The Employing the Frequency Inspection to Assess the Long Frost Resistance of Ceramic Tiles Made in Rako

Marta KORENSKA, Iveta PLSKOVA , Jan MARTINEK, Zdenek CHOBOLA
Brno University of Technology, Faculty of Civil Engineering, Physics Department, Brno, Czech Republic,

Abstract. The paper presents some results of our experimental study of the application potential of the frequency inspection method to the non-destructive assessment of long frost resistance condition of ceramic tiles made in Rako. Verification of the frost resistance period being doubled with respect to standard figures is expected to take place.

Introduction

The analysis was applied to a two sets (A and B) of ceramic tiles, form square 33 cm x 33 cm and thickness 0.8 cm, which had been fabricated in Rako in year 2002 using a new technology.

To assess the long frost resistance, the ceramic tiles were subject to 300 freezing - thawing tests to ČSN EN ISO 10545-12 [1].

Prior to the tests, the ceramic tiles were immersed into a vessel containing water whose temperature was t_1 = 5°C. After having been pulled out of water, the specimen was wiped with a wet rag. Immediately after the removal from water, the ceramic tiles were placed in a refrigerating chamber. The tiles being frozen, the refrigerating chamber temperature was maintained at t_2 = -5°C for 15 minutes.

The freezing cycle being completed, the tiles were immersed into water for 1 to 2 hours in order to thaw out. The ceramic tiles were left lying in water till the test continuation.

A check measurement was carried out prior to stress cycle start and, subsequently, after the completion of 50, 100,150, 200 and 300 cycles.

A metal hammer of a mass of 169 g, which was hinged in a fixture ensuring a constant release level, h=2 cm [2], was used to hit the tile.

The tile response to the exciting impulse was picked up by means of a piezoelectric sensor of Sedlák S7 type, whose operating frequencies range from 100 Hz to 50 kHz. The sensor was fitted to the tile surface at a point of coordinates x = 18 cm, y = 16.5 cm, i.e., in the maximum amplitude region [3].

The response voltage was fed into the input of a Yokogawa DL1540CL digital oscilloscope and further processed by means of a special signal-analysis software package.

1. Experiment results and discussion

Table Nos. 1-12 shows the maximum frequencies and the respective attenuation ratios, λ, for specimen Nos.301- 306 type A and Nos.406-411-type B at different degradation test stages.

Table No. 1 – Ceramic tile type Rako No. 301

cycle	λ /s^{-1}	**f/Hz**
0	69	6389
50	79	7037
100	94	7057
150	107	7077
200	109	7080
300	112	7082

Table No. 2 – Ceramic tile type Rako No. 302

cycle	λ /s^{-1}	**f/Hz**
0	156	5405
50	159	5442
100	162	5921
150	178	6459
200	180	6461
300	184	6466

Table No. 3 – Ceramic tile type Rako No. 303

cycle	λ /s^{-1}	**f/Hz**
0	105	5442
50	122	5960
100	184	6429
150	193	6449
200	196	7065
300	201	7087

Table No. 4 – Ceramic tile type Rako No.304

cycle	λ /s^{-1}	**f/Hz**
0	132	6414
50	138	6429
100	141	6439
150	160	6470
200	172	6822
300	194	7097

Table No. 5 -Ceramic tile type Rako No. 305

cycle	λ /s^{-1}	**f/Hz**
0	69	6390
50	78	6409
100	93	6419
150	98	6439
200	154	6623
300	201	7091

Table No. 6 – Ceramic tile type Rako No. 306

cycle	λ /s^{-1}	**f/Hz**
0	109	5457
50	115	5462
100	117	5482
150	123	5510
200	164	5512
300	218	5518

Table No. 7 – Ceramic tile type Rako No. 406

cycle	λ /s^{-1}	**f/Hz**
0	106	5760
50	118	5801
100	123	5890
150	179	6559
200	181	6562
300	184	6568

