VARIOUS TEST METHODS FOR CHARACTERISING THE ANCHOR PULL-THROUGH RESISTANCE IN MINERAL WOOL

VERSCHIEDENE PRÜFVERFAHREN ZUR CHARAKTERISIE-RUNG DES ANKERDURCHZUG-WIDERSTANDS IN MINERALWOLLE

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SUMMARY

This paper reports on a comparative study of the behaviour of mineral wool in pull-through tests with plate anchors (Ø 60 mm) compared to compression tests with a steel punch of the same diameter. Two different test methods were used for the pull-through tests.

The aim of the work was to show the differences between these 3 test methods with regard to the amount of pull-through force and the course of the deformation curve. In particular, the test method using a steel punch was to be assessed for its suitability as a simpler test method that could be used, for example, as a so-called manufacturer's method within the framework of quality monitoring during production in a manufacturing plant. Performed experiments have shown that this method with a steel punch is in no way inferior to the other two test methods in terms of its informative value about the material quality.

ZUSAMMENFASSUNG

Die vorliegende Arbeit berichtet über eine vergleichende Untersuchung zum Verhalten von Mineralwolle bei Durchzugsversuchen mit Tellerdübeln (Ø 60 mm) gegenüber Druckversuchen mit einem Stempel aus Stahl gleichen Durchmessers. Bei den Durchzugsversuchen kommen 2 unterschiedliche Prüfverfahren zur Anwendung.

Ziel der Arbeit war es einmal die Unterschiede dieser 3 angewendeten Prüfverfahren hinsichtlich Höhe der Durchzugskraft sowie Verlauf der Verformungskennlinie darzustellen. Außerdem sollte hierbei die Prüfmethode mittels Stahlstempel auf ihre Eignung als einfacheres Prüfverfahren, das zum Beispiel im Rahmen der produktionsbegleitenden Qualitätsüberwachung in einem Herstellwerk als sogenanntes Herstellerverfahren zur Anwendung kommen könnte, beurteilt werden.

Es konnte exemplarisch gezeigt werden, dass die Methode mit dem Stahlstempel in seiner Aussagefähigkeit über den Dübeldurchzugswiderstand den beiden anderen Prüfverfahren in nichts nachstand.

1. INTRODUCTION

In external thermal insulation composite systems (ETICS) thermal insulation boards are usually glued but often additionally fastened with plate anchors. In the context of the proof of stability (general building authority approval) or in the monitoring of product quality (factory production control), the pull-through test, as described in this article, plays a certain role. In this study three test procedures are considered and compared with each other in regard of this purpose:

A: the test procedure in accordance with EAD 040083-00-0404:2019 [1], formerly ETAG 004
B: Modified test procedure based on the method according to EN 16382:2017 [2]
C: Modified test procedure based on the method according to EN 12430:2013 [3]

2. TEST METHODS USED AS PULL-THROUGH RESISTANCE

2.1 A: Method according to EAD 040083-00-0404 (ETAG 004)

The thermal insulation test sample, measuring 350 mm x 350 mm, with an anchor driven through the centre point of the sample, is fixed by hot melt adhesive on a rigid plywood sheet. The head of the anchor (Ø 60 mm) sits in the plane of the adhesive layer, but can move freely enabled by a drilled hole (Ø 80 mm) in the plywood sheet.

The plywood sheet is fastened at the base of the tensile testing machine, which is pulling the anchor through the mineral wool at a traction rate of 20 mm/min during the test. In this way, the plate anchor (Fig. 1) is moving through the thermal insulation material as the material may break out in a cone shape at the end.

Fig. 1: Metal plate anchor used

2.2 B: Method based on EN 16382 (pull-through resistance)

The structure of a single test specimen according to EN 16382:2017 is complex and therefore comparatively elaborate. Here is the brief description of the required construction of the test specimen.

The edges of the thermal insulation material are framed by two square templates with a central round opening held together by special clamps. The square templates provided with round recesses shall be resistant to bending. Suitable materials for templates are e.g. laminated wood plates with a thickness of at least 20 mm.

The anchor is placed in the centre of the sample. The plate of the anchor is covered with a non-adhesive foil beforehand.

The round load introduction plate, which fits exactly into the round opening of the upper template, is glued onto the upper side of the thermal insulation material. The tensile load is applied to the thermal insulation material through the round load introduction plate at a pulling rate of 20 mm/min during the test. The plate anchor is fastened at the base of the tensile testing apparatus.

