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REPORT Z-17-018

PROJECT OF APPLIED RESEARCH

INFLUENCE OF HYGROTHERMAL CYCLES TO MECHANICAL CHARACTERISTICS MW AND EPS BOARD FRAGMENTS WITH REINFORCED BASE COAT FOR ETICS

Applicant:

Bachl, spol. s r.o.

Evropská 669, 664 42 Modřice

IČO: 145 03 603

Contractor of research:

Building Research Institute – Certification Company, Ltd.
Pražská 16. 102 21 Prague 10 - Hostivař

Prague: 2017-12-27

ZKUŠEBNÍ LABORATOŘ VÚPS certifikační společnost

Ing. Tomáš Langer

Head of Testing Laboratory

1. REPORT SUBJECT

Goal of project is verify stability of properties of ETICS fragments without coat by conditions simulate climatic and operating load ETICS fragments appllied outside building constructions.

This report summarize measured test results of influence hygrothermal cycles to mechanical characteristics thermal insulations (mineral wool and EPS) with reinforced base coat. Tested parameters were tensile strenght perpendicular to faces and shear behaviour with modulus of elasticity. Report contains description of conditioning test samples by hygrothermal cycles, procedure of determination tested characteristics and posted measured values.

2. DESCRIPTION AND IDENTIFICATION OF TEST SAMPLES

2.1 Sampling representatives testing materials

Test samples were chosen representatives thermal insulation with thickness 140 mm and applied reinforced base coat.

After agreement with applicant were chosen these products as representatives:

- Mineral wool Knauf FKD S Thermal with nominal dimmensions (600 x 1000) mm and nominal thickness of product 140 mm;

- Expanded polystyrene Bachl EPS 70 Facade, thickness 140 mm;

- Adhesive VISCOflex 500 for ETICS (part of certified system ETICS VISCO alfa a VISCO beta);

- Glass fibre mesh VERTEX R131 (1.1 x 50) m. R 131 A101 - 160 g/m^2, the mesh size (3.5 x 3.8) mm.

Sampling of chosen representatives were made at trade by contractor´s workers. Trade were on 2016-08-18 and 2016-09-06, Seller Montako - obchod s.r.o, Vodárenská 732, 278 01 Kralupy nad Vltavou. During sampling were present representative of applicant. Total inventory were more than ten times higher than value of sampled samples. All sampled products were of the same batch.

Total amount of sampled representatives:

- mineral wool Knauf FKD S Thermal TR10 - 12 package => 24 boards

- expanded polystyrene Bachl EPS 70 Facade - 8 packages => 24 boards

- Adhesive VISCOflex 500 - 5 packages => 125 kg

- glass fibre mesh VERTEX R131 - 1 roll

All sampled samples were bought in original packages. By sampling were all individual boards indelibly marked by sample number.

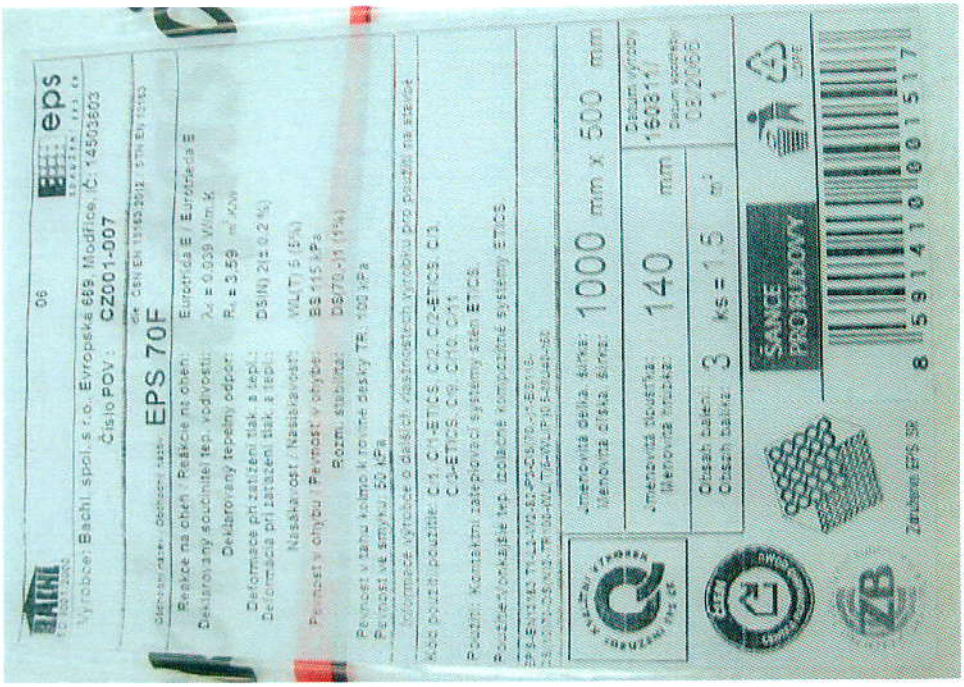
- mineral wool sampling -

2.2 Identification of thermal insulation products

Knauf FKD S Thermal:

MW-EN 13162-T5-CD/10/10-TR10-WS-WL(P)-MU1. Production date 150313. Producer Knauf Insulation s.r.o., Nová Baňa, Slovakia

Bachl EPS 70 Facade :
EPS-EN13163 T1-L2-W2-S2-P3-DS(70.-)1-BS115-CS(10)70-DS(N)2-TR100-WL(T)5-WL(P)0.5-MU40-t50. Production date 160811. Producer Bachl, spol. s r.o., Modřice, Czech Republic



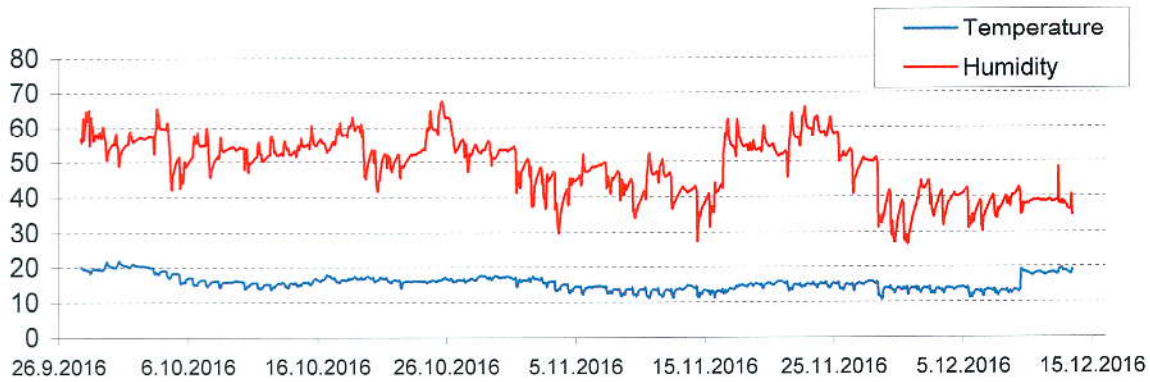
2.3 Preparing of test samples

Preparing of test samples from sampled products made representative of applicant.

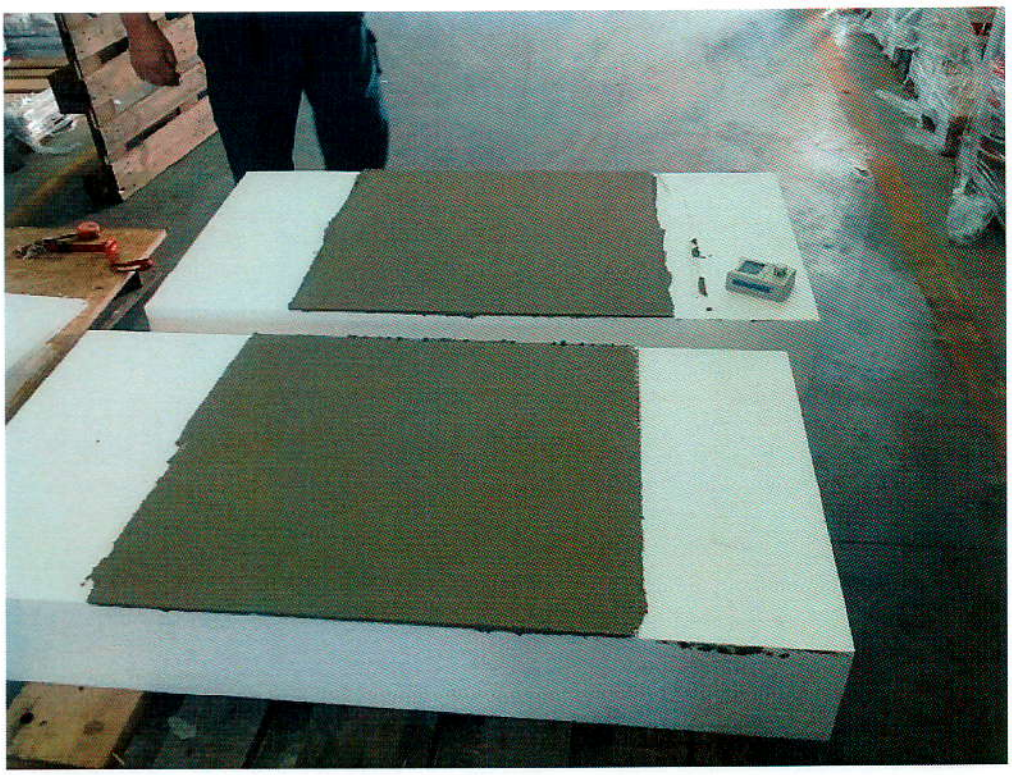
Test samples were completed from thermal insulation product with thickness 140 mm, glass fibre mesh VERTEX R131 and adhesive VISCOflex 500.

Preparing of test sample was performed in company VISCO s.r.o. on 2016-09-27, 2016-10-18 and 2016-10-19. Samples were after application of reinforced base coat stored in company VISCO during time of maturation. Contractor was monitoring air temperature and relative air humidity at place of maturation. Temperature interval was (10 - 20) °C, humidity (30 - 70) %. Between 2016-12-08 and 2016-12-12 was reinforced base coat brushed by applicant´s representatives and cut to dimmension (500 x 500) mm. On 2016-12-13 were samples packed into protection foil and transfered to contractor´s laboratory.

Monitoring of condition during maturation of reinforced base coat



- application of reinforced base coat of ETICS -



- application of reinforced base coat of ETICS -

Test samples delivered to laboratory:

Each package was marked by individual evidence number, individual boards were after that marked by letters.

- 18 pcs boards of mineral wool Knauf FKD S Thermal, thickness 140 mm with reinforced base coat VERTEX R131 + VISCOflex 500.
  Evidence numbers: 194/16 A, B to 202/16 A, B;
- 6 boards of mineral wool Knauf FKD S Thermal thickness 140 mm in original package.
  Evidence numbers: 203/16 A, B to 205/16 A, B;
- 18 ks boards of expanded polystyrene Bachl EPS 70 Facade, thickness 140 mm with reinforced base coat VERTEX R131 + VISCOflex 500.
  Evidence numbers: 262/16 A, B, C to 267/16 A, B, C;
- 6 ks boards of expanded polystyrene Bachl EPS 70 Facade, thickness 140 mm in original package.
  Evidence numbers: 268/16 A, B, C and 269/16 A, B, C;

All samples were delivered without visual defects, which could affect test results.

All groups of samples were sort into samples for identification, for reference and for tests after hygrothermal cycling.

Sorting of test samples:

Material	Sorting	Test sample no.
Mineral wool	Identification tests	204/16 A, 204/16 B 205/16 A, 205/16 B
Mineral wool	Reference tests	196/16 A 196/16 B
Mineral wool	Hygrothermal cycling	194/16 B, 199/16 B, 200/16 A, 201/16 A, 201/16 B, 202/16 A
Expanded polystyrene	Identification tests	268/16 A, 268/16 B, 268/16 C
Expanded polystyrene	Reference tests	262/16 A, 263/16 A, 263/16 C
Expanded polystyrene	Hygrothermal cycling	262/16 B, 263/16 C, 265/16 C 266/16 B, 266/16 C, 267/16 A

Rest of test samples was stored in laboratory conditions 23/50 as deposit samples for project.
During test was used one deposit sample 263/16 C for repeating reference tests of shear behaviour lengtwise.

3. METHODICS OF MEASUREMENT

3.1 Tested characteristics

Within project were determinate following characteristics:

Identification tests of thermal insulation products performed on samples without reinforced base coat:

- determination of tensile strenght perpendicular to faces for samples of mineral wool
- determination pressure strenght by 10% compression for boards of expanded polystyrene

On samples with reinforced base coat were performed tests:

Determination of tensile strenght perpendicular to faces for EPS and MW:

- on samples without cycling;
- on dryed samples after 15 hygrothermal cycles;
- on wet samples after 15 hygrothermal cycles;

Determination of shear behaviour and modulus of elasticity:

- samples without cycling, cut out of the board lenghwise;
- samples without cycling, cut out of the board transverse;
- on dryed samples after 15 hygrothermal cycles, cut out of the board lenghwise;
- on dryed samples after 15 hygrothermal cycles, cut out of the board transverse;
- on wet samples after 15 hygrothermal cycles, cut out of the board lenghwise;
- on wet samples after 15 hygrothermal cycles, cut out of the board transverse;

3.2 Aging process – hygrothermal cycles

In response to determined application boards for ETICS and their hygrothermal load on buildings was chosen process of hygrothermal aging of boards. Aging contains alternate wetting of boards by higher temperature and freezing of boards.One cycle contains phase of wetting and phase of freezing. After end of each individual phase is sample visually controled and is measured its weight. Duration of complete cycle is one week. Change of individual phases was held ever on Monday and Friday.

Influence of aging rated by determination of elementary mechanical characteristics important for function of product used as ETICS – shear behaviour and tensile strenght perpendicular to faces and comparision with values measured on reference boards. From measured influences was determined quantity of stability for monitored characteristics – graph of influence.

Default quantity of cycles before determination of mechanical characteristics on individual cycled samples was set after agreement with applicant at 15.

First aging phase - wetting

Sample was placed at water level temperated to (50 ± 1) °C, so under sample is 100% humidity. Outer surface was in laboratory conditions. Laboratory conditions were monitored. After taking sample out of the wetting device, surface water was delete by free dropping and after visual control was measured weight of sample.

Second aging phase - freezing

Sample was placed into freezing device (refrigator) at (-20 ± 2) °C in the same position like by wetting - orientation of sample was not change during whole cycling. Samples in freezing device were above themselves with 50 mm gap for air circulation. After that phase was sample visually controled and measured its weight.

Cycling was performed between 6.1.2017 and 21.4.2017.

4. MEASURED VALUES AND TEST RESULTS

In following paragraph is summary of test results – identification tests of tested materials, reference tests of samples with reinforced base coat and test results of samples with reinforced base coat after 15 hygrothermal cycles and it is posted weight increasing during cycling.