Table No. 8 – Ceramic tile type Rako No. 407

cycle	λ /s^{-1}	**f/Hz**
0	98	5690
50	105	5711
100	110	6120
150	169	6549
200	183	6551
300	201	6556

Table No. 9 – Ceramic tile type Rako No. 408

cycle	λ /s^{-1}	**f/Hz**
0	128	6420
50	149	6480
100	162	6559
150	194	7196
200	196	7198
300	201	8002

Table No. 10 – Ceramic tile type Rako No. 409

cycle	λ /s^{-1}	**f/Hz**
0	106	6490
50	108	6520
100	140	6539
150	181	6570
200	183	6575
300	189	6582

Table No. 11 – Ceramic tile type Rako No. 410

cycle	λ /s^{-1}	**f/Hz**
0	118	6510
50	123	6559
100	131	6568
150	176	7196
200	182	7198
300	211	7204

Table No. 12 – Ceramic tile type Rako No. 411

cycle	λ /s^{-1}	**f/Hz**
0	62	6556
50	94	6559
100	119	6570
150	179	6590
200	181	6598
300	186	6604

Fig. No. 1 shows a recording of No. 305 specimen response as picked up at the tile centre prior to the expected low-temperature-induced degradation. Being placed at that point, the sensor picked up the response bending vibration amplitude for the most part. The response impulse duration was 42 milliseconds. The attenuation ratio was found to equal λ = 69 s^{-1} [3].

Fig. 2 shows the power spectral density (in relative units) versus frequency plot for specimen No.305. A dominant frequency f_0 = 6390 Hz may be observed.

Fig. 3 shows a recording of No. 305 specimen response as picked up at the tile centre after the completion of 300 freezing and thawing cycles. The response impulse duration was 26 milliseconds. The attenuation ratio was found to equal λ = 201 s^{-1} [3].

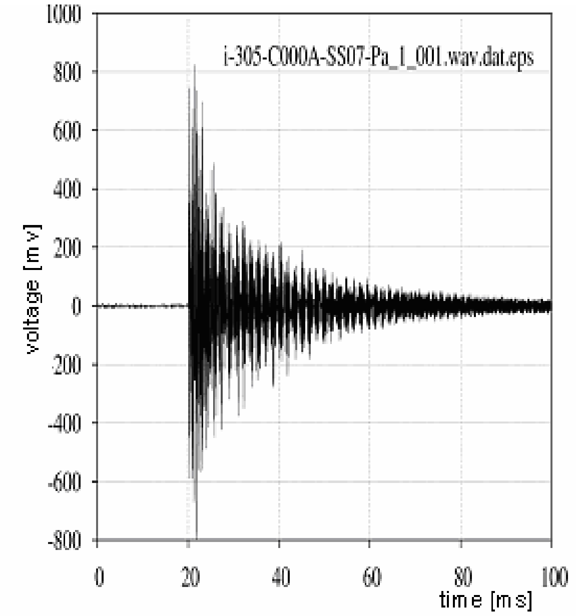

Fig.1 Time-domain response record for a ceramic tile No.305 before degradation.

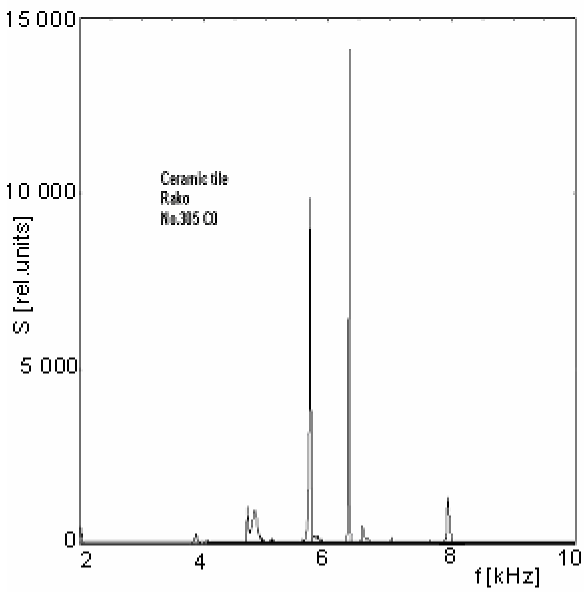

Fig.2 The power spectral density versus frequency plot for a ceramic tile No.305 before degradation.

