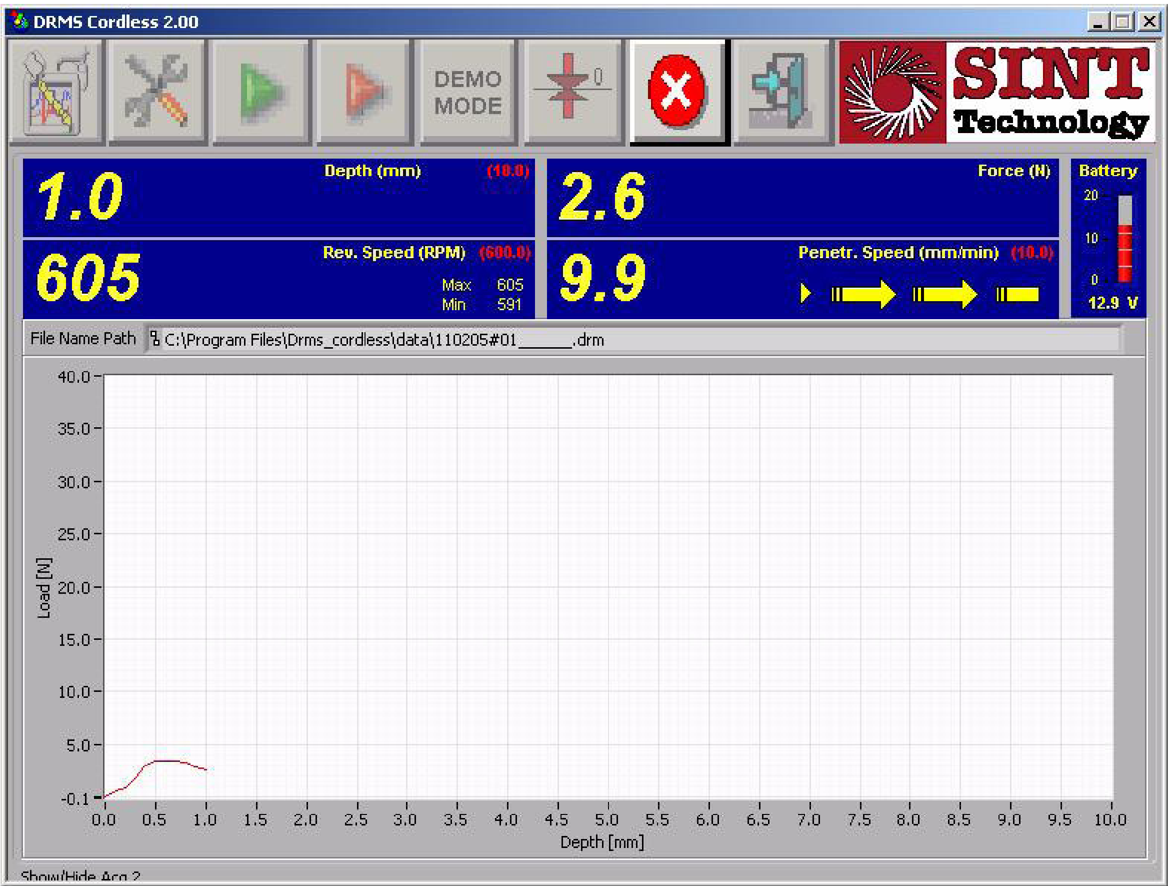

Figure 3.8: Force vs penetration graph that appears after drilling is commenced (SINT 2007)

If the start button on the handle of the mechanical instrument is pressed again during the test, the test is aborted and you are asked if you want to save the test (Figure 3.9).

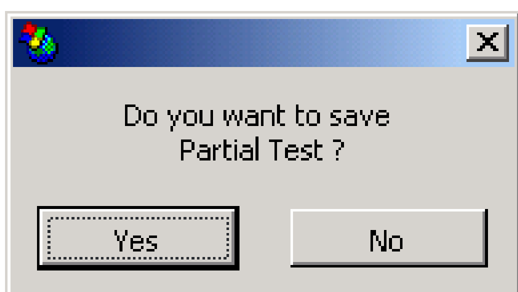

Figure 3.9: Dialogue box for saving partial test (SINT 2007)

Upon completion of a test, the window containing the graph appears as in Figure 3.10,

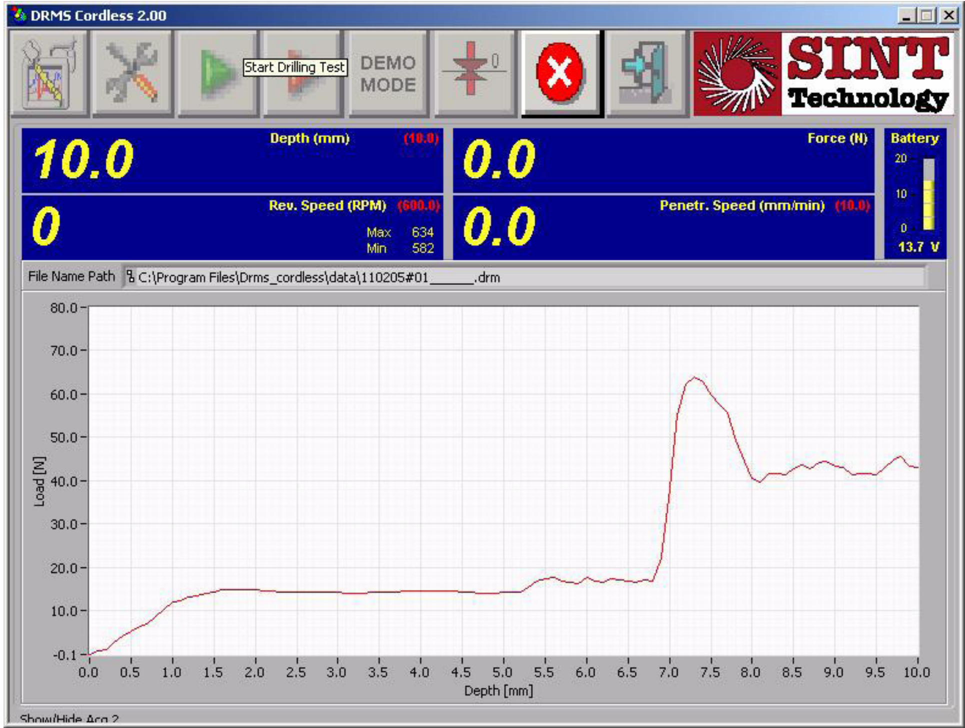

Figure 3.10: Successfully completed test (SINT 2007)

The test was completed successfully and the data was saved on file and in the specified directory. To close this window, press the “Abort/Exit acquisition mode” button, after which we go back to the main control panel and we can start again with another selection.