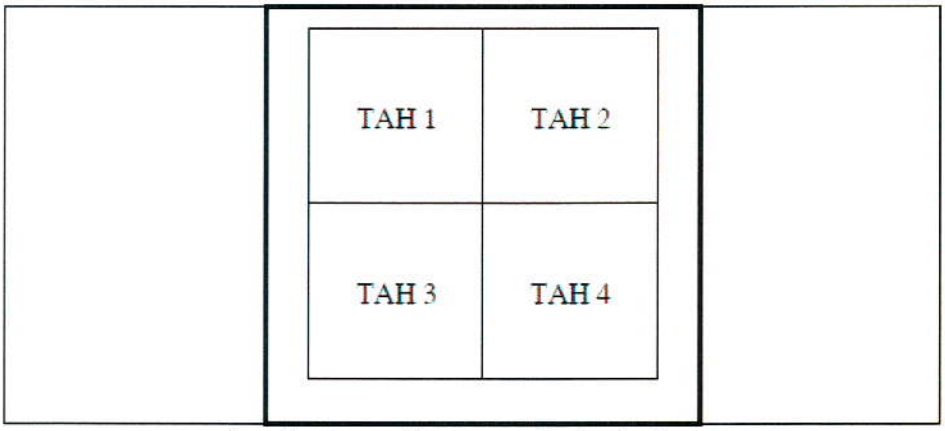
Determination of tensile strength perpendicular to faces was performed in accordance with ČSN EN 1607: 2013 - Thermal insulating products for building applications - Determination of tensile strength perpendicular to faces.

Determination of shear behaviour and modulus of elasticity was performed in accordance with ČSN EN 12090: 2013 - Thermal insulating products for building applications - Determination of shear behaviour ; double specimens method.

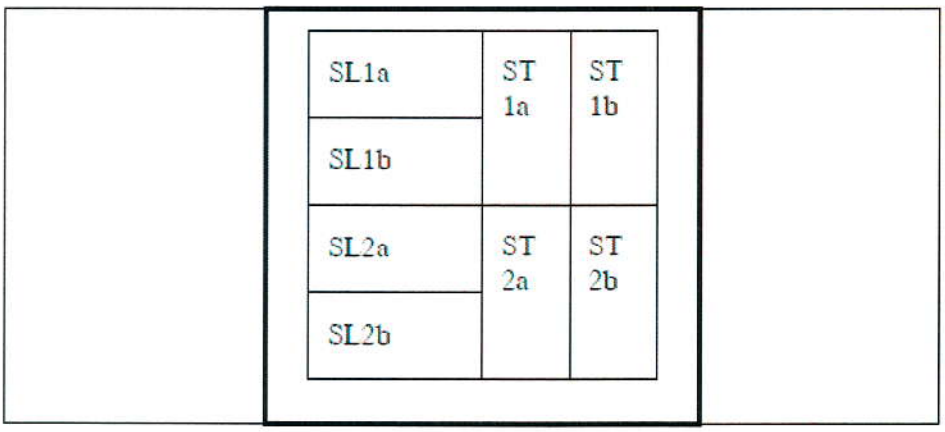
Pressure strenght by 10% compression was performed in accordance with ČSN EN 826:2016 - Thermal insulating products for building applications - Determination of compression behaviour

Sampling of specimen with reinforced base coat was in accordance with following schema:

Sampling of specimens was performed by band saw – from edge of test sample board was cut material 50 mm wide.



- tensile strength perpendicular to faces -



- shear behaviour -

SL – specimen cut lenghwise
ST – specimen cut transverse

4.1 Identification tests

4.1.1 Mineral wool - determination of tensile strength perpendicular to faces

Test was performed on test specimens without reinforced base coat, sample thickness 140 mm and dimmensions (300 x 300) mm. Surface of test specimens was without modification.

Test specimens were sampled from package marked 204/16 and 205/16. Each package contained 2 boards (A, B), of each board was sampled one specimen. Sampling was performed by cutting (band saw) from the middle of board.

Test samples were stored before test by laboratory conditions, air temperature = (22 ± 2) °C; RH = (55 ± 5).

Measured values and test results - **mineral wool Knauf FKD S Thermal (TR10)**

Sample no.	Tensile strenght perpendicular to faces σ_{mt} [kPa]	Type of failure
204/16 A	13.7	100 % MW
204/16 B	18.3	100 % MW
205/16 A	17.7	100 % MW
205/16 B	18.0	100 % MW
Test result - average value tensile strenght		**17 kPa**

All failure of test specimens were in 100 % of area MW.

Extended uncertainty of tensile strenght was stated as ± 5 $\%_{rel}$.

Declared value of tensile strenght perpendicular to faces posted on package label is 10 kPa.

Test results confirm suitability of chosen representative.

4.1.2 Expanded polystyrene - determination of compression behaviour by 10 % compression

Test was performed on test specimens without reinforced base coat, sample thickness 140 mm and dimmensions (150 x 150) mm. Surface of test specimens was without modification.

Test specimens were sampled from package marked 268/16. Each package contained 3 boards (A, B, C), of each board was sampled one specimen. Sampling was performed by cutting (band saw) from the middle of board.

Test samples were stored before test by laboratory conditions, air temperature = (22 ± 2) °C; RH = (55 ± 5).

Measured values and test results - **expanded polystyrene Bachl EPS 70 Facade**

Sample no.	Apparent density ρ_a **[kg/m^3]**	Compression behaviour σ_{10} **[kPa]**
268/16 A	15.0	73.7
268/16 B	14.6	74.2
268/16 C	14.8	74.0
Test result - average value compression behaviour		**74.0 kPa**

Extended uncertainty of compression behaviour was stated as ± 5 %$_{rel}$.

Declared value compression behaviour by 10 % compress posted on package label 70 kPa.

Test results confirm suitability of chosen representative.

4.2 Test on samples with reinforced base coat

Reference samples were stored before test by laboratory conditions, air temperature (22 ± 2) °C; RH = (55 ± 5) during more than 3 months.

Performation of reference tests were performed at the same time, by the same pocedures and by the same worker like tests of specimens of cycled samples.

Tests after hygrothermal cycling are differentiated to „wet" tests and „dry" tests.

„wet" test:

After hygrothermal cycling were test samples packed into vaporized PE foil and stored 14 days by laboratory conditions. Vaporized package ensured moisture of test samples AFTER CYCLING . After conditioning were samples unpackaged and prepared test samples from specimens. During preparation and fixing by adhesive were covered by PE foil. Tests were performed immediatelly after unpackaging of test samples.

„dry" tests:

After hygrothermal cycling were test samples dryed in hot air owen with circulation up to stable mass. Drying temperature was (65 ±5) °C. After drying were prepared test samples from specimens. During preparation and fixing by adhesive were placed by laboratory conditions 23/50.

Test results are in accordance with valid standards pointed as arithmetical average and given to two significant figures.

4.2.1 Determination of tensile strength perpendicular to faces

Test was performed on test specimens with reinforced base coat, sample thickness 140 mm and dimmensions (200 x 200) mm. Surface of test specimens was without modification.

„Wet" samples of EPS after hygrothermal cycling had damaged edges, so test samples dimmension were (100 x 100) mm. For mineral wool was possible use deposit cycled „wet" sample, for better comparison were tests performed on both sizes of test specimens.

Evaluation of type of failure was performed visually.

Measured values and test results - **mineral wool Knauf FKD S Thermal (TR10)**

Sample no.	Test type	Tensile strenght perpendicular to faces σ_{mt} [kPa]	Type of failure
196/16 A - T1	reference	16.4	100 % MW
196/16 A - T2	reference	19.7	100 % MW
196/16 A - T3	reference	19.7	100 % MW
196/16 A - T4	reference	23.3	100 % MW
200/16 A - T1	„dry"	6.4	100 % MW
200/16 A - T2	„dry"	9.7	100 % MW
200/16 A - T3	„dry"	6.4	100 % MW
200/16 A - T4	„dry"	9.6	100 % MW
201/16 B - T1	„wet"100/100	4.4	100 % MW
201/16 B - T2	„wet"100/100	3.4	100 % MW
201/16 B - T3	„wet"100/100	1.7	100 % MW
201/16 B - T4	„wet"100/100	3.2	100 % MW
194/16 B - T1	„wet"	2.6	100 % MW
194/16 B - T2	„wet"	2.6	100 % MW
194/16 B - T3	„wet"	2.8	100 % MW
194/16 B - T4	„wet"	- *	100 % MW
Average value tensile strenght reference sample			**20 kPa**
Average value tensile strenght after 15 HT cycles „dry"			**8.0 kPa**
Average value tensile strenght after 15 HT cycles „wet"			**3.0 kPa**

* Test sample 194/16 B T4 – after aging „wet" test sample crashed during preparing. Deposit test sample was not available.

Measured values and test results - **expanded polystyrene Bachl EPS 70 Facade**

Sample no.	Test type	Tensile strenght perpendicular to faces σ_{mt} [kPa]	type of failure
263/16 A - T1	reference	106.8	85 % EPS, 15% reinf. base coat
263/16 A - T2	reference	113.3	85 % EPS, 15% reinf. base coat
263/16 A - T3	reference	87.4 *	85 % EPS, 10% PUR
263/16 A - T4	reference	123.0	85 % EPS, 15% reinf. base coat
263/16 C - T1	„dry“	126.5	90 % EPS, 10% reinf. base coat
263/16 C - T2	„dry“	129.9	90 % EPS, 10% reinf. base coat
263/16 C - T3	„dry“	120.4	85 % EPS, 15% reinf. base coat
263/16 C - T4	„dry“	133.1	90 % EPS, 10% reinf. base coat
266/16 A - T1	„wet“100/100	156.1	85 % EPS, 15% reinf. base coat
266/16 A - T2	„wet“100/100	157.7	90 % EPS, 10% reinf. base coat
266/16 A - T3	„wet“100/100	149.2	75 % EPS, 25% reinf. base coat
266/16 A - T4	„wet“100/100	120.7	70 % EPS, 30% reinf. base coat
Average value tensile strenght reference sample			**110 kPa**
Average value tensile strenght after 15 HT cycles „dry“			**130 kPa**
Average value tensile strenght after 15 HT cycles „wet“			**150 kPa**

* On test sample 206/16 A3 was partial failure at adhesive, result was excluded from average. Due to giving results to two significant figures, average value is without influence.

Extended uncertainty of tensile strenght was stated as ± 5 $\%_{rel}$.

4.2.2 Determination of shear behaviour

Test was performed on test double specimens with reinforced base coat, sample thickness 140 mm and dimmensions (200 x 100) mm. Surface of test specimens was without modification.

Measured values and test results - **mineral wool Knauf FKD S Thermal (TR10)**

Sample no.	Test type	Shear behaviour τ [kPa]	Modulus of elasticity G [kPa]
196/16 B ST1	reference - transverse	12.5	493
196/16 B ST2	reference - transverse	12.9	405
196/16 B SL1	reference - lenghwise	17.2	874
196/16 B SL2	reference - lenghwise	18.9	814
199/16 A ST1	„dry"- transverse	7.5	349
199/16 A ST2	„dry"- transverse	7.3	352
199/16 A SL1	„dry"- lenghwise	8.7	444
199/16 A SL2	„dry"- lenghwise	8.7	598
202/16 A ST1	„wet"- transverse	2.8	226
202/16 A ST2	„wet"- transverse	4.0	232
202/16 A SL1	„wet"- lenghwise	4.7	326
202/16 A SL2	„wet"- lenghwise	5.0	409
Average value of shear behaviour - REFERENCE TRANSVERSE			**13 kPa**
Average value of modulus of elasticity shear - REFERENCE TRANSVERSE			**450 kPa**
Average value of shear behaviour - REFERENCE LENGHWISE			**18 kPa**
Average value of modulus of elasticity shear - REFERENCE LENGHWISE			**850 kPa**
Average value of shear behaviour - DRY TRANSVERSE			**7.4 kPa**
Average value of modulus of elasticity shear - DRY TRANSVERSE			**350 kPa**
Average value of shear behaviour - DRY LENGHWISE			**8.7 kPa**
Average value of modulus of elasticity shear - DRY LENGHWISE			**520 kPa**
Average value of shear behaviour - WET TRANSVERSE			**3.4 kPa**
Average value of modulus of elasticity shear - WET TRANSVERSE			**230 kPa**
Average value of shear behaviour - WET LENGHWISE			**4.9 kPa**
Average value of modulus of elasticity shear - WET LENGHWISE			**370 kPa**

Extended uncertainty of shear behaviour was stated as ± 5 $\%_{rel}$.
Extended uncertainty of modulus of elasticity shear was stated as ± 7.5 $\%_{rel}$.

Measured values and test results - **expanded polystyrene Bachl EPS 70 Fasádní**

Sample no.	Test type	Shear behaviour τ [kPa]	Modulus od elasticity G [kPa]
262/16 A ST1	reference - transverse	29.4	1400
262/16 A ST2	reference - transverse	30.3	1003
262/16 A SL1	reference - lenghwise	27.9	1599
263/16 C SL1	reference - lenghwise	41.6	1047
263/16 A ST1	„dry"- transverse	36.2	1479
263/16 A ST2	„dry"- transverse	34.9	1383
263/16 A SL1	„dry"- lenghwise	29.3	1072
263/16 A SL2	„dry"- lenghwise	29.0	1161
265/16 C ST1	„wet"- transverse	42.4	1448
265/16 C ST2	„wet"- transverse	40.3	1451
265/16 C SL1	„wet"- lenghwise	40.4	1187
265/16 C SL2	„wet"- lenghwise	40.8	1316
Average value of shear behaviour - REFERENCE TRANSVERSE			**30 kPa**
Average value of modulus of elasticity shear - REFERENCE TRANSVERSE			**1200 kPa**
Average value of shear behaviour - REFERENCE LENGHWISE			**35 kPa**
Average value of modulus of elasticity shear - REFERENCE LENGHWISE			**1300 kPa**
Average value of shear behaviour - DRY TRANSVERSE			**36 kPa**
Average value of modulus of elasticity shear - DRY TRANSVERSE			**1400 kPa**
Average value of shear behaviour - DRY LENGHWISE			**29 kPa**
Average value of modulus of elasticity shear - DRY LENGHWISE			**1100 kPa**
Average value of shear behaviour - WET TRANSVERSE			**41 kPa**
Average value of modulus of elasticity shear - WET TRANSVERSE			**1400 kPa**
Average value of shear behaviour - WET LENGHWISE			**41 kPa**
Average value of modulus of elasticity shear - WET LENGHWISE			**1300 kPa**

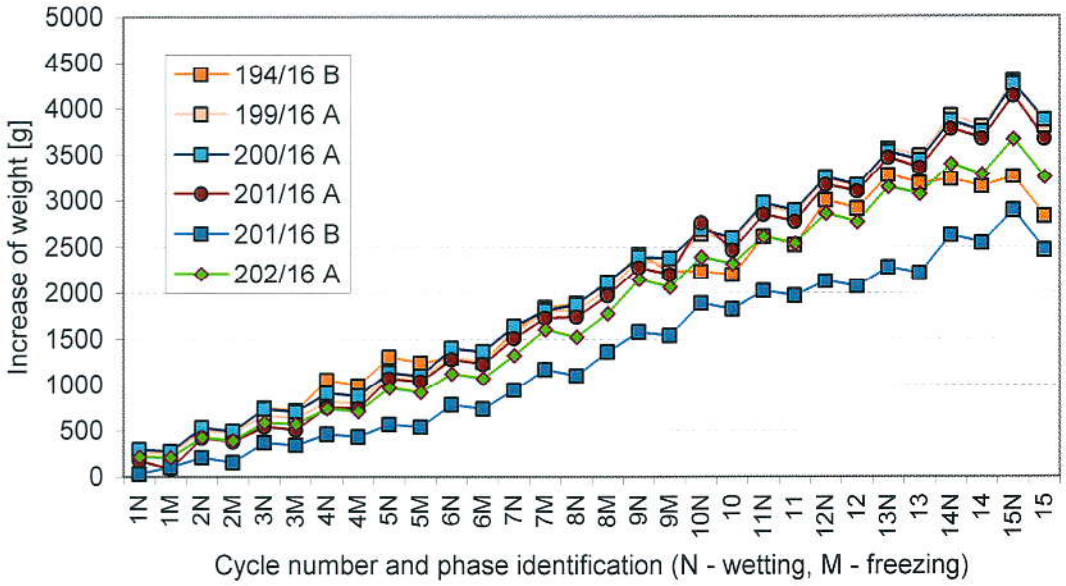
Extended uncertainty of shear behaviour was stated as ± 5 $\%_{rel}$.
Extended uncertainty of modulus of elasticity shear was stated as ± 7.5 $\%_{rel}$.

