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Shotcrete Penetrometer User Guide

For the measurement of resistance force
to calculate the compressive strength
of young sprayed concrete
to EN ISO 14488-2 (Method A)

Mecmesin
FORCE & TORQUE TEST SOLUTIONS
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431-447-01

July 2014

This user guide

This guide covers the use of the Mecmesin Shotcrete Penetrometer, as supplied for the measurement of the resistance force of young sprayed concrete. It also covers the procedure for the subsequent calculation of the compressive strength of the concrete according to EN ISO 14488-2 (Method A) and similar industry test methods.

For detailed operation and technical specification of the gauge instrument, please refer to the *Advanced Force Gauge Operating Manual* (Part No. 431-213) also included. Sections covering the AFG 1000 model are relevant.

Part no. 431-447-01

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1. The Shotcrete Penetrometer

1.1 Introduction

Mecmesin's shotcrete penetrometer provides accurate readings of the forces required to penetrate sprayed or poured concrete during the initial strength development stage of curing. These resistive force readings are then used to convert to a compressive strength value. Its accuracy and portability make it ideal for on-site testing to BS EN ISO 14488 (Method A).

2. Using the Penetrometer

2.1 EN ISO 14488-2 overview

The test standard series 14488 applies to concrete and related products. Part 2 specifically relates to 'Compressive strength of young sprayed concrete'.

The strength development of young sprayed concrete is assessed in the ranges of 0.2 MPa to 1.2 MPa with Method A of the standard, which requires penetration needle apparatus. The Mecmesin Shotcrete Penetrometer is used to perform these in-situ tests.

This user guide refers to EN ISO 14488-2, however there are other related standards which apply the same process: EN 14488-2, DIN EN 14488-2, ISO 14488, BS ISO 14488.

The following sections of this user guide refer to those sections of the standard specifically applicable to usage of the penetrometer.

2.2 Principle

The penetrometer is fitted with a penetration needle of specified dimensions and Method A is used to measure the force required to push the needle into the sprayed concrete to a depth of 15 mm ±2 mm.

The penetrometer indicates the resisting force, from which an estimated compressive strength can be derived by means of the appropriate example conversion curve, included with the product and shown in Appendix A.

2.3 Apparatus

Penetrometer

The Mecmesin Shotcrete Penetrometer is suitable for testing to this standard at the required accuracy of 10 N (please refer to the specifications for the AFG 1000 N Digital Force Gauge).

Needle

The penetration needle should have a diameter of 3 mm ± 0.1 mm and a tip with a taper angle of 60° ±5°.

The Mecmesin Shotcrete Penetrometer includes 15 needles which fit into the adaptor and are secured by a grub screw, as shown below.

2.4 Test protocol form

The resulting strength calculation from the test data requires the measurement of compressive force at multiple sample points. A test protocol form is needed to record these data; an example form is provided in Appendix B.

The standard indicates the required information to be recorded in order to meet the regulations, and those data will be referenced in this user guide.

2.5 Test specimen

The testing procedure can be used for measurements at any location without advance preparation.

A sprayed concrete layer of no less than 100 mm thickness is required for testing.

2.6 Conversion curves

Appendix A of this user guide contains a graph of conversion curves to enable the calculation of the equivalent compressive strength (MPa) of the concrete from a penetrometer force reading (N).

This graph is derived from the example calibration curves provided in EN 14488-2 Annex A (informative) of the test standard.

Two linear curves and their associated formulae are reproduced for two typical aggregate mixes of <8 mm and <=16 mm respectively. The compressive strength value on the y-axis may be derived from a resistance force reading on the x-axis either by direct extraction from the curve, or calculation via the appropriate formula, as indicated.

These curves are provided as reference examples based on data published in the standard, however the individual concrete mix will affect the accuracy of the approximation. The user is at liberty to implement their own correlation function if this would be more appropriate.