At the end of each hole, the average force and the average penetration speed during the hole are automatically displayed.

NOTE: Right clicking on either axis and clicking “Autolabel X” or “Autolabel Y” allows the graph to adjust as readings are taken

3.4 Demo Mode

By enabling this function, with the “Demo mode” button pressed and flashing red clicking on the “Start drilling test” button starts a hole-drilling demonstration showing a typical hole drilling procedure. The mechanical setup does not perform any operation. To leave this mode, you must click on the “Abort/Exit acquisition mode” button and disengage the “Demo mode” button.

3.5 Set Zero Reference

This button is active in the “Signal monitor” mode (Figure 3.5). Pressing it resets the load cell force reading to zero.

3.6 Abort/Exit acquisition mode

This button is active in the “Demo mode” and “Start drilling test” procedures. It allows you to abort testing in progress (whether demonstration or real testing) and to go back to the main control panel (Figure 2.5).

3.7 Exit program

This function closes the program.

4.0 PREPARING THE DRMS FOR TESTING

Note: Most of the set up can be performed with the DRMS on OFF. However, moving the drill and chuck requires the drill to be ON.

4.1 Testing Hand Samples

1. The following materials are required in order to place and secure a small specimen for drilling, in addition to those used to operate the drill normally
    a. 1 plate
    b. 3 threaded bars
    c. 3 wing nuts
    d. 3 nuts
2. Insert and secure the drill bit into drill chuck, making sure the bit does not extend beyond the plate. If the bit does extend beyond the plate please:
    a. Connect and turn on the DRMS and open the program as outlined above
    b. Click the "Signal Monitor" button.
    c. Press the trigger of the drill and note which way the drill bit moves according to the drill plate. The drill bit and chuck can be moved the opposite way by clicking the button above the trigger.
3. Attach the second outer plate with the threaded bars and wing nuts.
4. Place your sample centered between the plates and tighten the wing nuts on the threaded bars to secure the sample on all three sides

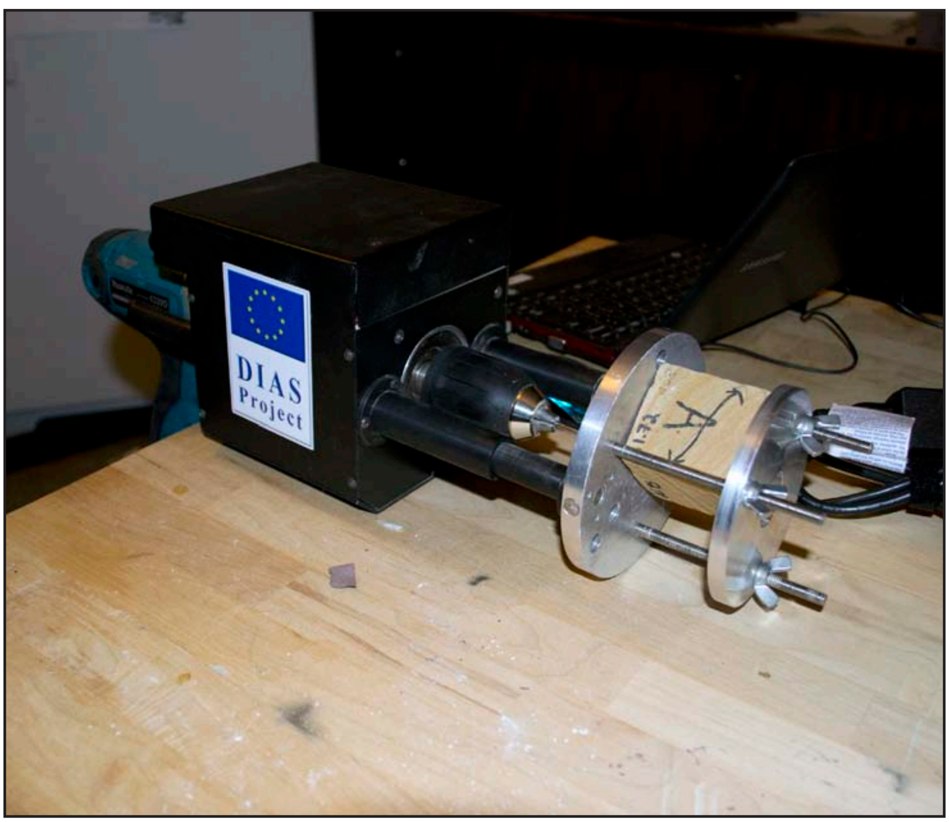

Figure 4.1: Successfully completed test (McNabb 2012)

4.2 Testing In Situ

1. The following materials are required in order to drill in situ or on a large object, in addition to those used to operate the drill normally
    a. 3 wall push rods
    b. Monopod
1. Insert and secure the drill bit into drill chuck, making sure the bit does not extend beyond the plate. If the bit does extend beyond the plate please:
    a. Connect and turn on the DRMS and open the program as outlined above
    b. Click the “Signal Monitor” button.
    c. Press the trigger of the drill and note which way the drill bit moves according to the drill plate. The drill bit and chuck can be moved the opposite way by clicking the button above the trigger.
2. Attach the three wall push rods to the plate which will be rested against the surface to be tested
3. Attach the monopod to the bottom of the DRMS by screwing it in the bottom of the black load cell box
4. Prior to running the drill test, ensure the operator is applying adequate force in order to reduce kickback caused as the drill hits the surface of the material. 2 or more people are recommended for this type of drilling.

Figure 4.2: Successfully completed test “in-situ” test (McNabb 2012)

Following completion of set up for either test:

1. Once the specimen is secure, connect the USB connection to the drill and computer as described earlier.
2. Turn the DRMS “ON” and note that the Yellow “acquisition” light and green “ON” light are on
3. Open the computer and to click “RUN AS ADMINISTRATOR”
4. If set up is done correctly, no error messages appear and there should be an audible “dong” played the computer. The control panel will then appear.
5. Click the test configuration button (wrench and screwdriver symbol) and input the desired parameters. **REMEMBER TO NOT SAVE YOUR SETS IN THE SAME FOLDER AS YOUR DESTINATION PATH. YOUR DATA WILL NOT BE RECORDED.** As mentioned earlier, it is possible to save your sets within a folder within the destination path. For example, the destination path was chosen as Desktop/DRMS/Brownstone/Sample1. The location of my saved sets for this sample were located in Desktop/DRMS/Brownstone/Sample1/Sets.
6. Insert your sample ID number. Limit input to 5 characters as the rest will not be included in the file name generated by the DRMS. For example b1_h1 (for sample b1, hole 1)
7. Once your information has been placed into the program, click “close” to get out of the test configuration. If you open the test configuration panel again, you will see your information has been automatically saved.
8. Click “Start Drilling Test” (Blue arrow) to begin drilling. Press the trigger on the drill when prompted.
9. Watch as your data is automatically recorded. The software records data initially despite not being in contact with the material. This is corrected when the drill bit first encounters the material
10. Exit graph when drilling is complete.