4.2.3 Evolution of weight during hygrothermal cycles

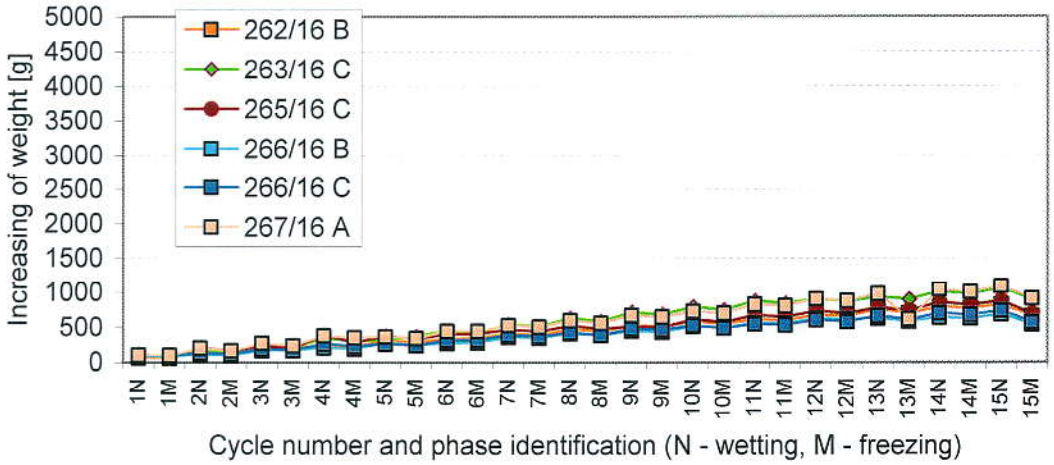
Afrer finishing each phase of hygrothermal cycling was measured control sample weight. Influence to precision of weight determination can be caused by free water on sample´s surface after wetting phase, by icing after freezing phase and possible loss of material during work.

Next graphs posted increasing of weight individual test samples after each individual phases of hygrothermal cycling.

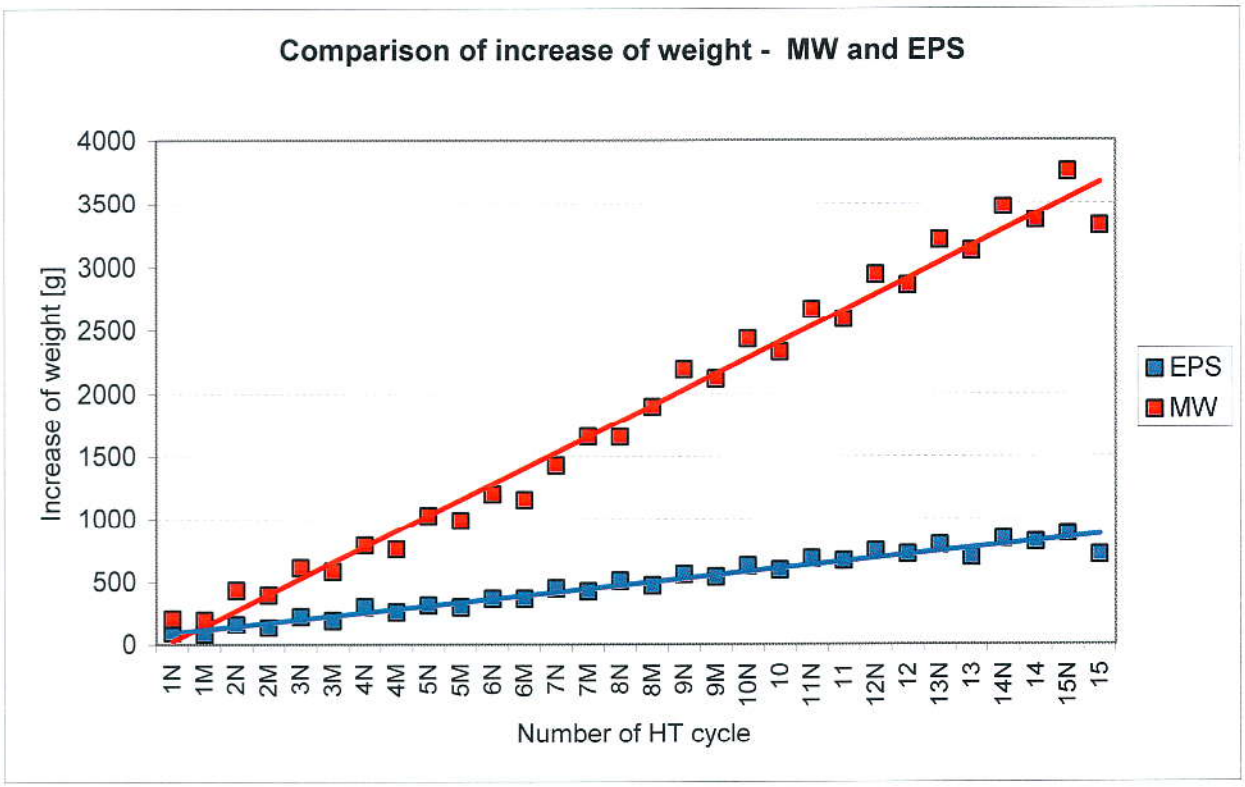
Increasing of weight after individual phases of HT
MINERAL WOOL



Increasing of weight after individual phases of HT
EXPANDED POLYSTYRENE



Next graph posted comparison of increasing of weight during hygrothermal cycling for MW and EPS. At graph is posted <u>average value for all test specimen</u> for each material separately.



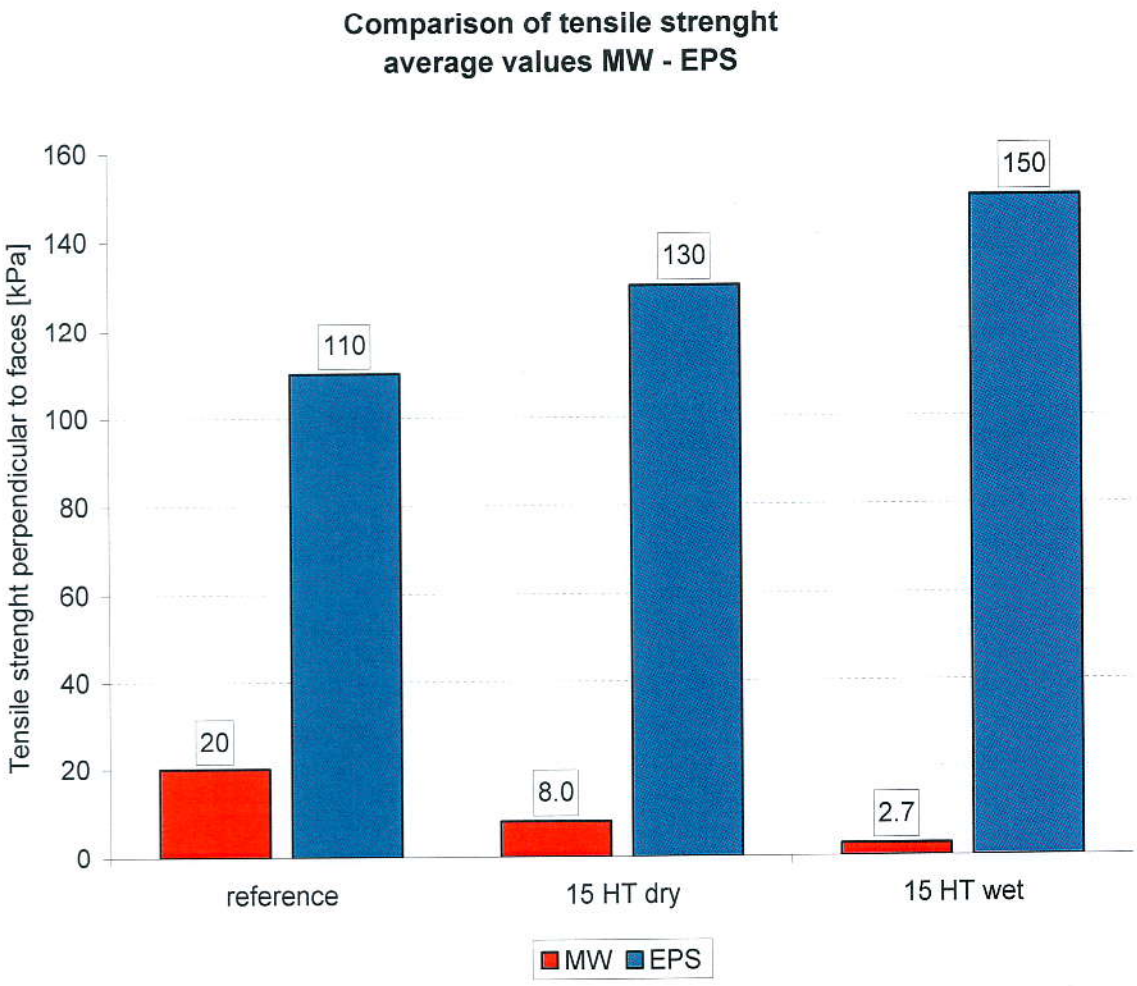
List of annexes:
Annex 1 – Graphs of measured values
Annex 2 – Phototodocumentation of tests