3. Penetrometer Test Procedure

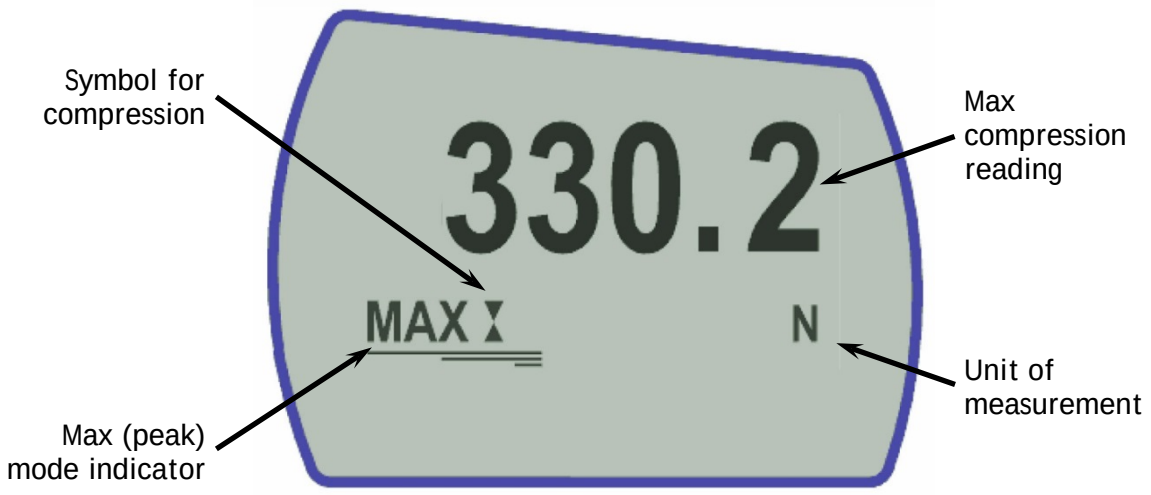
The testing procedure of EN ISO 14488-2 (Method A) is repeated at several time intervals, for example at 5, 20, 40, 60 and 120 minutes, or up to the time when the calculated compressive strength values still remain below 1.5 MPa.

NOTE: When the calculated compressive strength values increase to above 1.5 MPa, the penetrometer procedure is no longer applicable, as this indicates the concrete has cured beyond the initial strength development phase. Please refer to the full test standard for more information.

3.1 Prepare the penetrometer

The penetrometer is supplied with the gauge ready to use for compressive strength evaluation. Please refer to the Advanced Force Gauge Operating Manual if necessary, to apply the following conditions:

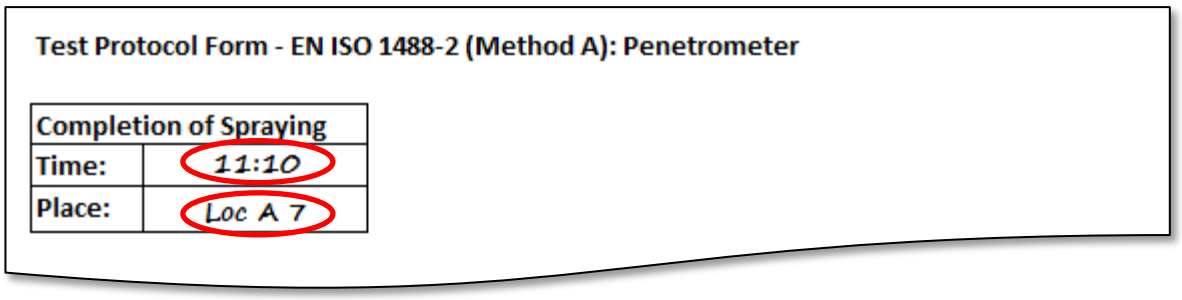
1. The penetrometer is set to record maximum (peak) readings.
2. The unit of measurement is set as appropriate for the conversion formula/curve (Newton).
3. The display is oriented to be conveniently read (inverted).