The dimension for the side length *b* of the square template and of the sample shall be at least 50 mm larger than the diameter *ds* of the round recess of the template.

The minimum diameter of the round recess in the template *ds* is calculated from the diameter of the anchor plate *dp* and the thickness *tl* of the tested thermal insulation material as follows:

$ds \geq dp + 2\times tl + 50$ in mm

where

ds is the diameter of the circular recess in the template, in mm;
dp the diameter of the anchor plate taking into account additional plates, if used, in mm;
tl is the thickness of the thermal insulation material, in mm.

The modified method used in the study is related to the way of load introduction.

The main difference is that the tensile force acts directly on the anchor and thus the plate anchor (Fig. 1) is pulled through the thermal insulation material as with method **A**. The thermal insulation test sample, measuring 350 mm x 350 mm, with an anchor driven through the centre point of the sample, lies on a substrate (e.g. laminated wood plate), which has a drilled hole (Ø 80 mm) in the middle. So, the plate anchor can move freely. On top of the test sample is the template with the corresponding circular recess (diameter $ds \geq dp + 2\times tl + 50$ in mm). The substrate, which is attached at the base of the testing machine, and the template are held together by screw clamps in the corners.

2.3 C: Method based on EN 12430 (point load test)

Following the test procedure according to EN 12430:2013 no plate anchor is used with the method **C**. Instead of that a cylindrical steel punch with a diameter of Ø 60 mm replaces the plate anchor, by which the testing machine working in the compression mode introduces the force at a loading rate of 20 mm/min during the test.

The test sample is located on a template with a round recess ($ds \geq dp + 2\times tl + 50$ in mm) as used with method **B**.

3. THERMAL INSULATION MATERIAL

For this comparative study two products of mineral wool thermal insulation boards with nominal thicknesses of 50 mm (**1**) and 80 mm (**2**) were selected. The average density was 184 kg/m³ (**1**) and 171 kg/m³ (**2**), respectively.

The structure of the mineral wool could be regarded as created by stone fibres mainly “lying”.

Both of the chosen thermal insulation products are specified by some properties in Table 1.

Table 1: Characteristics of the Selected Thermal Insulation Board Types

Property	**Standard**	**Unit**	**Types**	
			1	**2**
Thickness	EN 823	mm	51	79
Density	EN 1602	kg/m³	184	171
Tensile Strength	EN 1607	kPa	24	23
Compressive Strength at 10 % Deformation	EN 826	kPa	100	95

4. TEST RESULTS

The following Tables 2, 3 and 4 contain the test data on density and maximum force observed. The mean value and the value on the difference between maximum force and minimum force is also listed.

Table 2: A: Method according to EAD 040083-00-0404 (ETAG 004)

Type - Test specimen	**Thickness**	**Density**	**Maximum of Force**
No.	mm	kg/m³	N
1 - 1 1 - 2 1 - 3	50 51 50	183 181 187	801 999 932
Mean Value	50	184	911
Maximum - Minimum	---	6	198
2 - 1 2 - 2 2 - 3	79 79 79	169 164 178	877 959 1079
Mean Value	79	170	972
Maximum - Minimum	---	9	202

Table 3: B: Method based on EN 16382 (pull-through resistance)

Type - Test specimen	**Thickness**	**Density**	**Maximum of Force**
No.	mm	kg/m³	N
1 - 1 1 - 2 1 - 3	51 51 51	181 187 182	812 845 865
Mean Value	51	183	841
Maximum - Minimum	---	6	53
2 - 1 2 - 2 2 - 3	79 79 79	178 174 168	954 1024 959
Mean Value	79	10	979
Maximum - Minimum	---	10	70

Table 4: C: Method based on EN 12430 (point load test)

Type - Test specimen	**Thickness**	**Density**	**Maximum of Force**
No.	mm	kg/m³	N
1 - 1 1 - 2 1 - 3	50 51 50	183 181 187	801 999 932
Mean Value	50	184	911
Maximum - Minimum	---	6	198
2 - 1 2 - 2 2 - 3	79 79 79	169 164 178	877 959 1079
Mean Value	79	170	972
Maximum - Minimum	---	9	202

The following diagrams from Fig. 2 to 7 show the force-strain curves obtained.