Author of report: Ing. Tomáš Langer

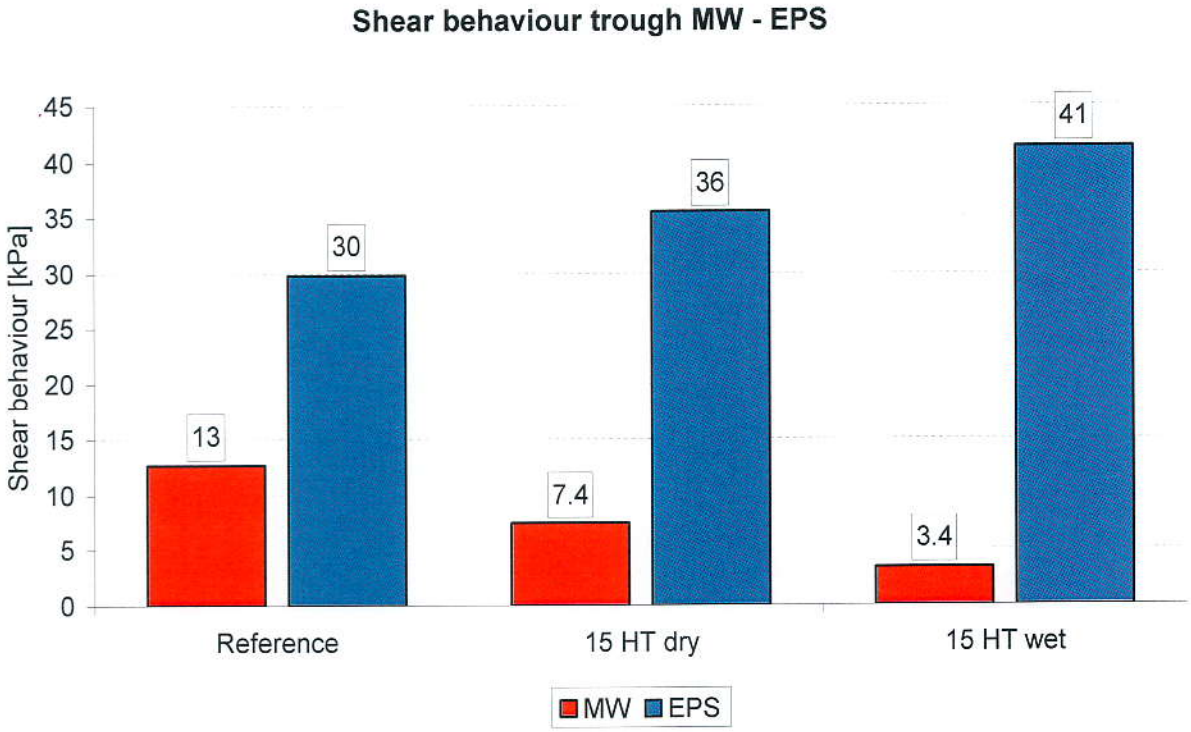
Prague on 27th December 2017

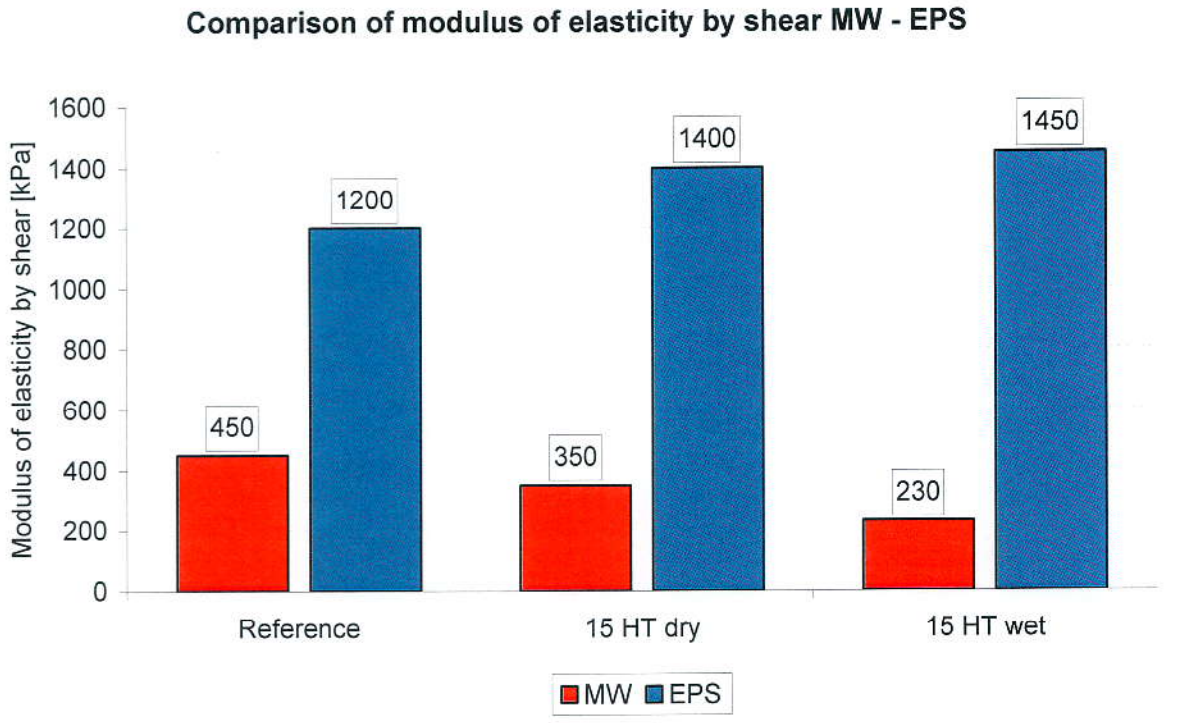
ANNEX 1 – GRAPHS OF TEST RESULTS

Tensile strenght perpendiculat to faces

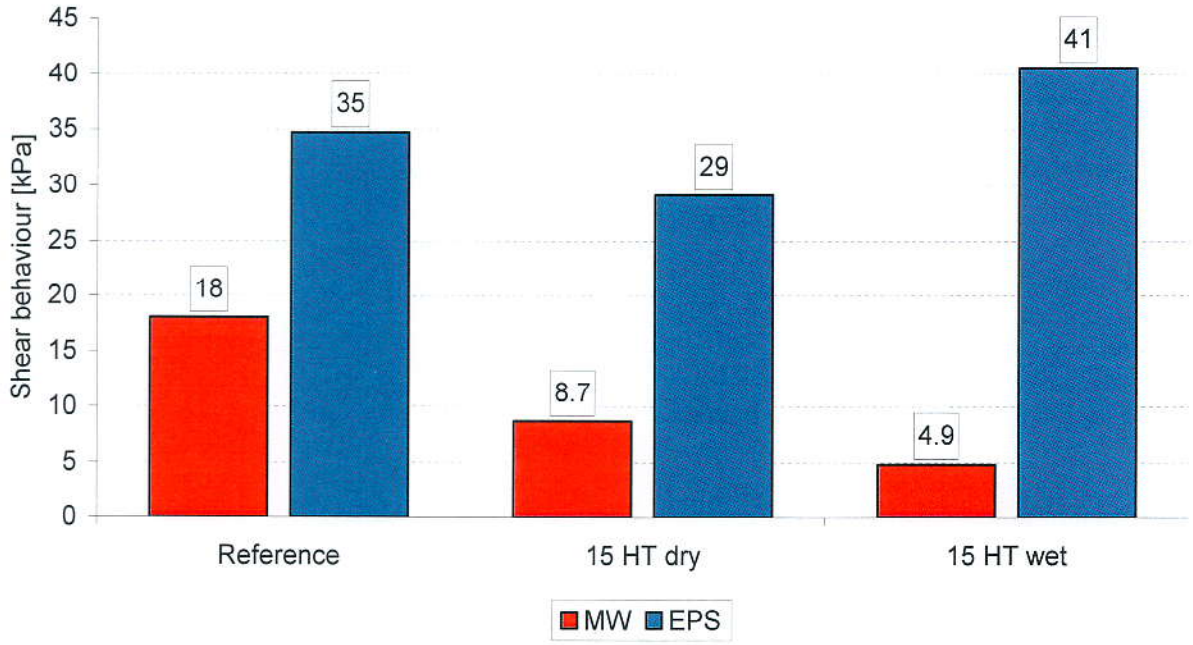


Shear behaviour and modulus od elasticity

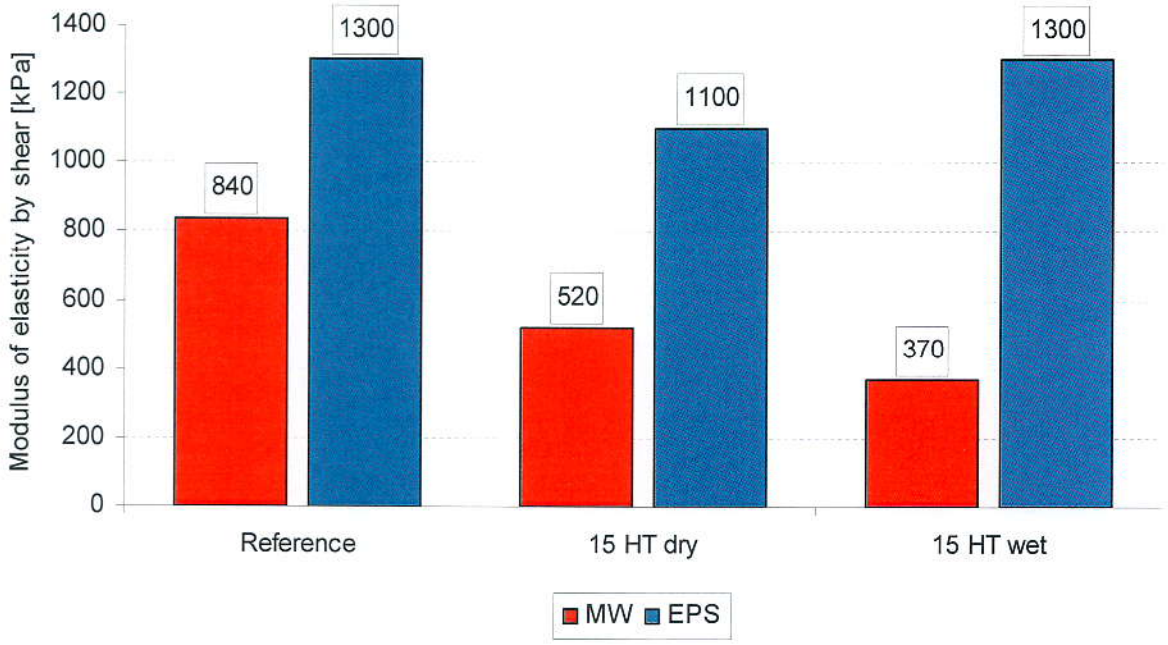




Shear behaviour lenghtwise MW - EPS

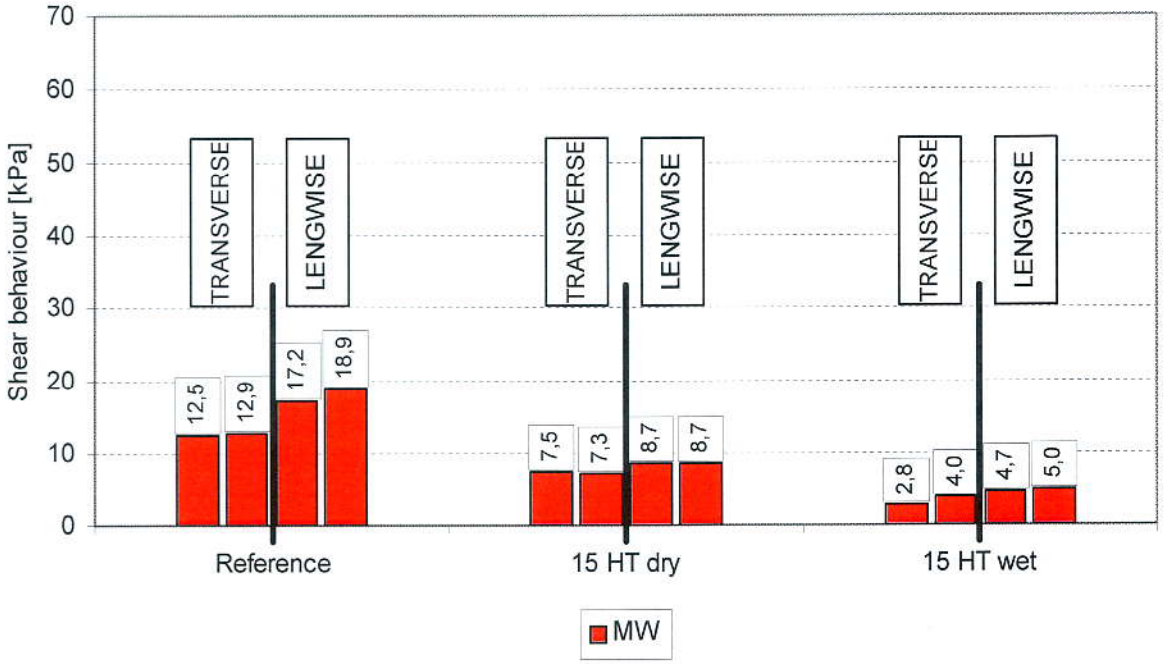


Comparison of modulus of elasticity by shear lenghtwise MW - EPS

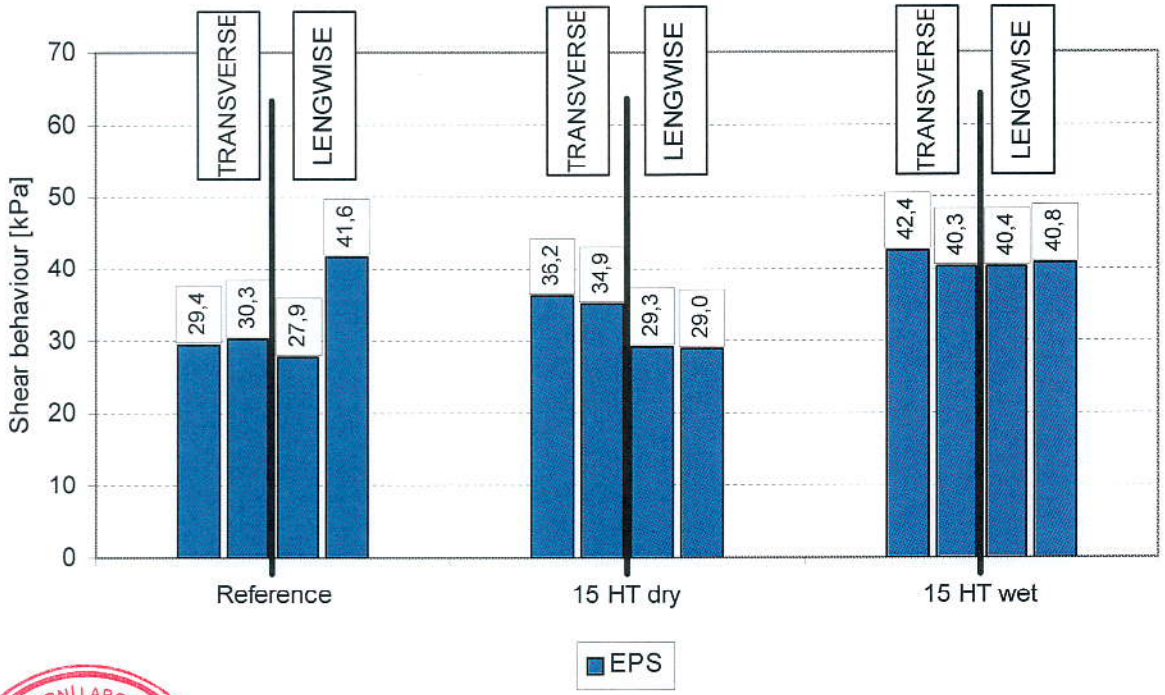


Comparison of shear behaviour and modulus of elasticity by shear for specimens sampled transverse and lenghwise.

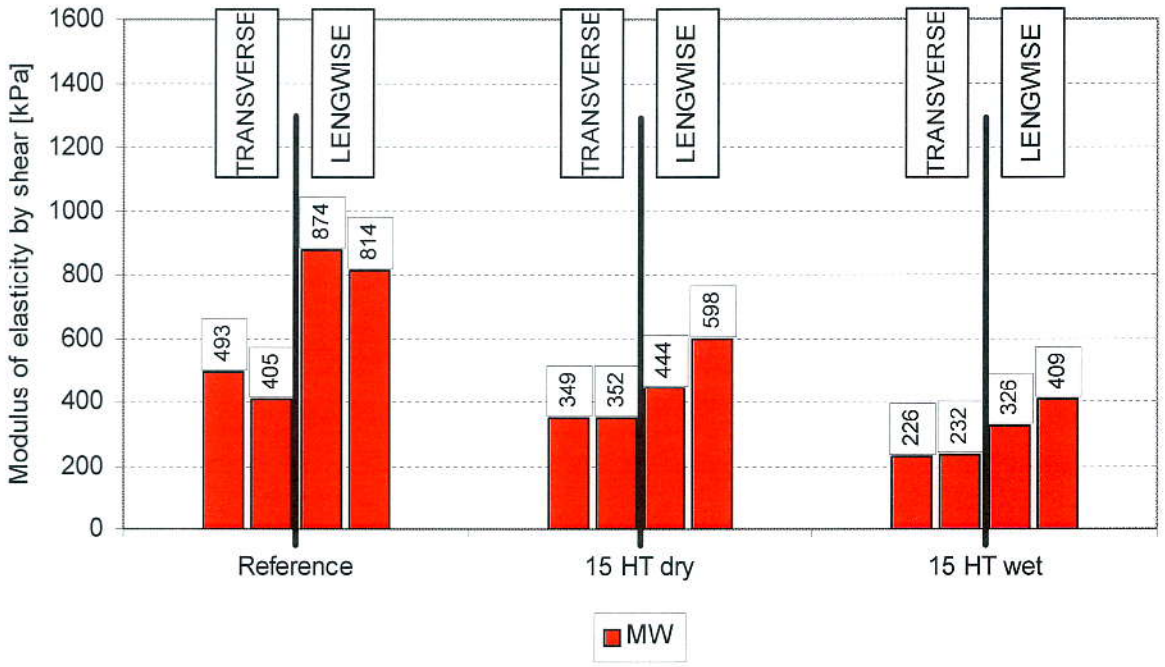
Shear behaviour for individual specimen MW