3.2 Prepare the test protocol form

Obtain a new, blank, test protocol form and record:

1. the time of the completion of spraying
2. the place of spraying.



Test Protocol Form - EN ISO 1488-2 (Method A): Penetrometer

Completion of Spraying	
Time:	11:10
Place:	Loc A 7

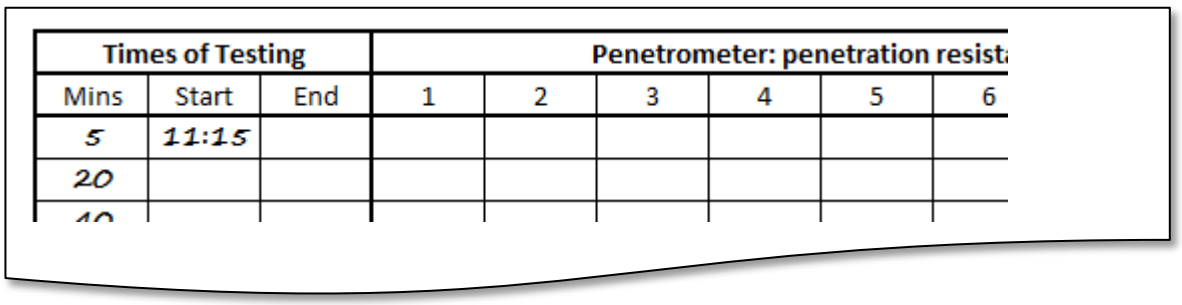
3.3 Test the concrete at ten sample locations

Prepare the sample data row

To calculate the single representative value for the compressive strength of the shotcrete at each test instance, 10 individual samples are taken with the penetrometer.

The data are entered into a row on the test protocol form against the timestamp, for example at 5, 20, 40, 60, 120 minutes.

Record the start time of the testing, for example at 5 minutes, enter the time in the cell as indicated below:

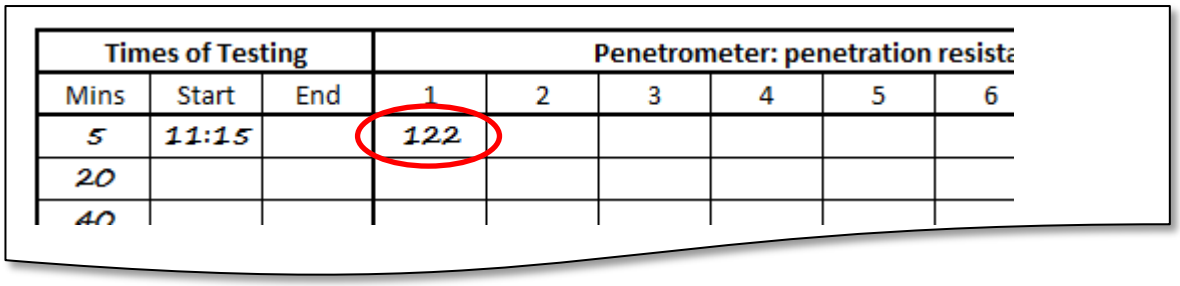


Times of Testing			Penetrometer: penetration resist					
Mins	Start	End	1	2	3	4	5	6
5	11:15							
20								
40								