5.0 DESCRIPTION OF DATA PROCESSING FUNCTIONS

5.1 Test Elaboration

This procedure is accessed by pressing the “Test elaboration” button on the software main control panel in Figure 2.5.

As soon as it is pressed, the data processing window shown in Figure 5.1 opens up.

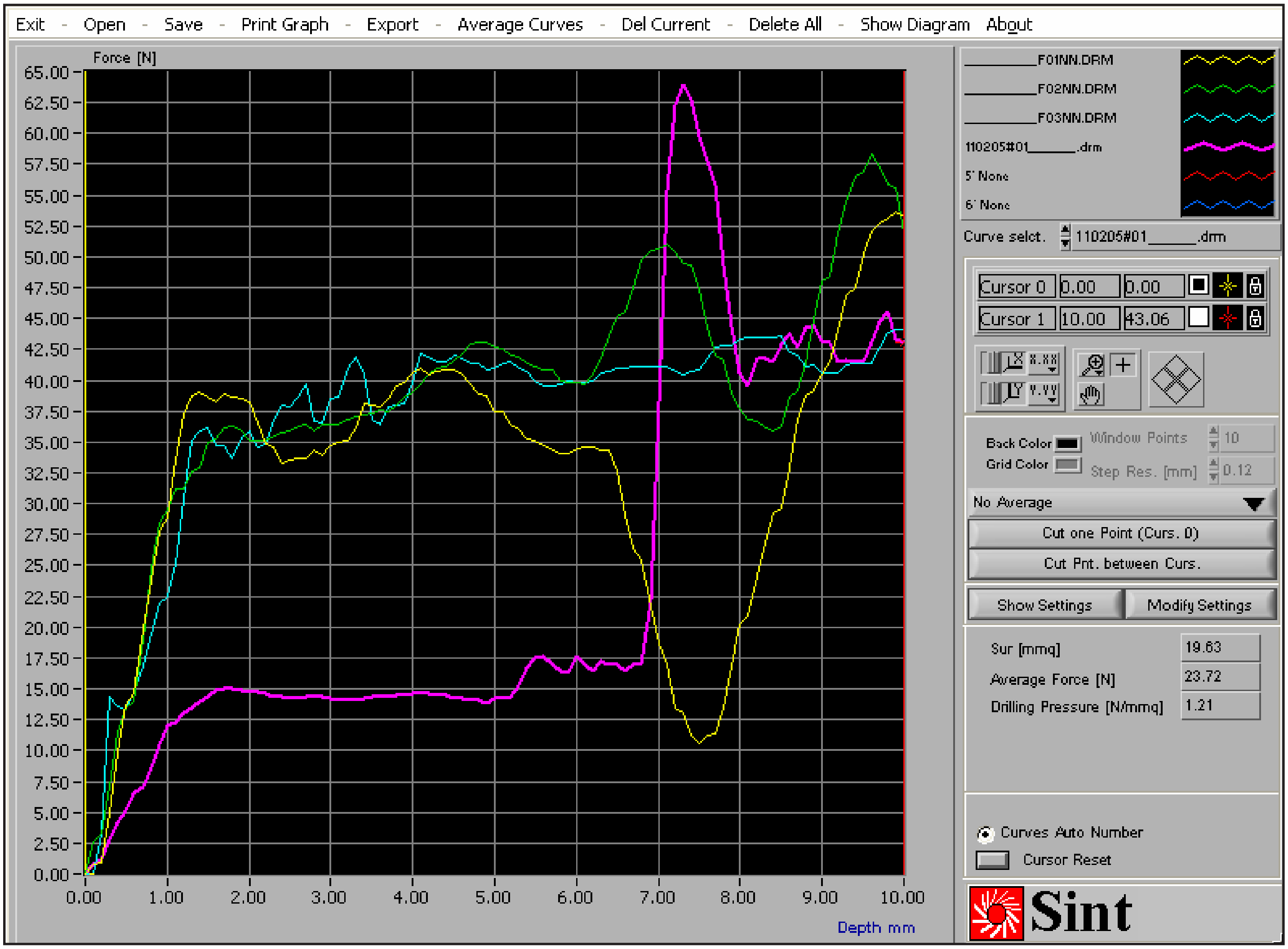

Figure 5.1: Data Processing window (SINT 2007)

This window allows you to analyze data that is stored in files (filename.DRM), allowing you to view as many as 6 acquisitions contemporaneously from separate files, to print and export data.

It contains a graph showing the force measured by the load cell versus penetration depth. The curves are distinguished by a different color and the selected curve is shown in bold print. You can choose the type and size of line to be used in the graphs. To change the color and format of the line used in the graphs, you can use the command in the dropdown menu that appears clicking with either of the two buttons on the mouse on the curve or the name of the corresponding file in the box (in the top right corner of the window) shown in Figure 23.

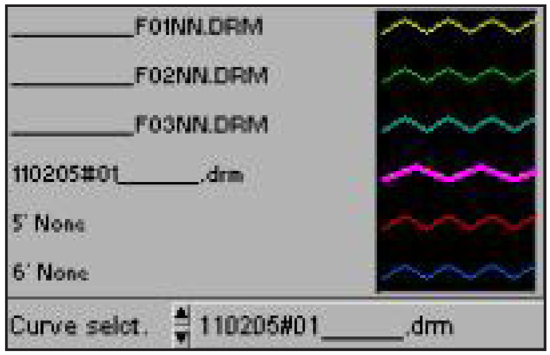

Figure 5.2: Data processing Panel box (SINT 2007)

There are also two cursors, "Cursor 0" and "Cursor 1", and the toolbar on the panel. Referring to Figure 5.3, you can see that there are a number of indicators showing:

- the name of the cursors ("Cursor 0" and "Cursor 1");
- the value of the x and y coordinates where the cursor is positioned;
- which of the two cursors is selected with a black square on a white field;
- the color of the cursor on the graph;
- if it is locked on the selected curve or free to move around the graph (open/closed lock);
- The X button sets the scale of the x-axes for full view of the curve to the end of the scale;
- The Y button sets the scale of the y-axes for full view of the curve to the end of the scale;
- The X.XX button sets the properties of the x-axis scale;
- The Y.YY button sets the properties of the y-axis scale;
- The magnify button allows you to zoom in on a part of the graph;
- The hand button allows you to move around the graph.