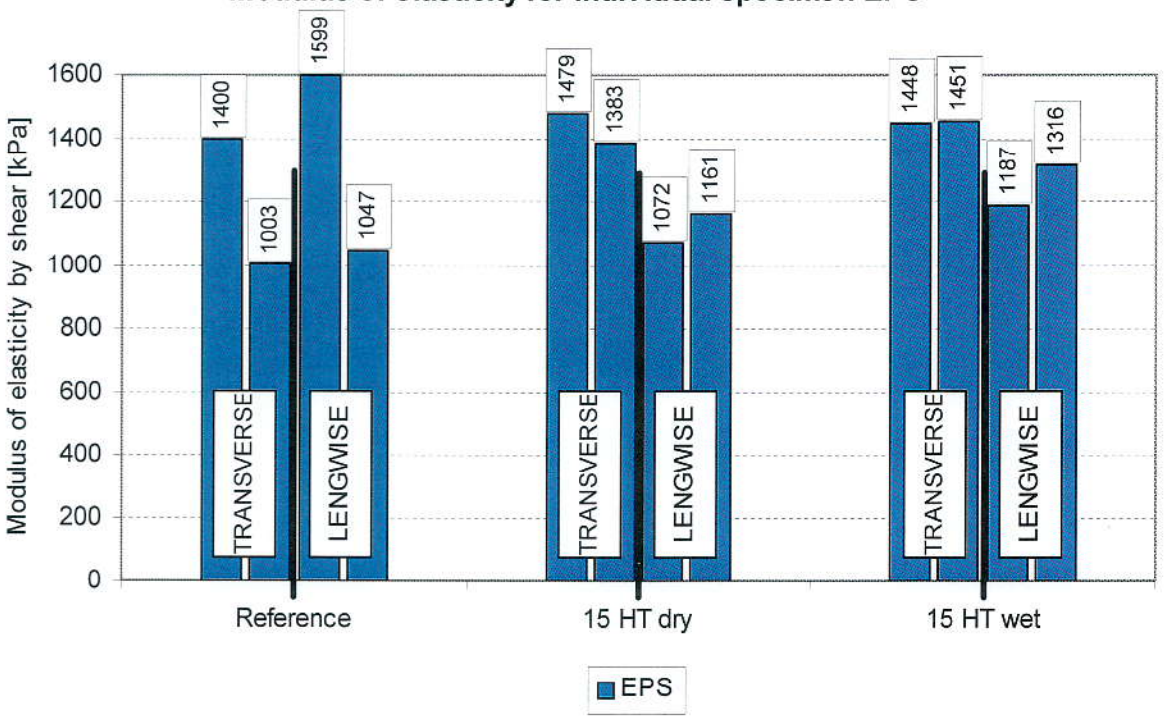
Shear behaviour for individual specimen EPS



Modulus of elasticity for individual specimen MW



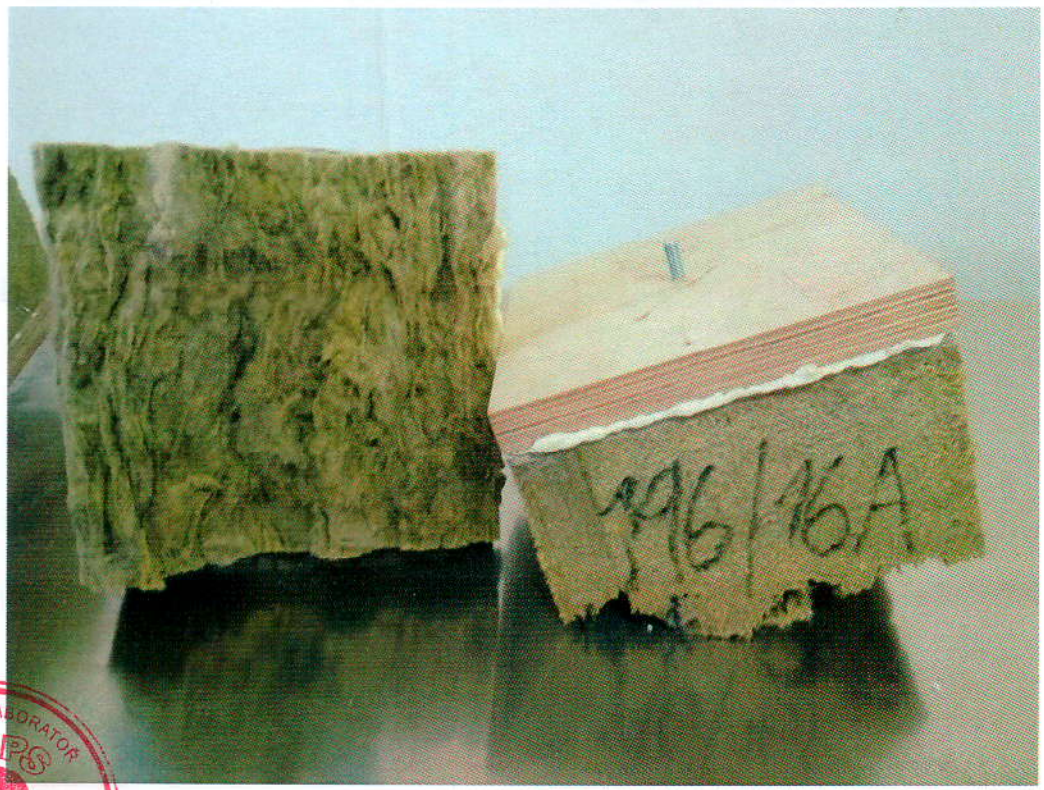
Modulus of elasticity for individual specimen EPS