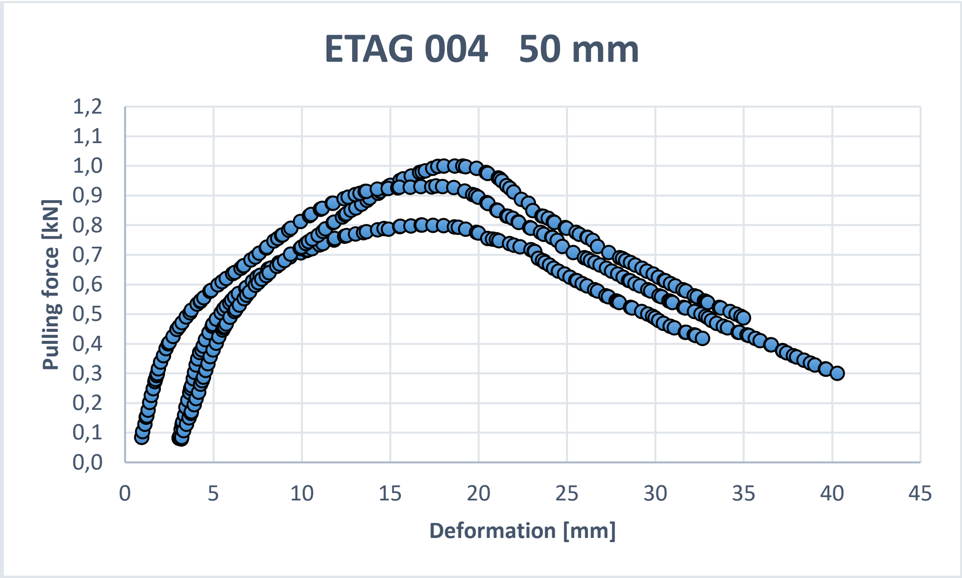

Fig. 2: Force-strain curve of 50 mm thick MW board type 1

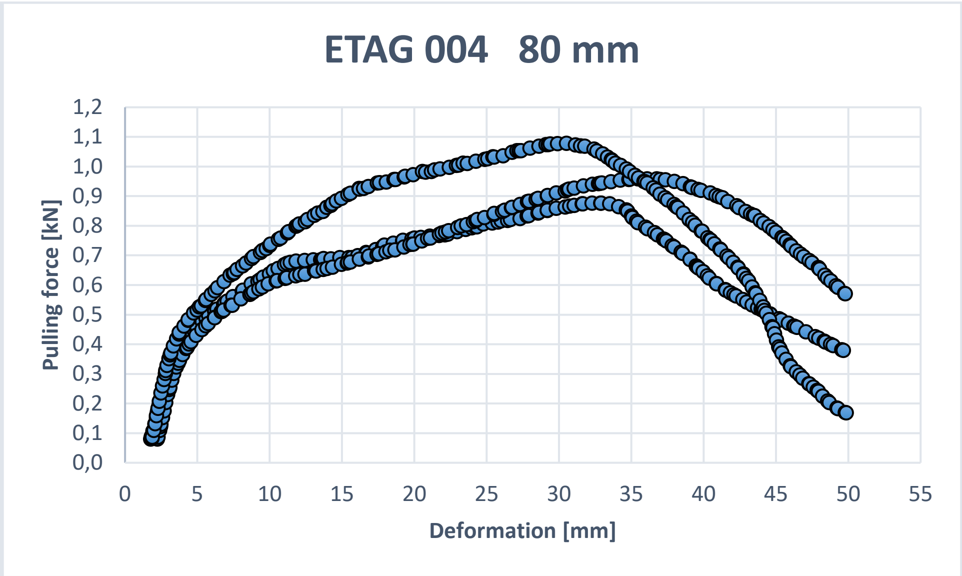

Fig. 3: Force-strain curve of 80 mm thick MW board type 2

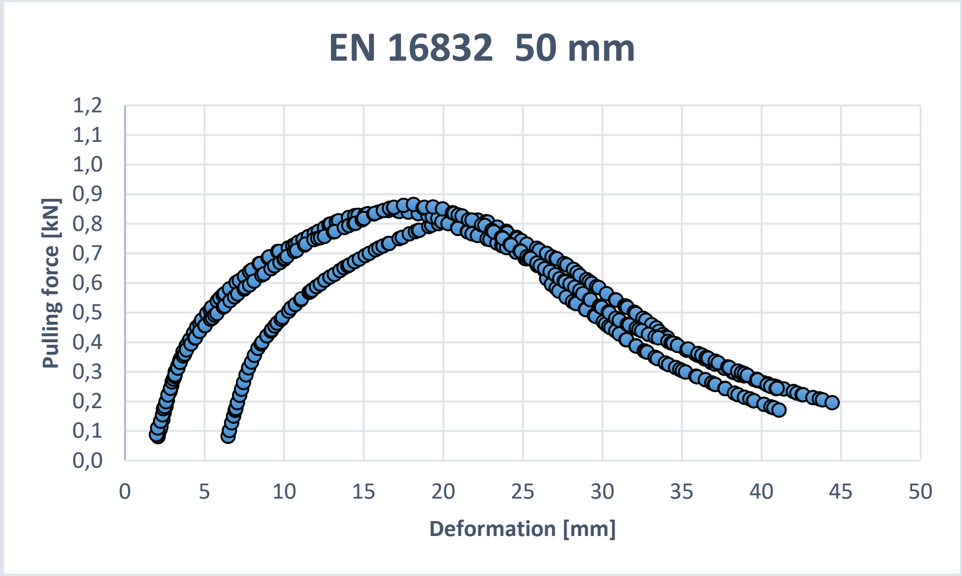

Fig. 4: Force-strain curve of 50 mm thick MW board type 1

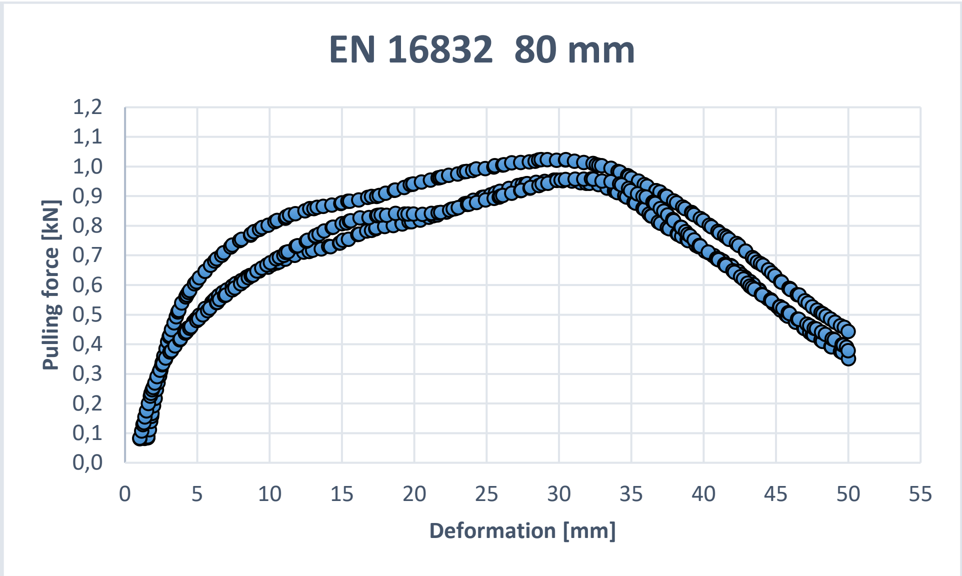