The cursors are automatically pegged to the curve selected in the box in the data processing panel headed "Curve Select." shown in Figure 5.2. The curve is easily recognized as it is highlighted in bold print (in our case 110205#01_____.drm).

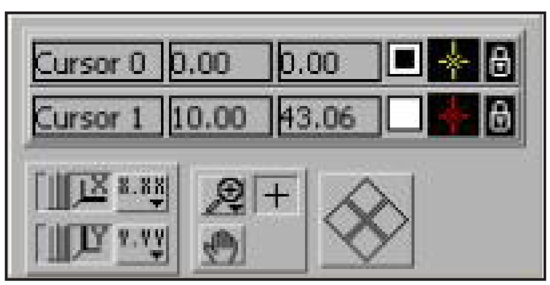

Figure 5.3: Cursors and Graph toolbar (SINT 2007)

For further information on these commands, you may refer to the documentation provided on National Instruments' site www.ni.com .

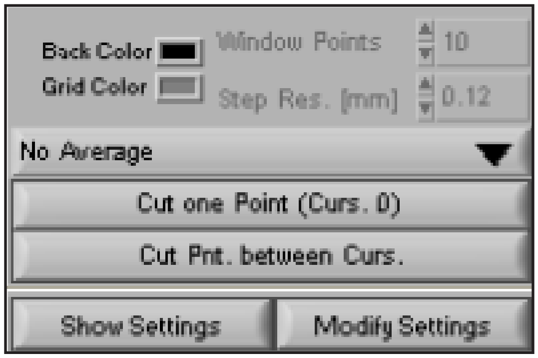

Figure 5.4: Averaging Commands (SINT 2007)

In Figure 5.4 you can see, from top down:

- "Back Color" and "Grid Color" button controls for the color of graphs: "Back Color" for the color of the background and "Grid color" for the color of the grid. The colors can be changed by clicking on them;
- · "Window points" sets the number of window points on which averaging is to be done;
- · "Step Res. (mm)" sets the graph resolution step once the average is calculated;
- · "No Average/Win. Average" averaging control button. When "Win. Average" is activated, the average of the selected curve is calculated with a movable window of a number of points specified in the "Window points" window;
- · "Cut one point" eliminates the point where Cursor 0 is positioned, if pressed; the selected point is replaced by the average value calculated from the preceding point and the following point;
- · "Cut Pnt Between Curs." removes the points between the two cursors from the graph;
- · "Show setting/Hide Setting" shows and hides the panel (Figure 5.5) containing all the additional information saved on the file selected by "Curve selct." on running the test.
- · "Modify setting" allows you to change saved data.

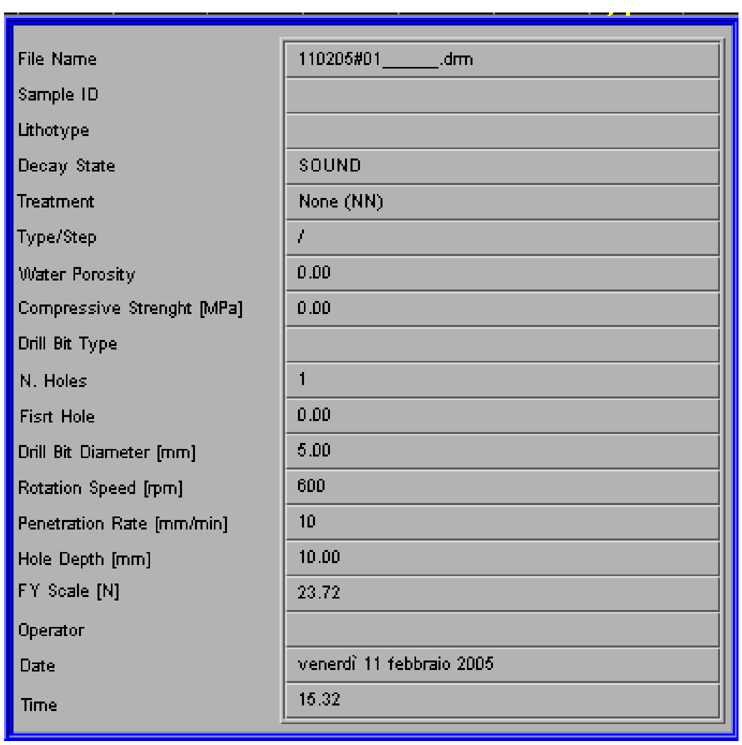

Figure 5.5: Panel showing additional data saved during hole drilling (SINT 2007)

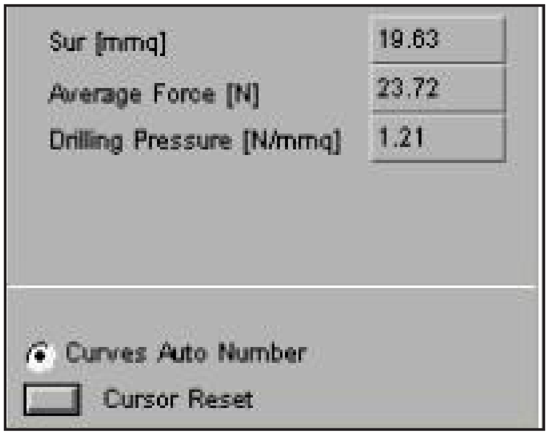

Figure 5.6: Averaging Feature parameter (SINT 2007)

Finally, there are a number of parameters (Figure 5.6) directly calculated on the selected curve, which are:

- · "Sur [mm2]" indicates the hole surface area in mm2;
- · "Average Force [N] is the average of the force values between the two cursors;
- · "Drilling Pressure [N/mm2]" is the ratio between the "Average Force [N]" and "Sur [mm2]";
- · "Curves Auto Number", when activated, allows several files to be loaded and viewed contemporaneously (up to a maximum of 6). When disactivated, only one file is viewed at a time;
- · "Cursor Reset" puts the two cursors back in the default position, if pressed.

The toolbar, at the top, contains the following commands (Figure 5.7):

Figure 5.7: Toolbar (SINT 2007)

- "Open" opens the dialog box which allows you to select the files to be loaded for viewing in the form of a graph. If "Curves Auto Number" is activated up to 6 drilling files can be loaded, otherwise only the last one opened is viewed;
- "Save" opens the dialog box that allows you to save the data being viewed. This allows you to have a single file containing the data of several curves or to save a curve that has been processed. The data is saved in a file with extension .drm; 25
- "Print Graph" opens a small window that gives you the following options:
    a. "HTML" opens a dialog box that allows you to save a report file in format .htm containing the graphs and configuration parameters forthe selected curve. Files are saved by default in the drms\ reports folder;
    b. "PRINTER" allows you to print out the report;
    c. "UNDO" closes the Print Graph window.
    d. Some versions have also the possibility to save the file in "doc" format – the relative option in "Print Graph" is the command "WORD"
- "Export" opens the dialog box that allows you to save the files viewed in the graphs in text format (.txt);
- "Del current" removes the selected curve from the graph;
- "Delete All" clears all curves from the graph;
- "Show diagram" is not active;
- "Exit" closes the program;
- "About" information on the software release.