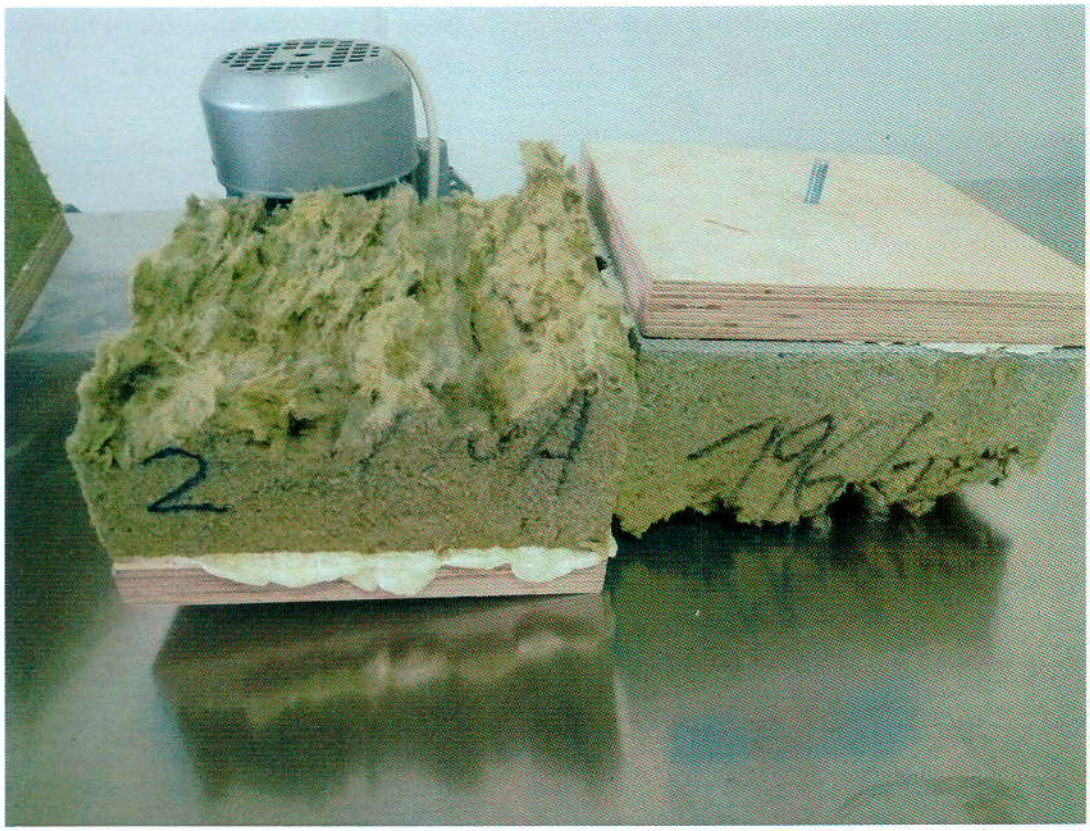
ANNEX 2 - PHOTODOCUMENTATION OF TESTS

Tensile strenght perpednicular to faces

196/16 A REFERENCE T1 – 16.4 kPa

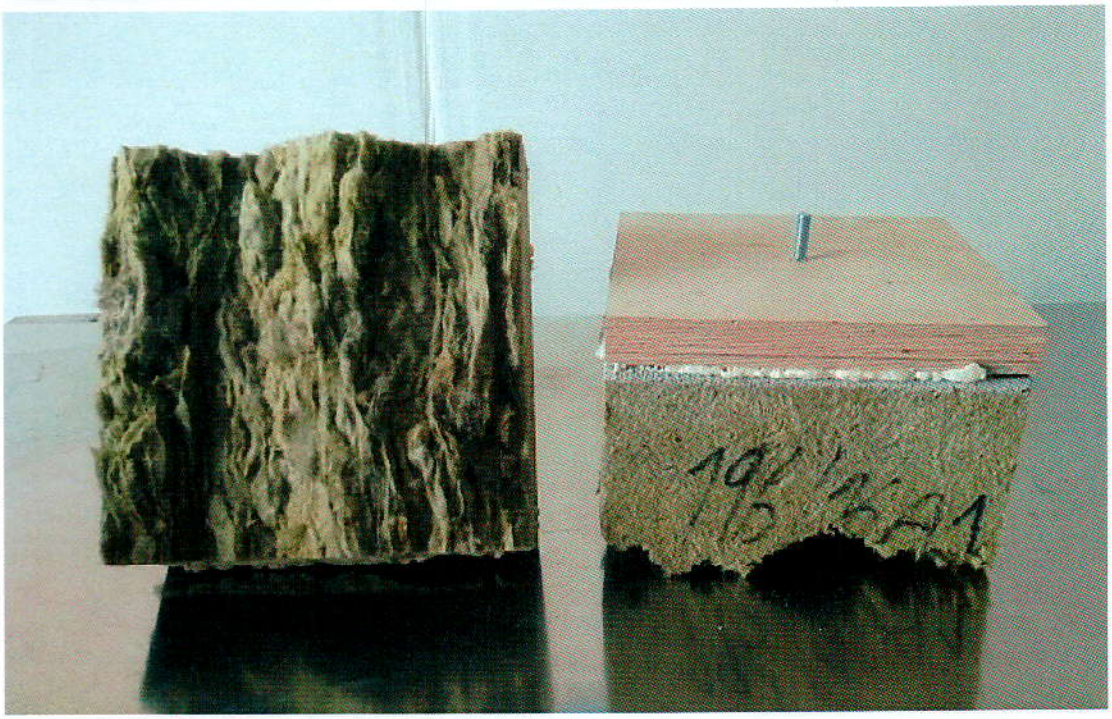


196/16 A REFERENCE T2 – 19.7 kPa



196/16 A REFERENCE T3 – 19.7 kPa

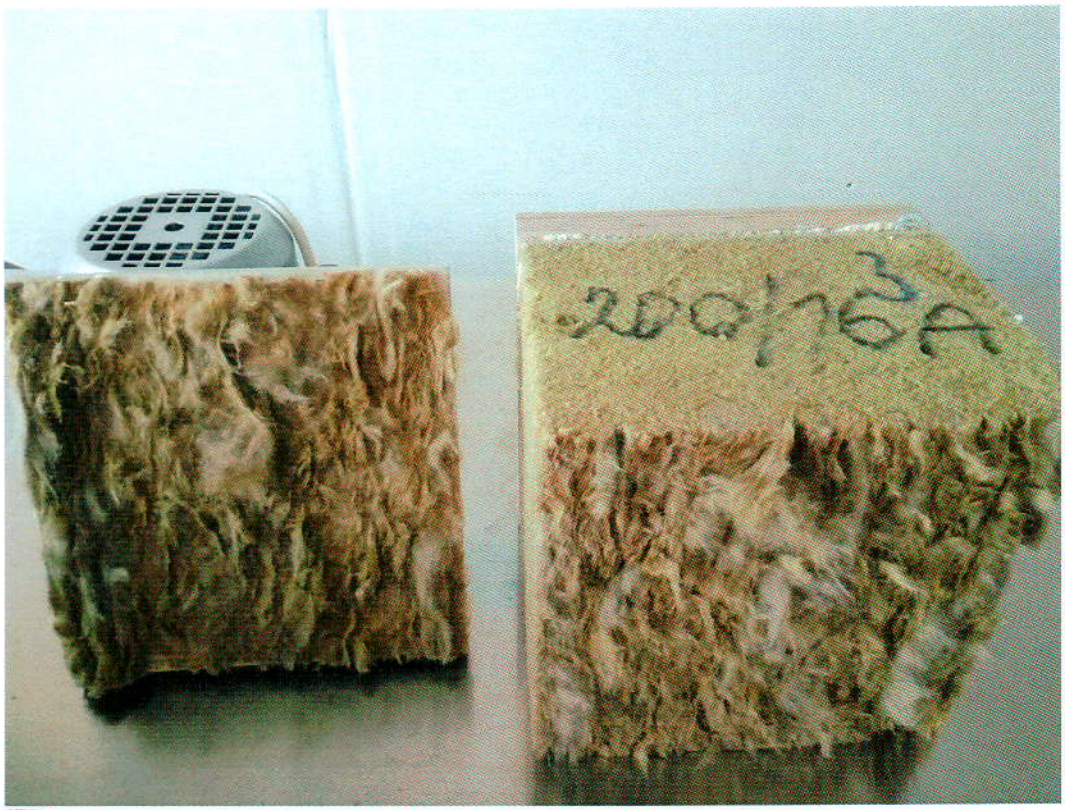
196/16 A REFERENCE T4 - 23.3 kPa



200/16 A AFTER CYCLING DRY T1 – 6.4 kPa

200/16 A AFTER CYCLING DRY T2 – 9.7 kPa

200/16 A AFTER CYCLING DRY T3 – 6.4 kPa

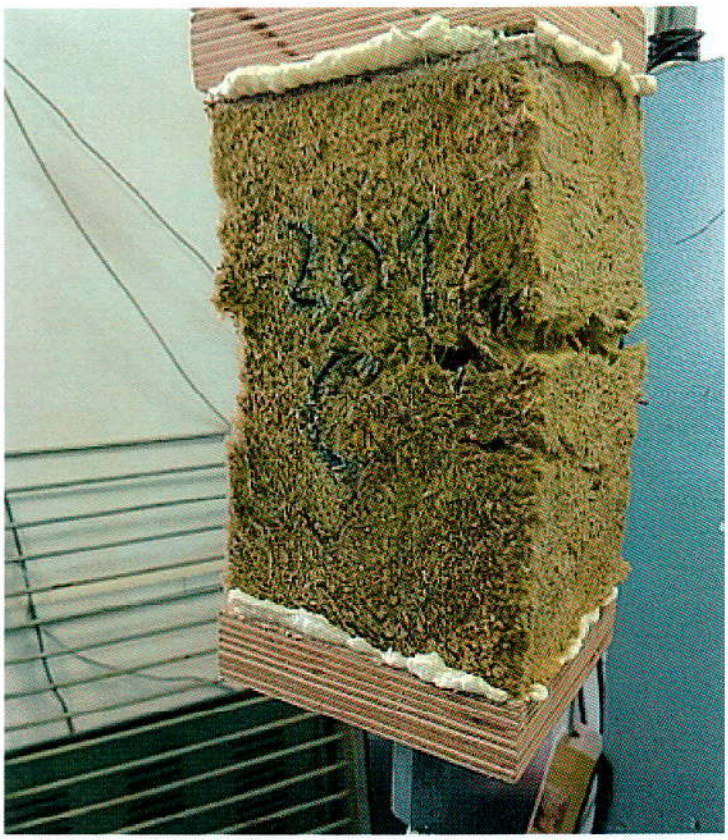


200/16 A AFTER CYCLING DRY T4 – 9.6 kPa

201/16 AFTER CYCLING WET T1 – 4.4 kPa

201/16 AFTER CYCLING WET T2 – 3.4 kPa

201/16 AFTER CYCLING WET T3 – 1.7 kPa



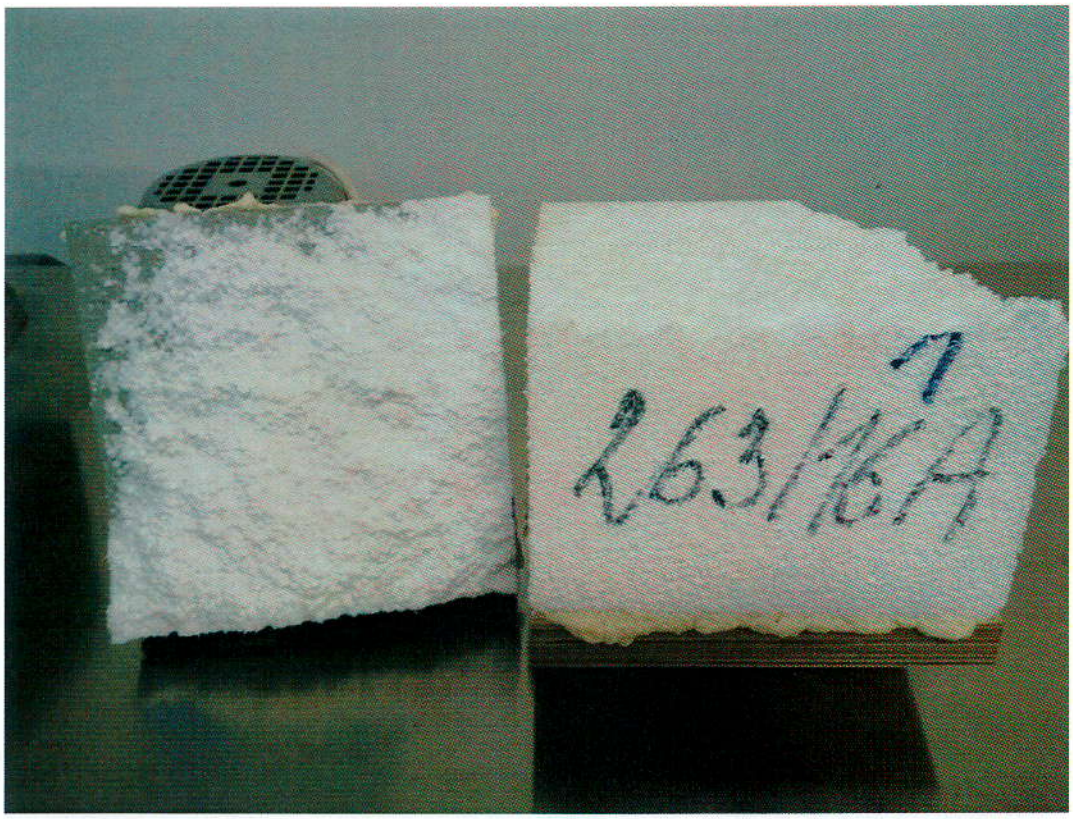
201/16 AFTER CYCLING WET T4 – 3.2 kPa

194/16 AFTER CYCLING WET T1 – 2.6 kPa

194/16 AFTER CYCLING WET T2 – 2.6 kPa

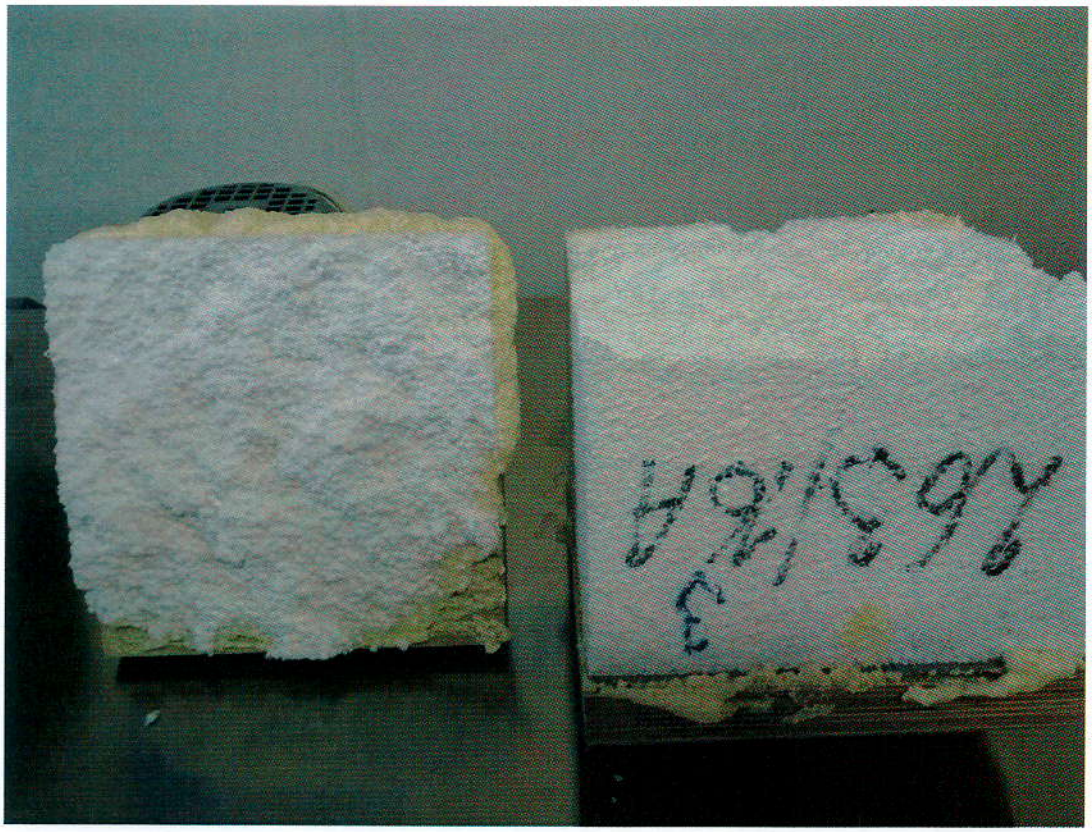
194/16 AFTER CYCLING WET T3 – 2.8 kPa

263/16 A REFERENCE T1 – 106.8 kPa



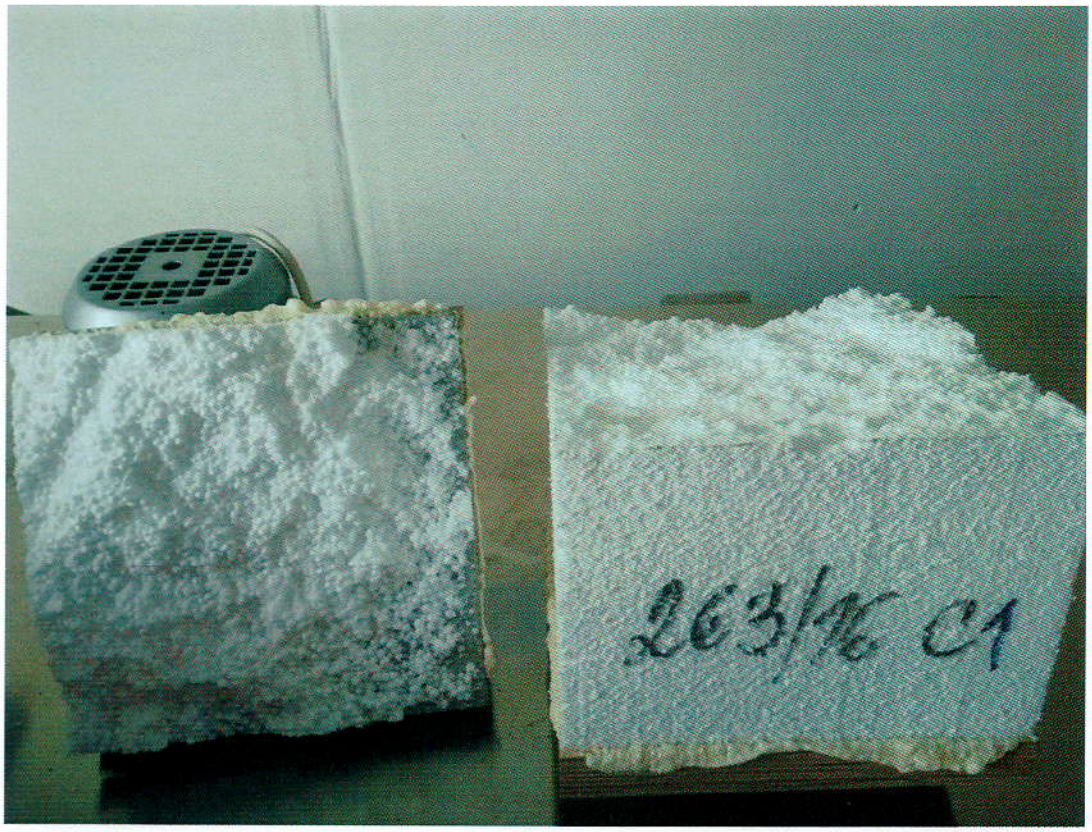
263/16 A REFERENCE T2 – 113.3 kPa

263/16 A REFERENCE T3 – 87.4 kPa

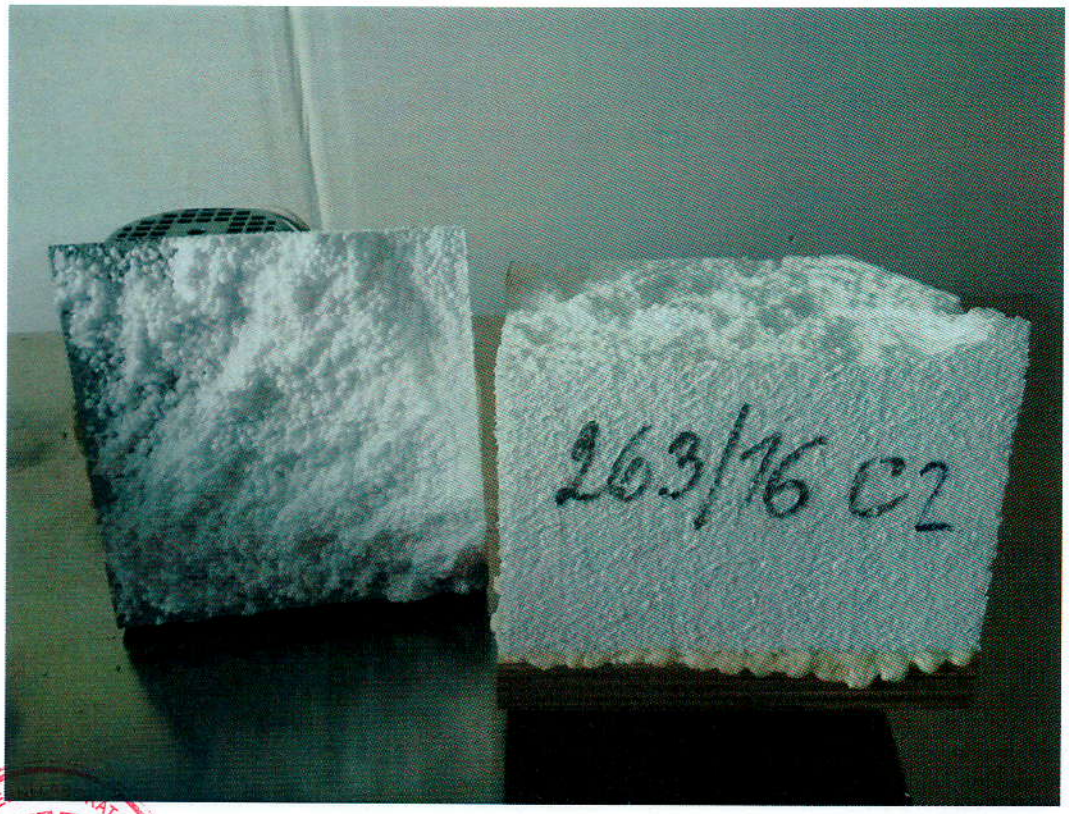


263/16 A REFERENCE T4 – 123.0 kPa

263/16 C AFTER CYCLING DRY T1 – 126.5 kPa

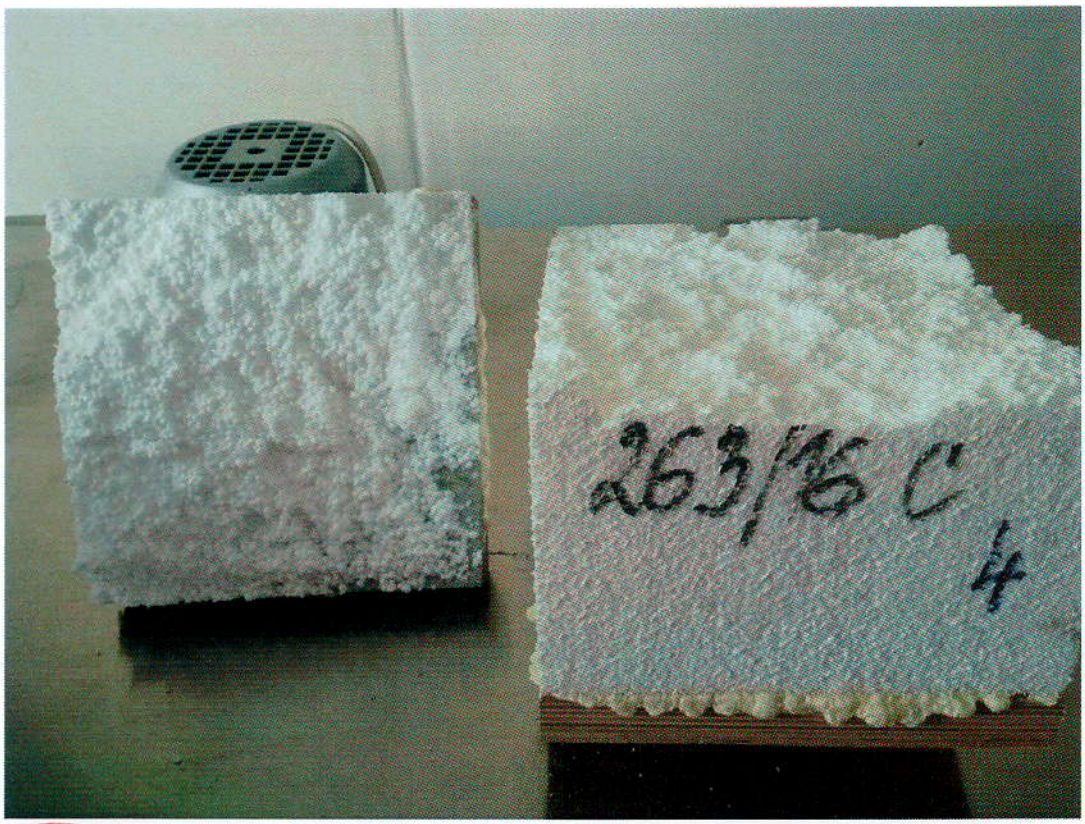