Fig. 5: Force-strain curve of 80 mm thick MW board type 2

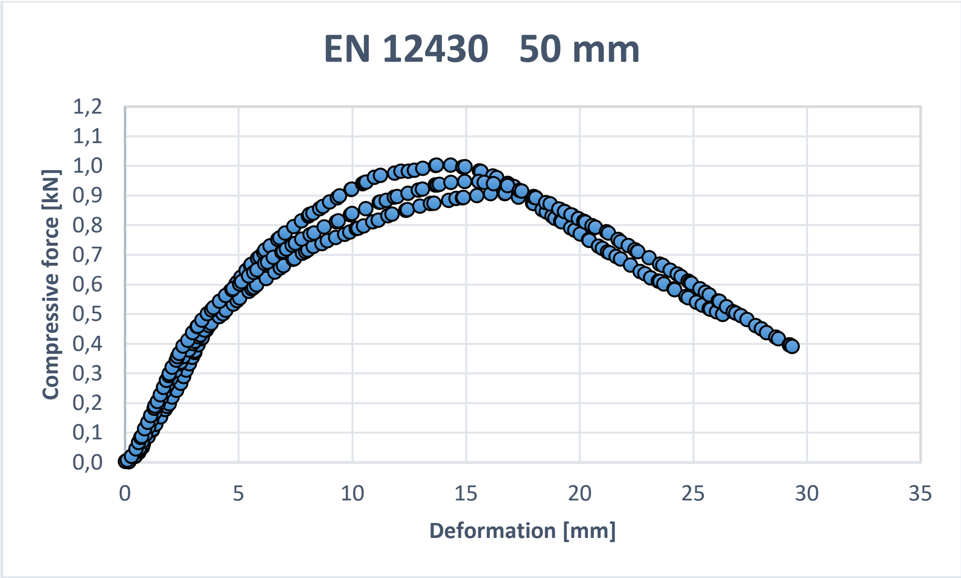

Fig. 6: Force-strain curve of 50 mm thick MW board type 1

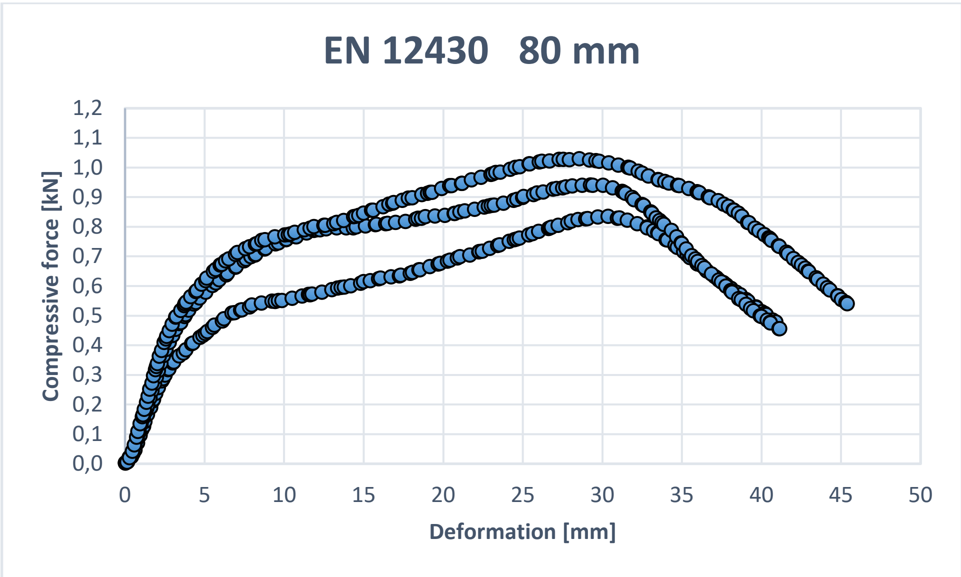

Fig. 7: Force-strain curve of 80 mm thick MW board type 2

The following images from Fig. 8 to 19 show exemplarily the condition after the test of one of the test samples, respectively.