Take the ten readings

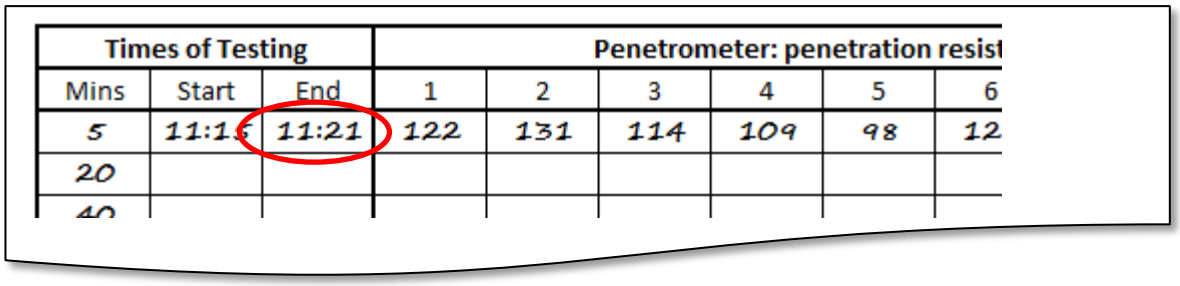
For each sample reading perform the following steps:

1. Ensure the penetrometer indicator is set to zero.
2. Select an area representative of the sprayed region.
3. Apply the device perpendicularly to the surface of the sprayed concrete layer and steadily push in the needle to a depth of 15 mm in a single continuous movement. If this is prevented, for instance because of a large aggregate particle or reinforcement, then discontinue and repeat in an adjacent location.
4. Read the maximum compressive (resistance) force from the display.
5. Record the value on the protocol form in the next column entry position on this time occurrence row:



Times of Testing			Penetrometer: penetration resista					
Mins	Start	End	1	2	3	4	5	6
5	11:15		122					
20								
40								

6. Clean the needle, if necessary.
7. Reset the penetrometer to the initial condition, as at point 1, above.
8. Repeat the test ten times as quickly as possible (and within one minute for strengths below 0.5 MPa) recording the force in the next cell on the test protocol form.
9. Record the end time for this timestamp:



Times of Testing			Penetrometer: penetration resist					
Mins	Start	End	1	2	3	4	5	6
5	11:15	11:21	122	131	114	109	98	12
20								
40								

4. Expression of Results

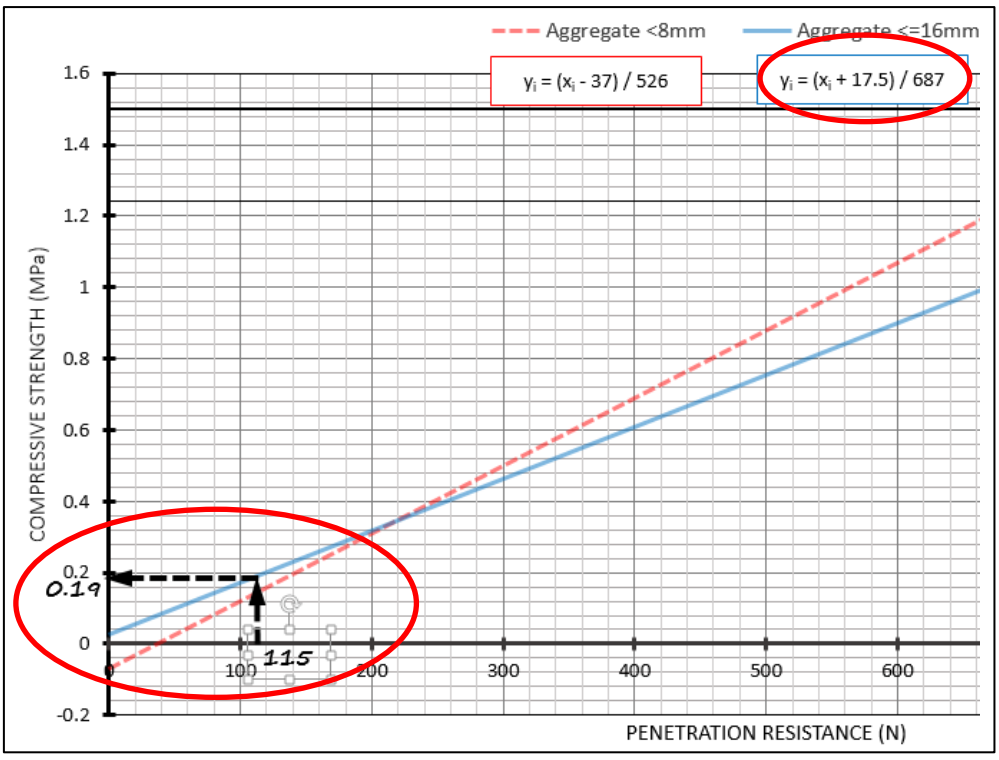
4.1 Calculation of compressive strength

For each of the performed test process cycles:

1. Calculate the mean resistance force from the ten readings on the form, and enter the value in the appropriate cell:

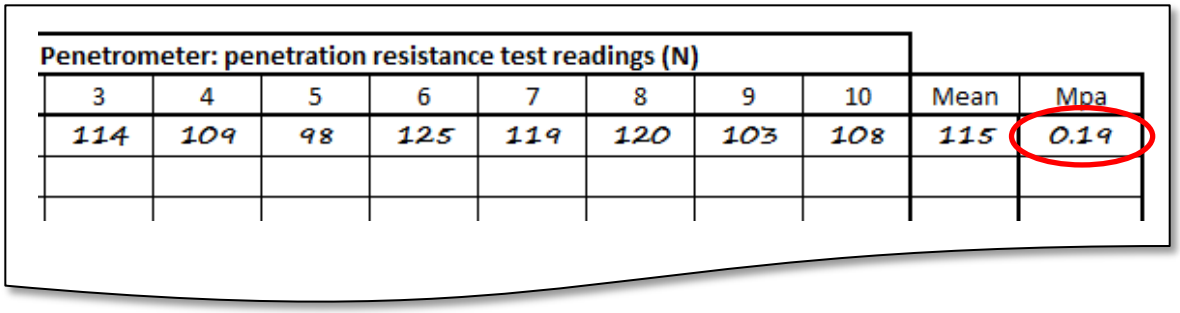
Penetrometer: penetration resistance test readings (N)										
1	2	3	4	5	6	7	8	9	10	Mean
122	131	114	109	98	125	119	120	103	108	115

2. Derive the estimated compressive strength, using the mean resistance force value, from the relevant conversion curve or formula. In the example below, the conversion relating to a mix with aggregate size less than or equal to 16 mm has been used (115 N ≡ 0. 19 MPa):



NOTE: Extrapolation beyond the limits on the conversion curve is not permitted (1.5 MPa).

3. Record the compressive strength value in the appropriate cell on the test protocol form:



Penetrometer: penetration resistance test readings (N)									
3	4	5	6	7	8	9	10	Mean	Mpa
114	109	98	125	119	120	103	108	115	0.19