The “Averaging curves” panel, shown in Figure 5.8, can be accessed by the command of the same name on the toolbar. The graph on this panel functions if 6 drilling files have been loaded in advance for processing. It visualizes:

- “1-3 Average – Cu1”, the average over curves 1 to 3 of the six loaded in the processing panel;
- “4-6 Average – Cu2”, the average over curves 4 to 6 of the six loaded in the processing panel;
- Cu1 – Cu2, the difference between the above mentioned curves.

At the foot of the panel (Figure 5.9), the following indicators are provided:

- “1-3 Average” (Cursor) and “4-6 Average” (Cursor) indicate the average of the values between the two cursors relating to the two sets of curves;
- “Difference Average” is the difference between the “1-3 Average” (Cursor) and
- “4-6 Average” (Cursor) values;
- “Curves List” indicates the files to which processing refers.

For as far as regards the toolbar for the cursors and graphs, refer to the previous section.

The “Averaging Curves” panel commands, shown in Figure 5.10, are as follows:

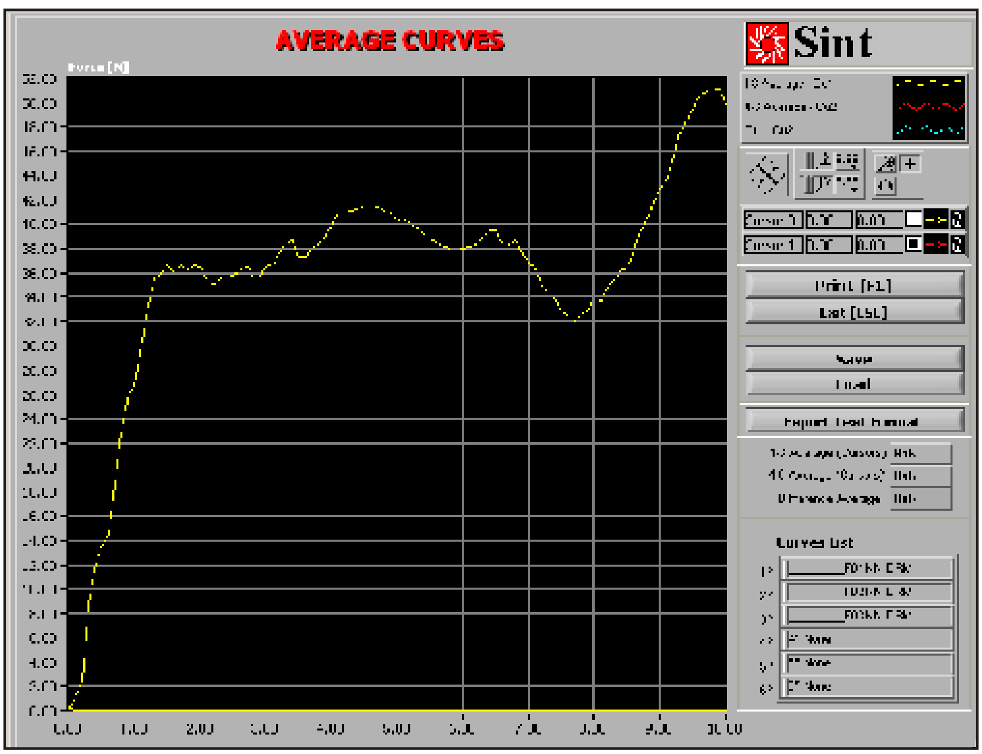

Figure 5.8: Averaging Curves Panel (SINT 2007)

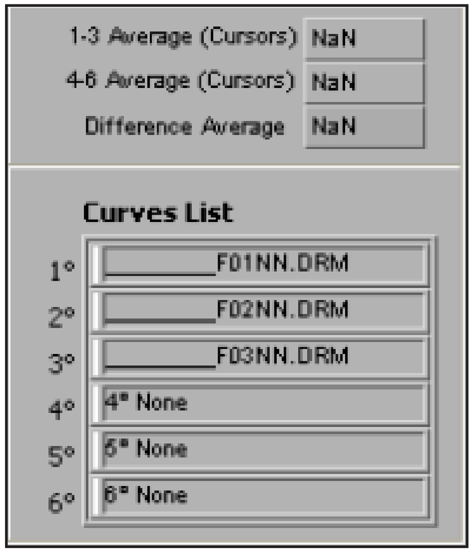

Figure 5.9: Averaging Curves Indicator (SINT 2007)

- "Print" prints out the graph;
- "Save" opens a dialog box that allows you to save a file with extension .cal containing all the data on the graph. The file is saved by default in the directory drms\calculation.
- "Load" opens a window allowing you to load a file saved with extension .cal to view the content;
- "Export Test Format" opens the dialog box where you can save the visualization in text format;
- "Exit" closes the window.

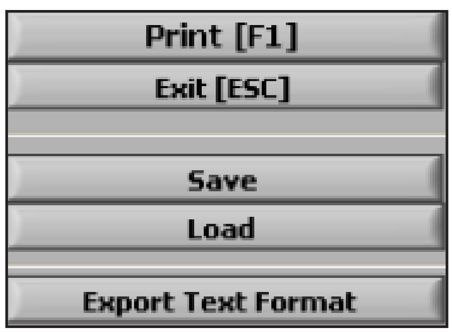

Figure 5.10: Averaging Curves Panel Indicator (SINT 2007)

6.0 TYPICAL TEST PARAMETERS AND USE OF REFERENCE MATERIAL FOR CHECKING BIT WEAR

6.1 Typical Parameters and Recommendations

All tests and system settings are conducted with the following parameters:
· 5 mm. diamond drill provided;
· 600 rpm speed of rotation;
· 10 mm/min penetration speed.

These parameters are to be considered “typical” for the majority of stone materials and form the basis for setting the system for a material with an unknown drilling resistance. When dealing with particularly hard material (eg. granite) or soft material (such as “pietra di Lecce” stone), the instrument may measure resistance values greater than 100 N and therefore the load cell protection system comes into operation if drilling granite or it may not give appreciable results as in the case of Lecce stone.

In these extremes, the penetration speed and speed of rotation settings can be changed to obtain a value within the instrument’s measuring scale.