A: Method according to EAD 040083-00-0404 (ETAG 004)

Fig. 8: Lower side of 50 mm test assembly

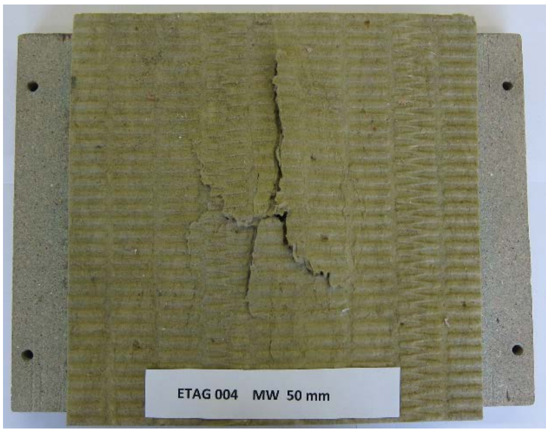

Fig. 9: Upper side of 50 mm test specimen

Fig. 10: Lower side of 80 mm test assembly

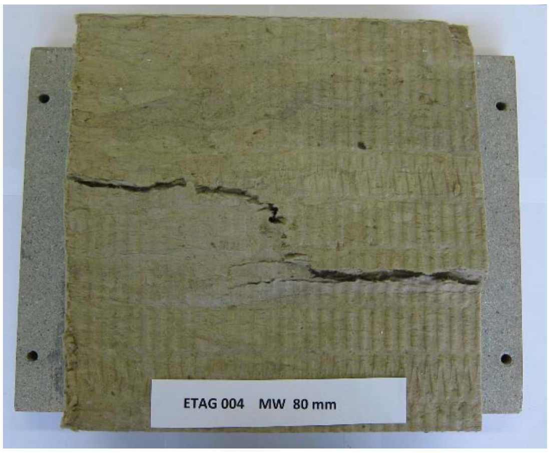

Fig. 11: Upper side of 80 mm test specimen

B: Method based on EN 16382 (pull-through resistance)