263/16 C AFTER CYCLING DRY T2 – 129.9 kPa



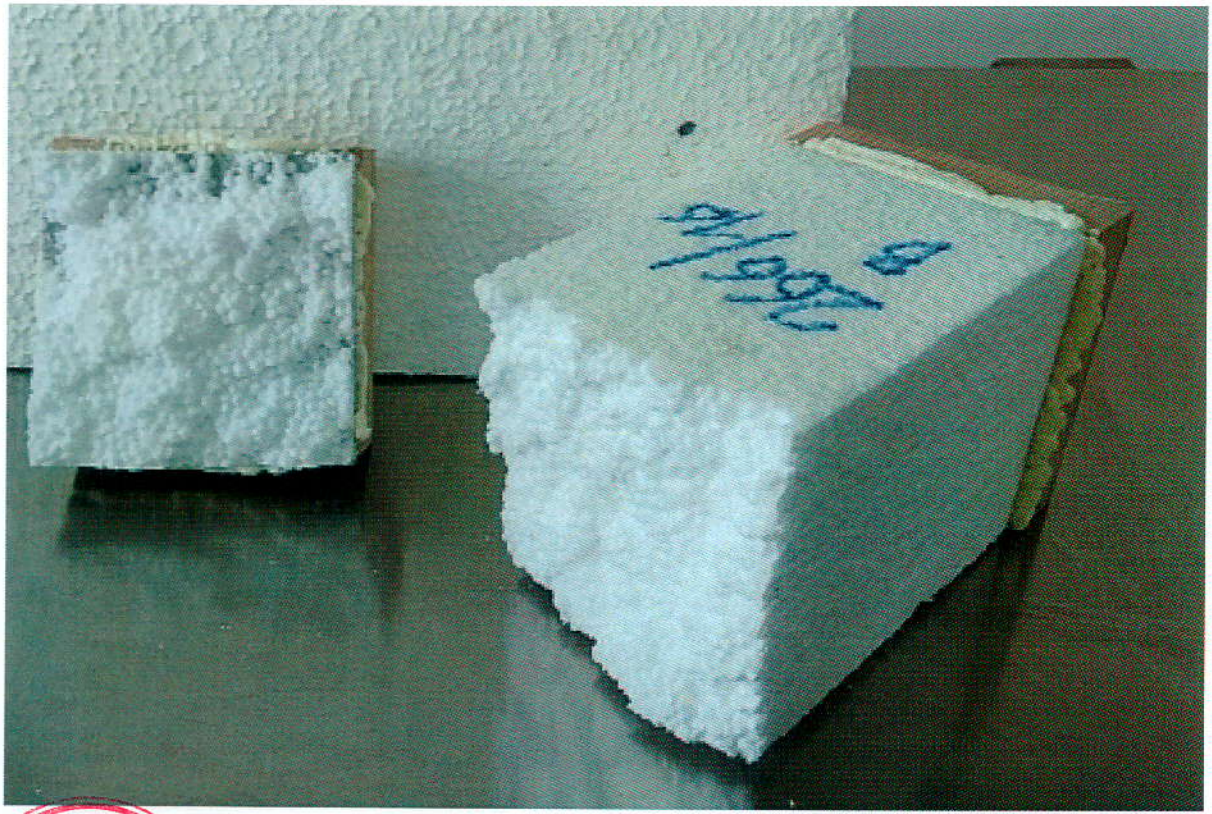
263/16 C AFTER CYCLING DRY T3 – 120.4 kPa

263/16 C AFTER CYCLING DRY T4 – 133.1 kPa



266/16 AFTER CYCLING WET T1 – 156.1 kPa

266/16 AFTER CYCLING WET T2 – 157.7 kPa



266/16 AFTER CYCLING WET T3 – 149.2 kPa

266/16 AFTER CYCLING WET T4 – 120.7 kPa

Shear behaviour

196/16 B – SHEAR BEHAVIOUR TRANSVERSE REFERENCE SL1 - 12.5 / 493 kPa

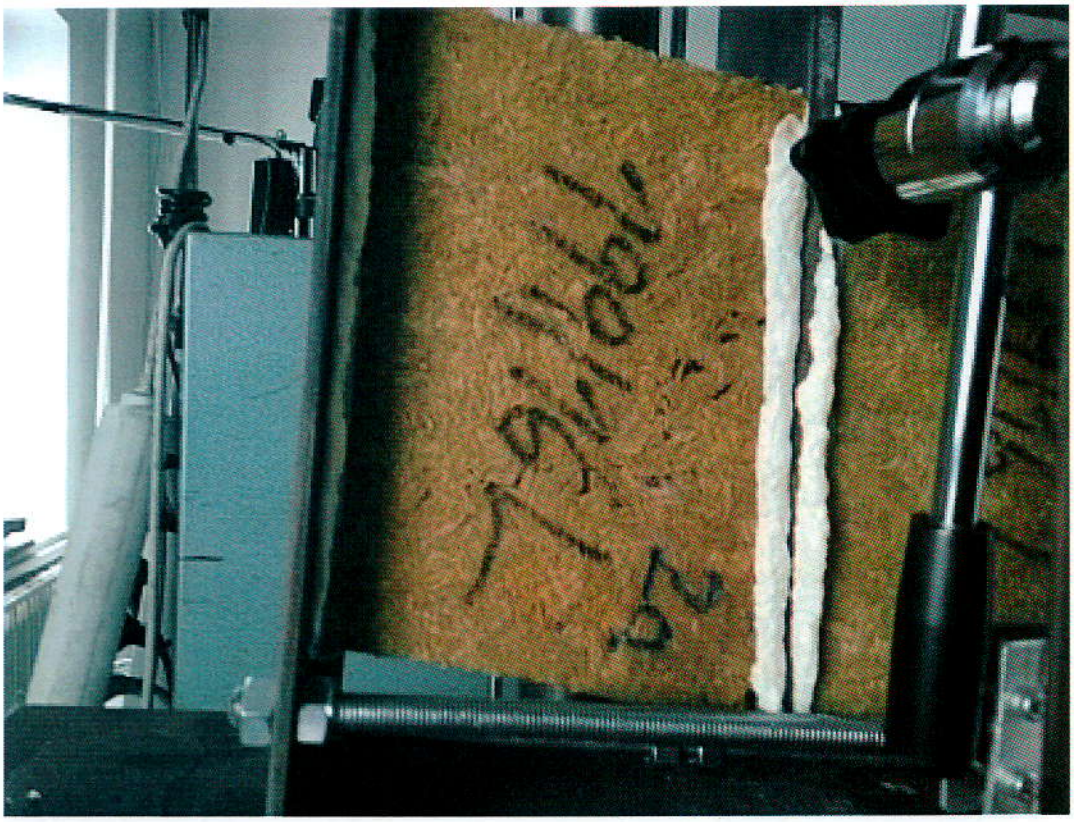
196/16 B – SHEAR BEHAVIOUR TRANSVERSE REFERENCE SL2 - 12.9 / 405 kPa

196/16 B - SHEAR BEHAVIOUR LENGHWISEREFERENCE ST1 - 17.2 / 874 kPa

196/16 B - SHEAR BEHAVIOUR LENGHWISEREFERENCE ST2 - 18.9 / 814 kPa

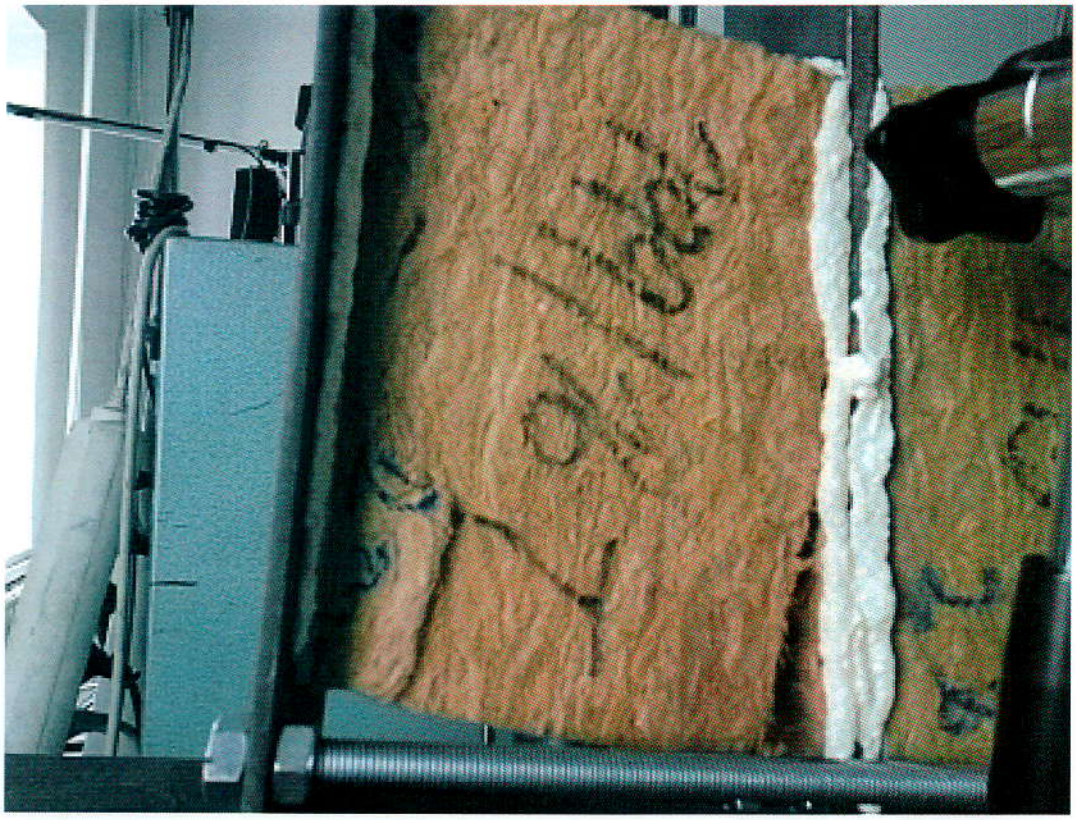
199/16 A - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING DRY SL1 - 7.5 / 349 kPa

199/16 A - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING DRY SL2 - 7.3 / 352 kPa



199/16 A - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING DRY ST1 - 8.7 / 444 kPa

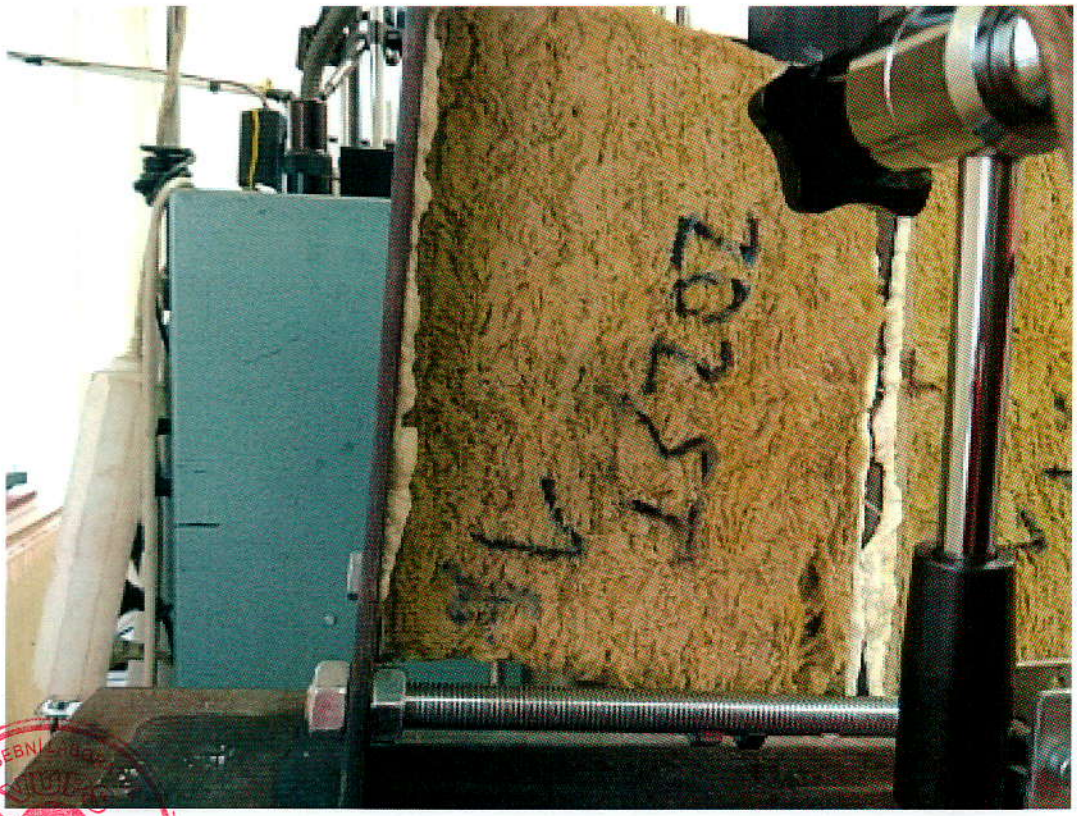
199/16 A - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING DRY ST2 - 8.7 / 598 kPa



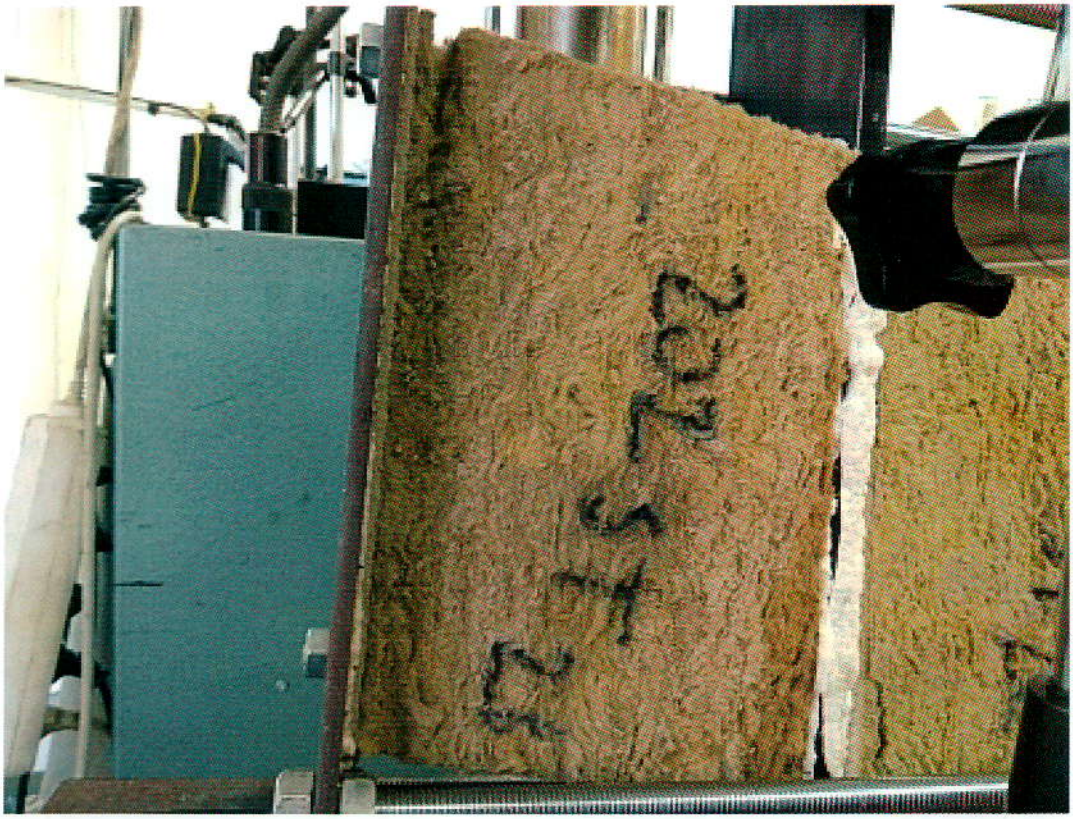
202/16 A - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING WET SL1 - 2.8 / 226 kPa