4.2 Test report

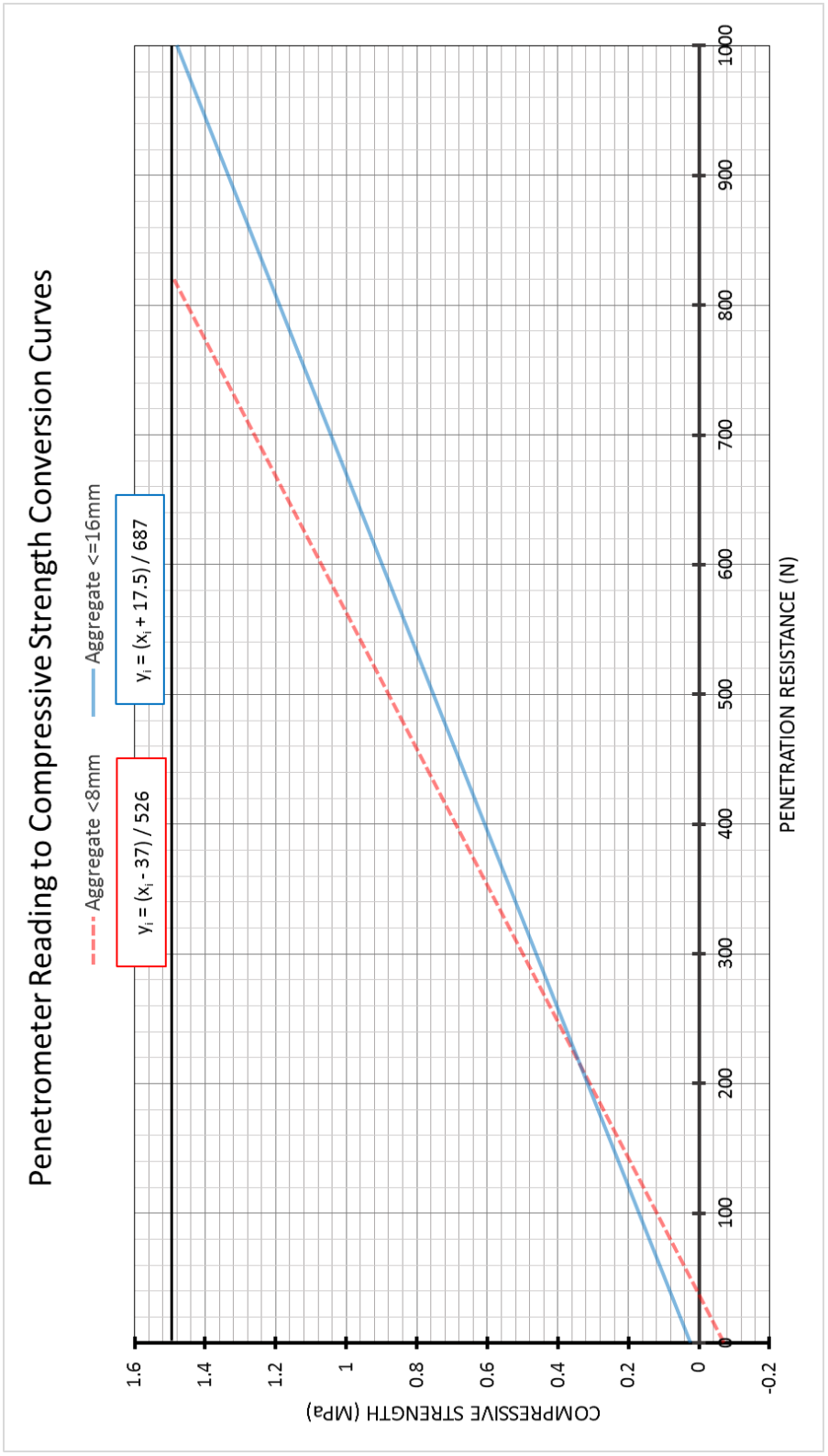
The test report for EN ISO 14488-2 (Method A) shall include:

1. test protocol form
2. description of the location and date of testing
3. type and serial number of the test equipment
4. times of completing spraying, and start and finish of testing, to the nearest minute
5. ten measurements of resistance force, and the mean value to nearest 10 N.