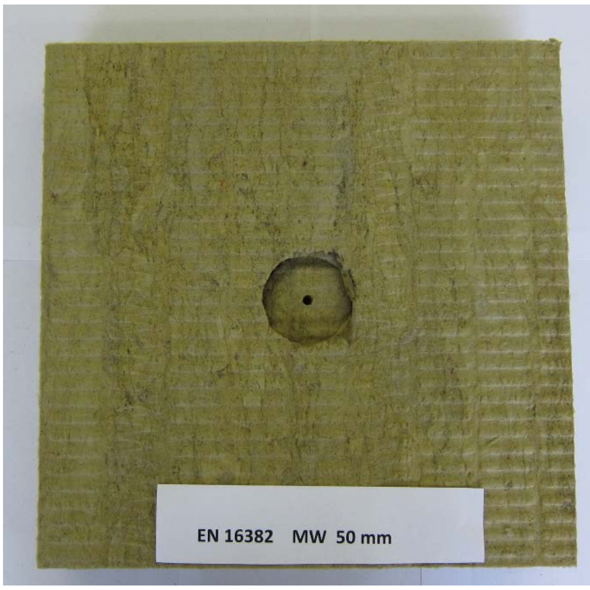

Fig. 12: Lower side of 50 mm test specimen

Fig. 13: Upper side of 50 mm test specimen

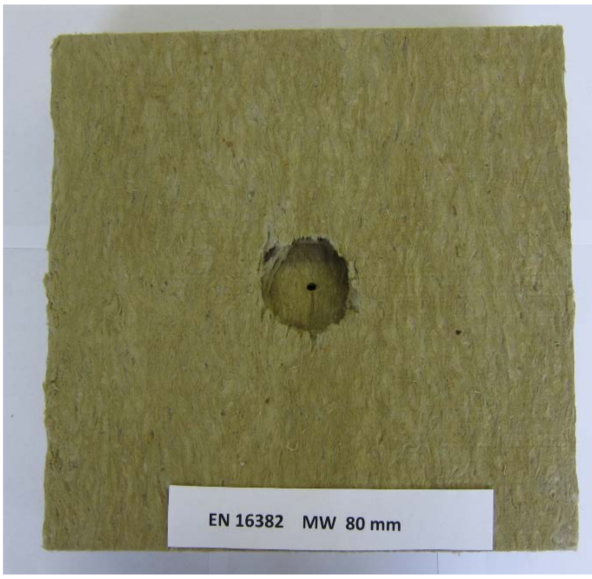

Fig. 14: Lower side of 80 mm test specimen

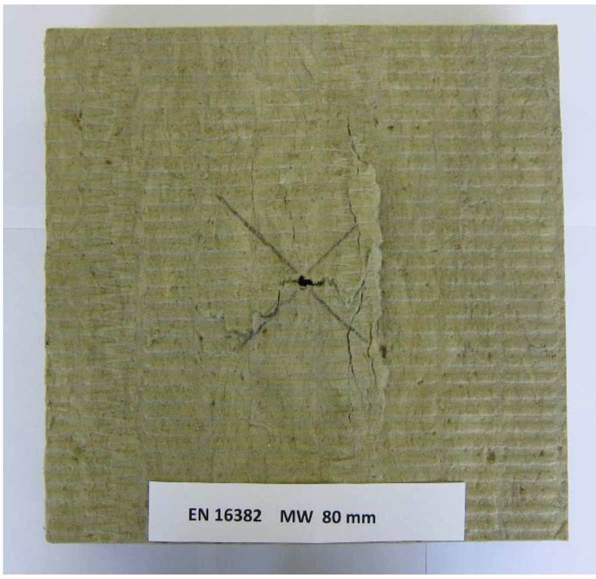

Fig. 15: Upper side of 80 mm test specimen

C: Method based on EN 12430 (point load test)