The following are examples of possible settings:

GRANITE.
Speed of rotation: 900 rpm
Penetration speed: 5 mm/min

LECCE STONE.
Speed of rotation: 20 rpm
Penetration speed: 40 mm/min

Good results have been achieved on granite using the parameters indicated above and off-the-shelf 5 mm diameter drills with Widia coatings. These values are provided purely as an indication and can vary considerably depending on the type and condition of the material concerned. It is clear that a comparison can only be made of curves obtained at the same speed of rotation and penetration speed and with the same type of bit.

6.2 Checking Bit Wear

The system is supplied with five diamond bits and a specimen for checking bit wear (designation ARS).

The first hole made with a bit is always on this specimen (ARS), and then you go on to drilling specimen materials. Depending on the recognized abradability of each material (eg, marble: low abradability, sandstone stone: high abradability) a certain number of drilling procedures is performed and then another sample hole is drilled in the ARS specimen. Comparing the result with the first hole made with the bit when new, you assess wear of the bit and decide whether to continue drilling more holes or to change the bit.

7.0 ERROR MESSAGES & TROUBLE SHOOTING

7.1 Acquisition Error 1

The error message which displays "Acquisition Error Occurred Property Node (arg 1) in VISA Configure Serial Port.vi->Connect Motor Driver.vi->Advancing Motor Manager.vi->Read Speeds.vi->Acquisition Routine.vi-"" can be triggered by a variety reasons and is one of the most common error messages encountered.

It can be caused be the following:
1. The program has opened without doing so as an administrator
2. The program has been opened prior to turning on the drill
3. The USB port on the computer is malfunctioning or the acquisition cable is improperly attached
4. A combination of the above problems

If this error appears before drilling has begun, please consult the preliminary set up steps in Section 2.

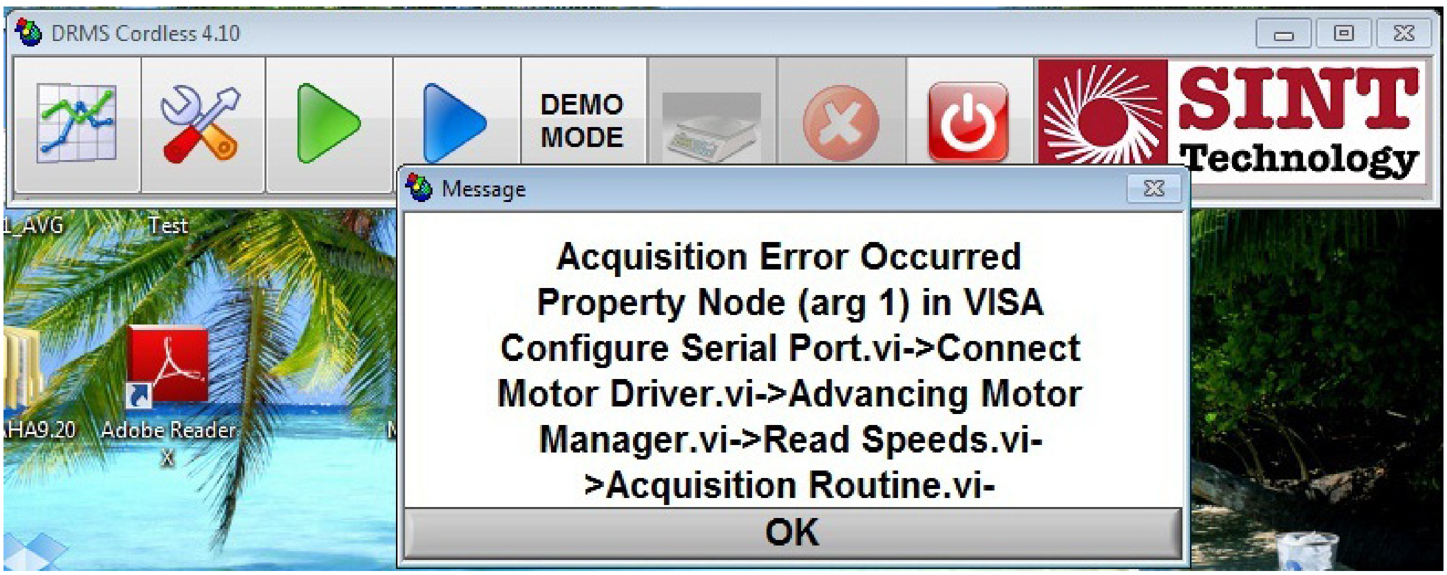

Figure 7.1: Acquisition Error 1 (McNabb 2012)

7.1 Acquisition Errors 2

The error message which displays “Acquisition Error Occurred VISA Read in VISA Read (Last Field).vi->Advancing Motor Manager.vi->Acquisition Routine.vi->DRMS_Light.vi”“ can be triggered a faulty battery.

It can be caused be the following:

1. Insufficient charge on the battery that is not recorded on the program
2. A battery that is no longer to hold a sufficient charge and must be replaced

In order to remedy the problem:

1. Remove the battery and replace with a fresh 14.4V Ni-MH 2.6Ah battery. These can easily be purchased online.

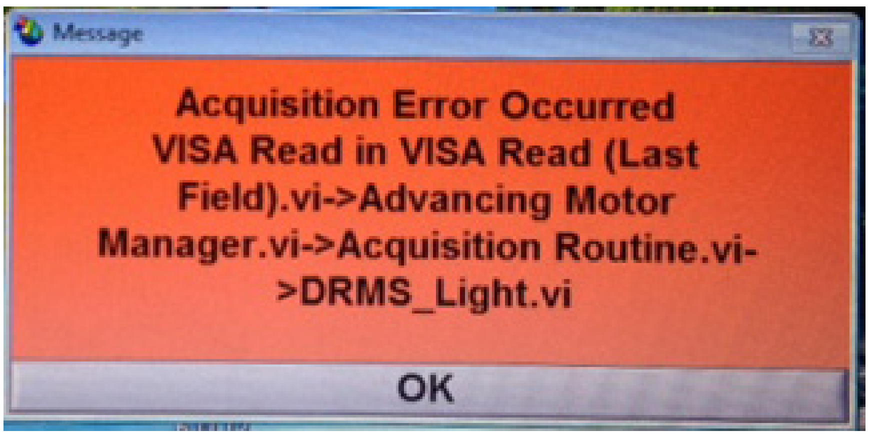

Figure 7.2: Acquisition Error 2 (McNabb 2012)

8.0 DATA CORRECTION AND ANALYSIS

The following procedure for data analysis was taken from Delgado Rodrigues and Costa (2004) "A New Method for Data Correction in Drill Resistance Tests for the Effect of Drill Bit Wear". This method was developed to address issues of drill bit wear on abrasive materials and to serve as a correction method for the affected drilling resistance values.