202/16 A - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING WET SL2 - 4.0 / 232 kPa

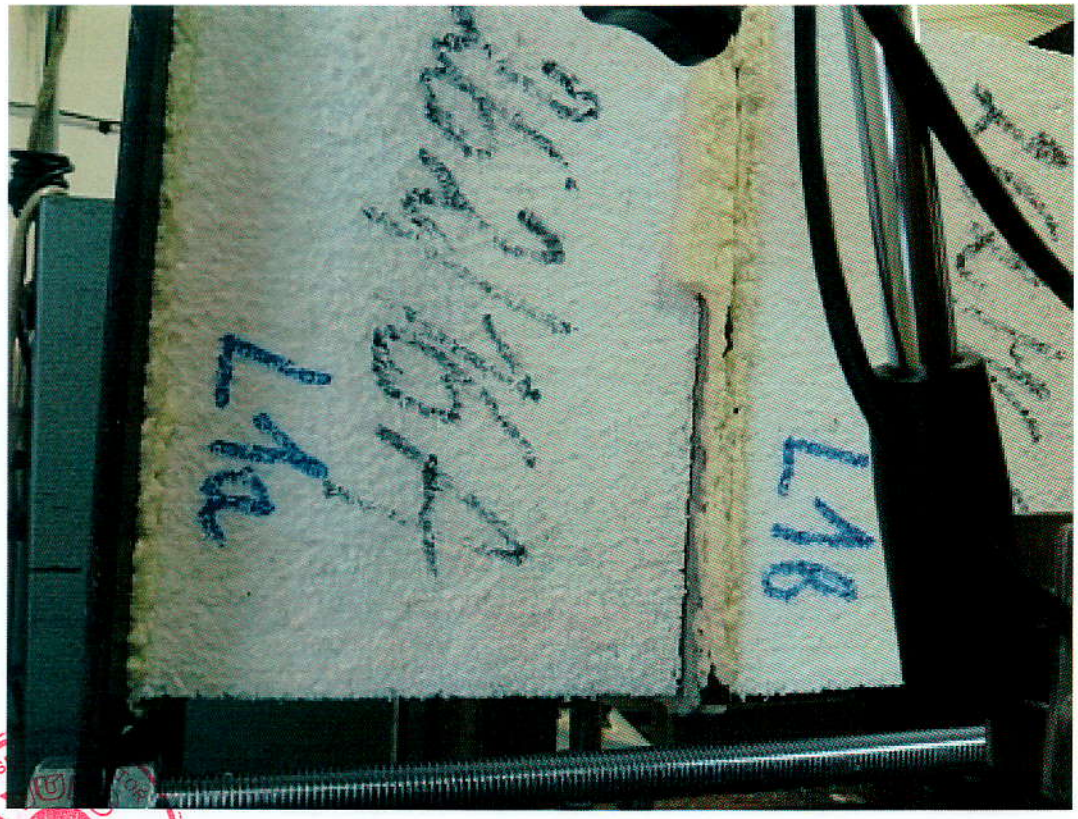
202/16 A - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING WET ST1 - 4.7 / 326 kPa



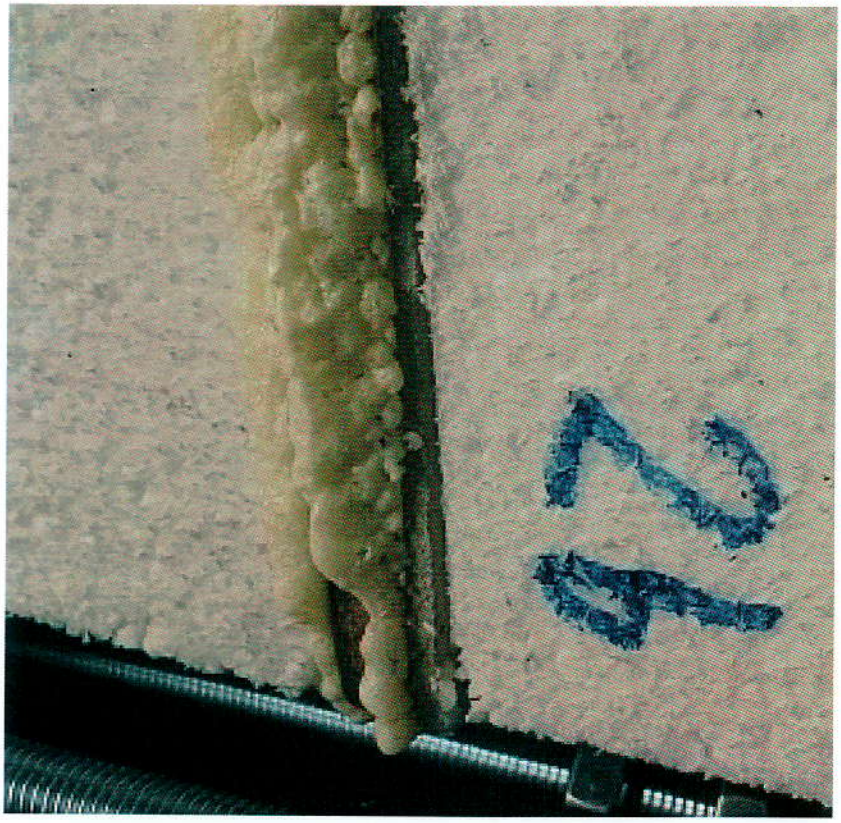
202/16 A - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING WET ST2 - 5.0 / 409 kPa



262/16 A - SHEAR BEHAVIOUR TRANSVERSE REFERENCE SL1 - 29.4 / 1400 kPa



262/16 A - SHEAR BEHAVIOUR TRANSVERSE REFERENCE SL2 - 30.3 / 1003 kPa

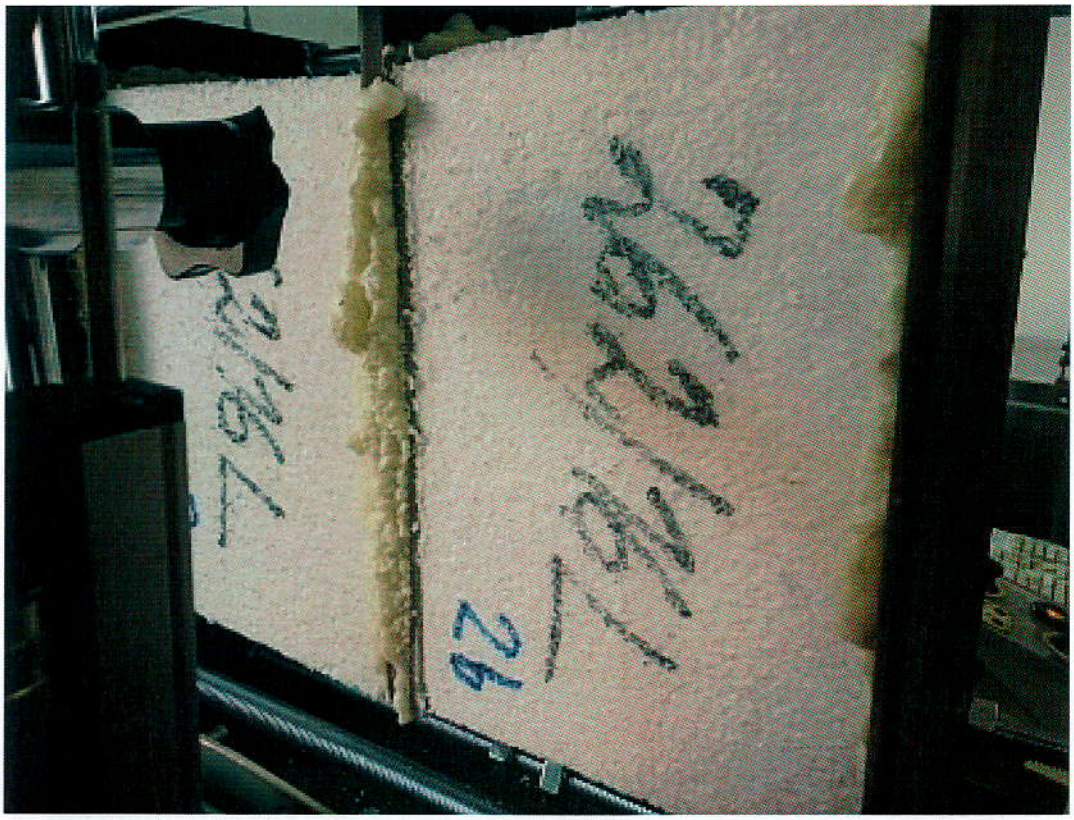


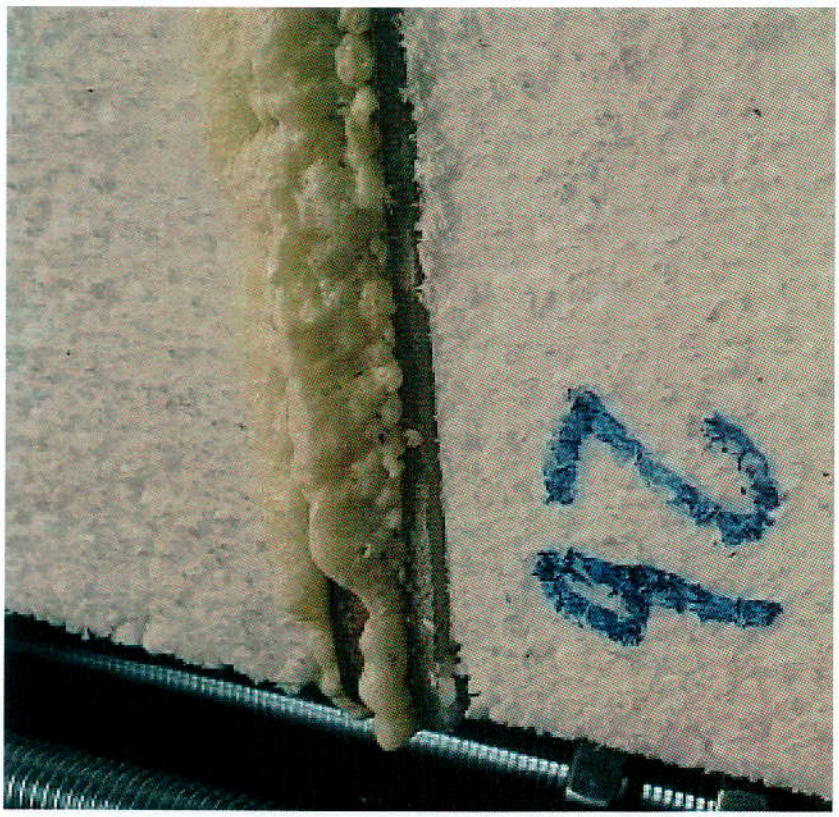
262/16 A - SHEAR BEHAVIOUR LENGHWISEREFERENCE ST1 - 27.9 / 1599 kPa

263/16 C - SHEAR BEHAVIOUR LENGHWISEREFERENCE ST2 - 41.6 / 1047 kPa

262/16 B - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING DRY SL1 - 36.2 / 1479 kPa

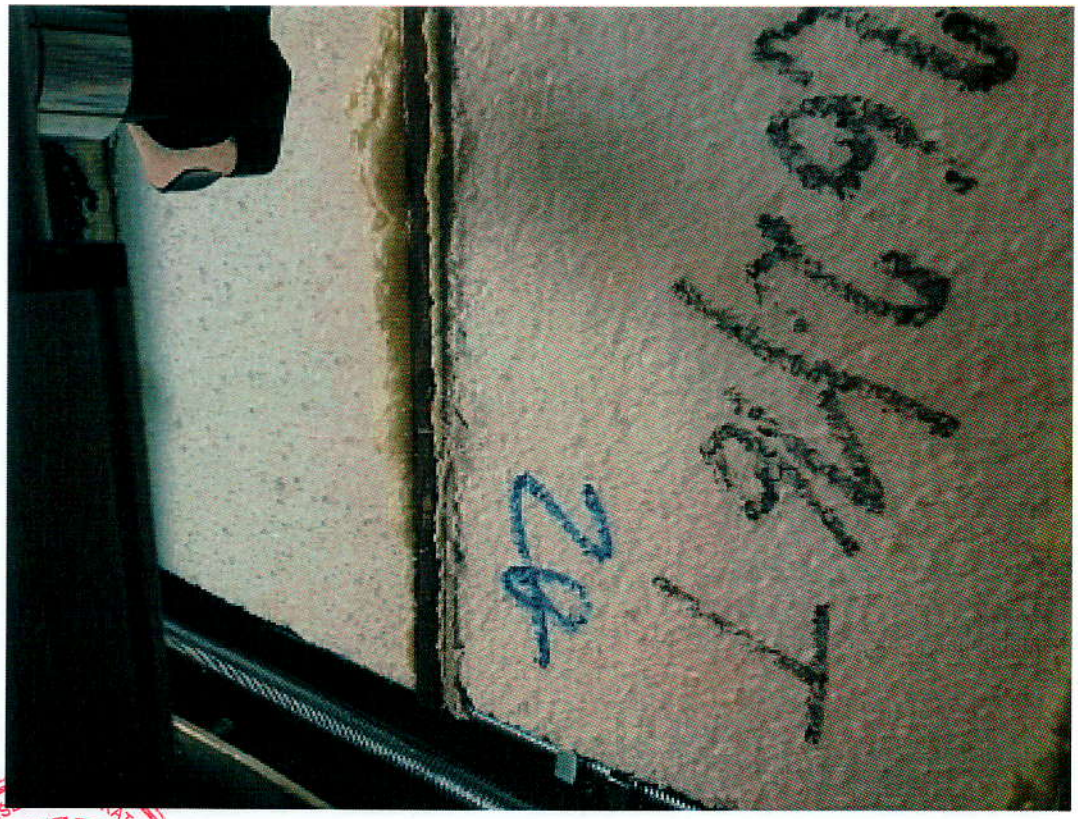
262/16 B - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING DRY SL2 - 34.9 / 1383 kPa





262/16 B - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING DRY ST1 - 29.3 / 1072 kPa

262/16 B - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING DRY ST2 - 29.0 / 1161 kPa



265/16 C - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING WET SL1 - 42.4 / 1448 kPa

265/16 C - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING WET SL2 - 40.3 / 1451 kPa

265/16 C - SHEAR BEHAVIOUR LENGHWISEAFTER CYCLING WET ST1 - 40.4 / 1187 kPa

265/16 C - SHEAR BEHAVIOUR TRANSVERSE AFTER CYCLING WET ST2 - 40.4 / 1316 kPa