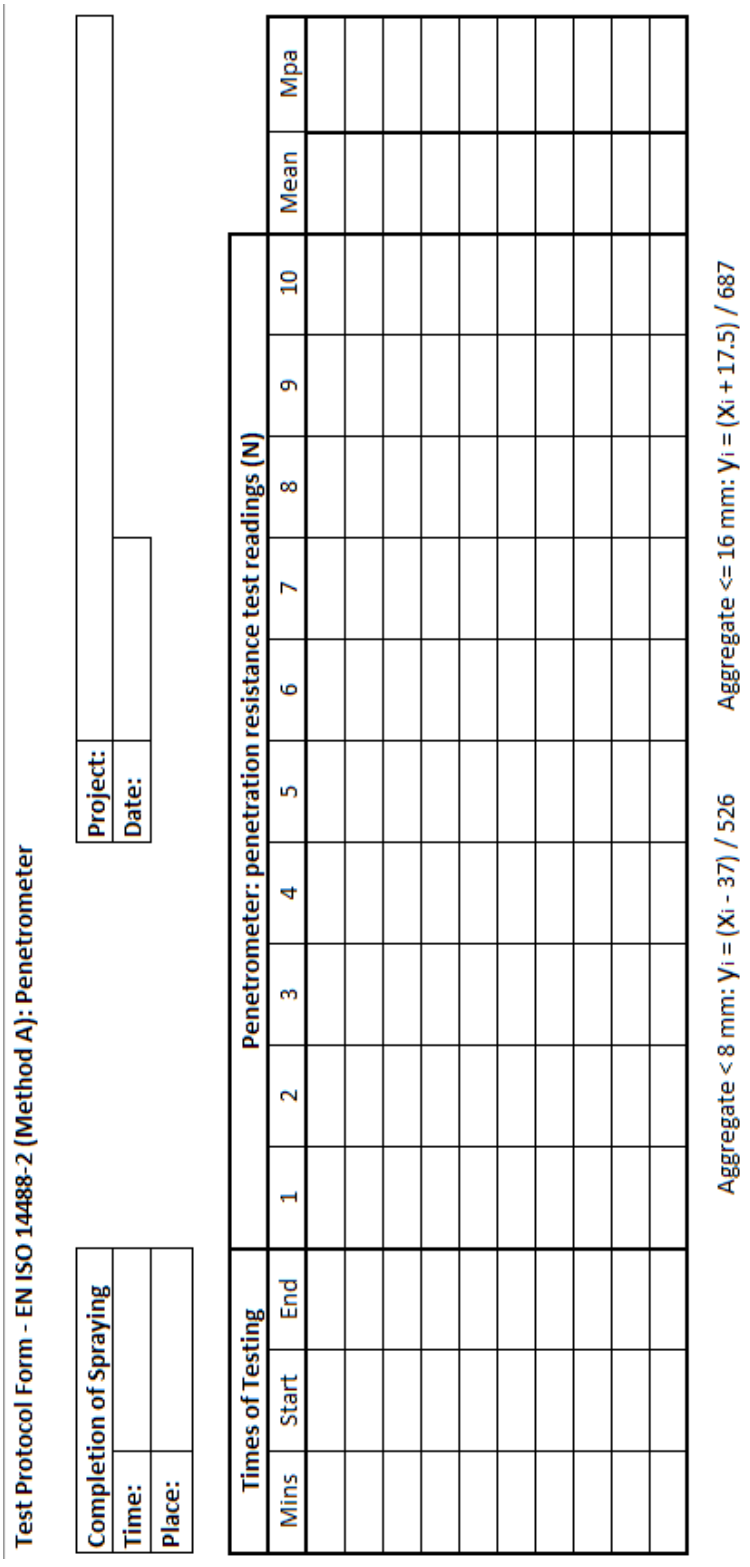
4.3 Usage of the Method A test report

On completion of the initial strength development phase, the Method A test report will indicate a number of calculated compressive strength values for several time points. These data should be plotted on a graph, with the similar data from Method B of the standard, to indicate the evolution of the compressive strength over time. This complete graph can then be used to categorise the concrete product to the specific strength classes according to EN 14487-1 or equivalent standards.

Appendix A
Conversion Curves Graph



Appendix B
Example Blank Test Protocol Form



Test Protocol Form - EN ISO 14488-2 (Method A): Penetrometer

Completion of Spraying	
Time:	
Place:	

Project:	
Date:	

Times of Testing		Penetrometer: penetration resistance test readings (N)											
Mins	Start	End	1	2	3	4	5	6	7	8	9	10	Mean	Mpa

Aggregate < 8 mm: $y_i = (X_i - 37) / 526$

Aggregate <= 16 mm: $y_i = (X_i + 17.5) / 687$

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