The following methodology assumes that the corrected values are a fraction of the actual measured values. A correction fraction can be determined experimentally during each program.

8.1 Testing Terminology:

Assume the following terminology

- **Stone A** – is the stone under study (it can be extended to any material other than stones provided the DRMS instrument is applicable),
- **Correction specimen** – is a piece of the same material ("stone A") left undisturbed where the correction factor is to be determined,
- **Correction holes** – are the holes made in the "correction specimen",
- **F0** – is the drilling resistance obtained in the first hole made in the "correction specimen" and it represents the best approximation of the "true" Drilling Resistance of the material. As seen later, this value is also susceptible to be corrected,
- **Average resistance** – is a value computed between any two defined points along the drilling resistance graph. It can be obtained directly in the instrument or in the exported Excel files.

Figure 8.1: Increased drill resistance values caused by drill bit wear through numerous sucessive trials. (Delgado Rodrigues & Costa 2004)

8.2 Testing Methodology

1. Select a specimen of “stone A” on which the correction holes are to be made. This will remain as the “correction specimen”,
2. Make the first hole with the new drill bit in the “correction specimen” (1cm depth). The average resistance of this hole shall be called F0. In order to avoid the influence of the first 1-2 mm, where the drill bit tip form has a large influence, the interval between 2 and 8 mm is suggested,
3. Drill the required test holes in the specimens under testing,
4. At regular intervals of the drilling life of the drill bit, drill a new 1cm hole in the “correction specimen” (these resistances are called Fi), The interval between two correction holes has to be adapted according to the abrasivity of the stone. It shall be shorter for more abrasive stones and longer for the less abrasive ones,
5. For the case of Sander sandstone, for a diamond drill bit, the correction holes may be carried out at every 50 mm of drilling length until five reference holes are available. From then onwards, one new reference hole should be made at every 100 mm.

The correction function can be successfully calculated using a minimum of two holes but accuracy increases with a higher number of correction holes. Since drill bit wear occurs progressively after the correction hole and testing data, it is not necessary to create multiple correction holes in the beginning of the test.

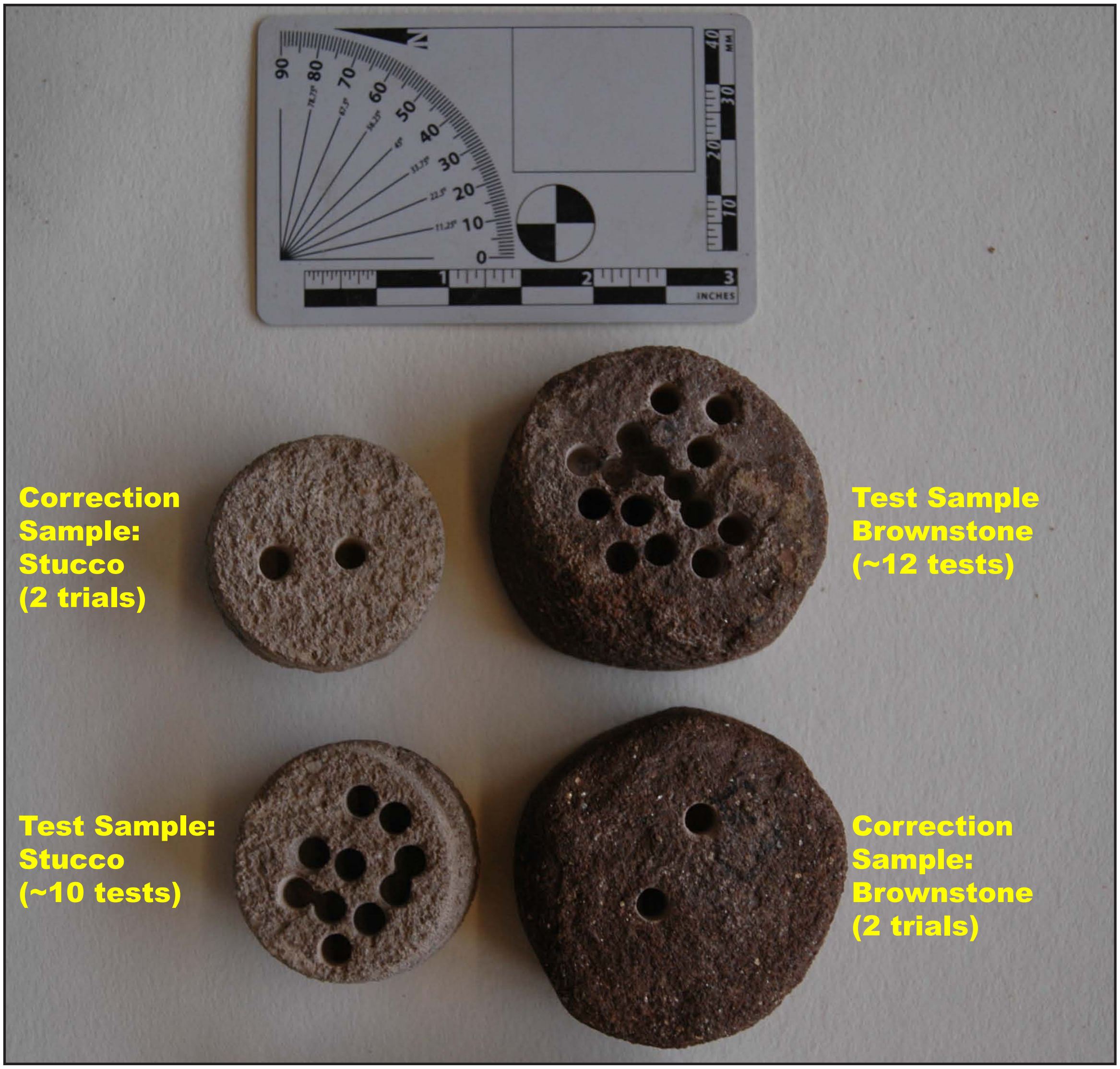

Figure 8.2: Test specimens and correction specimens for DRMS Test on Stucco and Brownstone (McNabb 2012)

8.3 Data Correction Methodology

The implementation of the correction methodology can be made through the following protocol:

1. The drilling resistance obtained at every correction hole shall be averaged between 2 and 8 mm,
2. Successive Fi resistances shall be divided by F0,
3. The average resistance of the hole is assigned to the starting point of that specific hole, that is to say, for the first point, F1/F0 shall be plotted at x=0mm; for the hole drilled between 80 and 90 mm, the result Fi/F0 shall be plotted at x=80 mm,
4. For all the available correction holes, plot the drilling resistance in function of the total length drilled until that specific hole,
5. In ordinates plot Fi/F0. In abscissa plot the total drilled length until point i,
6. Adjust a regression line to the correction data. Use one or more straight lines according to the type of data See Fig. 3 for easier understanding,
7. The first regression line shall, in principle, cross at point XY (0;1) or very close to it. Large divergences from this assumption shall be analysed carefully and explained before proceeding with the correction procedure,
8. Determine the regression equation for each regression line.