Fig. 16: Lower side of 50 mm test specimen

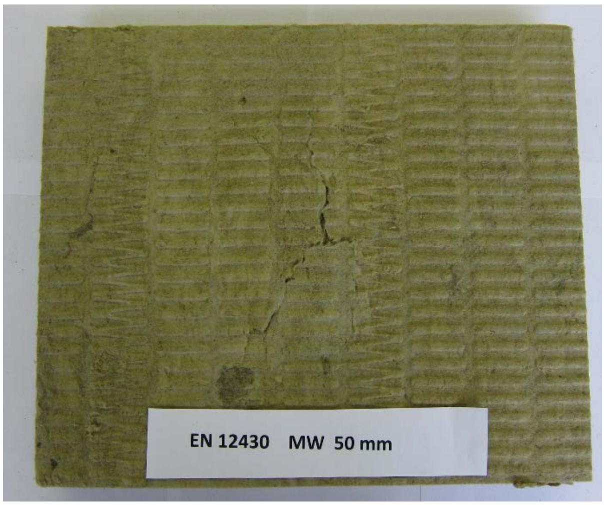

Fig. 17: Upper side of 50 mm test specimen

Fig. 18: Lower side of 80 mm test specimen

Fig. 19: Upper side of 80 mm test specimen

5. CONCLUSION

Based on the obtained results the following statements on the behaviour and the pull-through resistance of the selected material from mineral wool can be made.

- It can be concluded that the behaviour of the mineral wool can be realistically captured with all three test methods used. The curves of the force-elongation curves differed only insignificantly.
- The observed maximum values of force largely lie in the same range, that means, no significant difference among the three test methods used can be recognized.
- The scattering of the maximum values of force points out that the mineral wool is relatively inhomogeneous (Fig. 20).

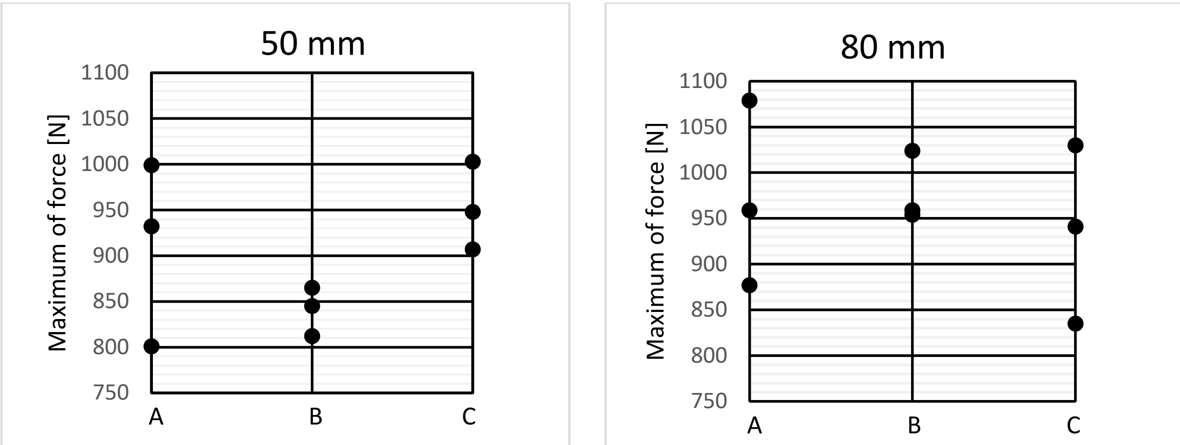

Fig. 20: Distribution of the maximum values in comparison of the three methods used

- In particular, the present comparative study suggests that the easily performed test method C with the metal punch may be an equivalent alternative routine test method to be used in certain areas.

It can be assumed that tests with an insulation material that proves to be more homogeneous (e.g. wood fibre boards or EPS boards) will provide clearer evidence of the statements made.

REFERENCES

[1] European Assessment Document EAD 040083-00-0404:2019 External Thermal Insulation Composite Systems (ETICS) with Rendering (ETAG 004 Guideline for European Technical Approval of External Thermal Insulation Composite Systems (ETICS) with Rendering)

[2] EN 16820:2017 Thermal insulating products for building applications – determination of the pull-through resistance of plate anchors through thermal insulation products

[3] EN 12430:2013 Thermal insulating products for building applications – determination of behaviour under point load