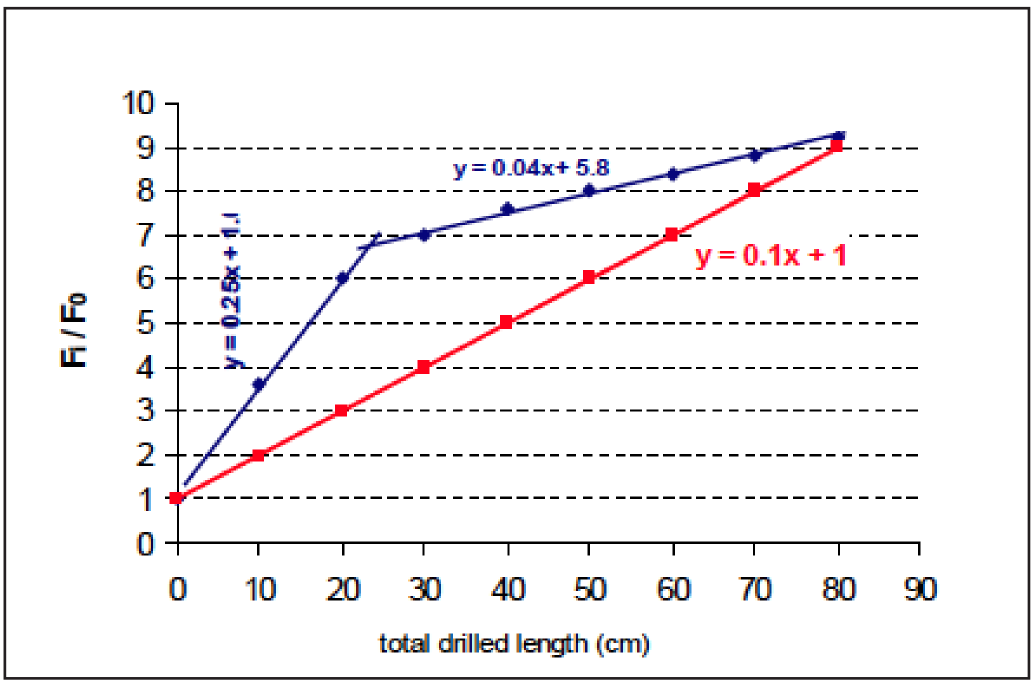

Figure 8.3: 2 hypothetical correction functions on two different materials (Delgado Rodrigues & Costa 2004)

Once the regression equation has been determed, the drilling data can then be autocorrected automatically from point to point. The general correction formula is:

$$Fc_i = \frac{Fm_i}{a + bx_i}$$

where:
Fci = corrected resistance at point i
Fmi = measured resistance at point i
x i = total length drilled with the concerned drill bit until point i
a = ordinate at the origin. For the first part of the graph, it should be very close to one
b = angular coefficient of the regression line,

For further information, please consult Delgado Rodrigues and Costa (2004) “A New Method for Data Correction in Drill Resistance Tests for the Effect of Drill Bit Wear”. Several hypothetical tests are described in detail that may provide additional insight.

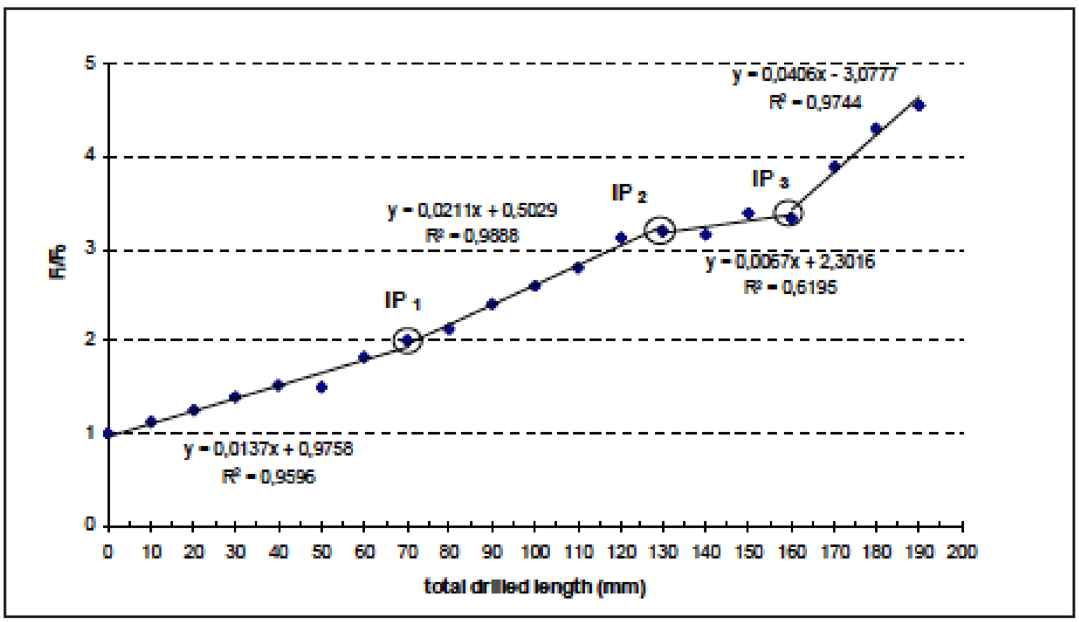

Figure 8.4: Correction functions in a sandstone. IP indicates point where a new wear rate begins and a new set of correction parameters should be used (Delgado Rodrigues & Costa 2004)

9.0 REFERENCES AND ARTICLES OF INTEREST

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Delgado Rodrigues J. and da Costa, D. 2004 “A New Method for Data Correction in Drill Resistance Tests for the Effect of Drill Bit Wear,” *International Journal for Restoration.* V.10, No.3. 1-18

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Lotzmann, S., and H.R. Sasse. 1999. “Drilling Resistance as an Indicator for the Effectiveness of Stone Consolidant.” The Use and Need for Preservation Standards in Architectural Conservation ASTM USA STP 1355: 77-89.

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“Drilling Resistance: Overview and Outlook.” Ges. Geowiss., 158/3: 665-676

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More aticles may be found here:

http://www.icvbc.cnr.it/drilling/publications/index_of_publications.htm