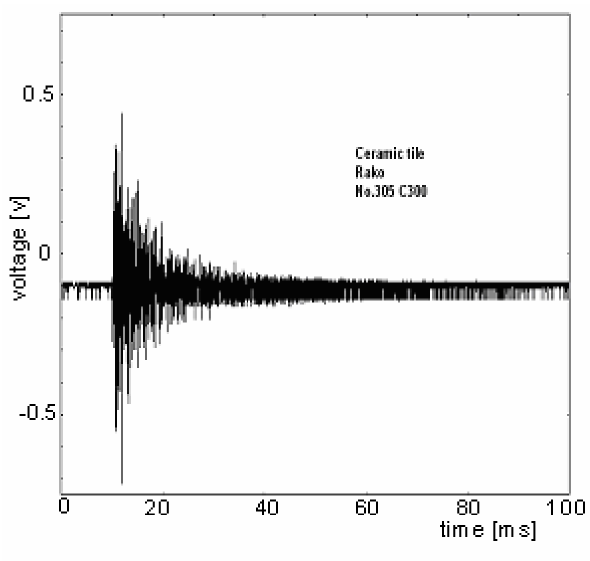

Fig.3 Time-domain response record for a ceramic tile No.305 after the completion of 300 freezing and thawing cycles.

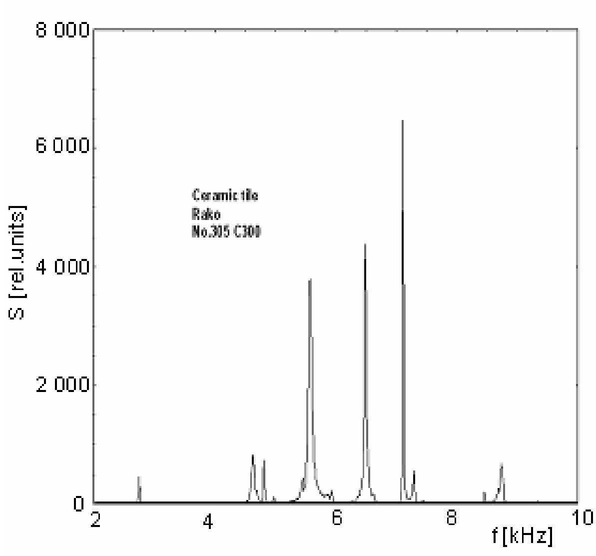

Fig.4 The power spectral density versus frequency plot for a ceramic tile No.305 after the completion of 300 freezing and thawing cycles.

Fig. 4 shows the power spectral density (in relative units) versus frequency plot for specimen No.305 after the completion of 300 freezing and thawing cycles. A dominant frequency f_0 = 7091 Hz may be observed.

The changes that were observed in the tile may be taken as an indication of certain structure impairment having taken place during the period between the 100 and 300 freezing and thawing cycle completion. The structure impairment appeared to be reflected in a change of the resonance frequency distribution.

With the exception of a single ceramic tile, only insignificant resonance frequency changes took place in the frequency interval from Δ= 61 Hz to 1645 Hz, average value $\phi\Delta$ = 807 Hz by type A and Δ= 48 Hz to 1582 Hz, average value $\phi\Delta$ = 682 Hz by type B in the course of the 300 freezing and thawing cycles. This gives evidence of a very good quality as well as long frost resistance of this ceramic tiles types, from which a long service life may therefore be predicted.

2. Conclusion

The analysis was applied to a two sets (A and B) of ceramic tiles, of a plain tile type, which had been fabricated in Rako in 2002 using a new technology. To assess the long frost resistance, the ceramic tiles were subject to 300 freezing - thawing tests.

With the exception of a ceramic tile, only small resonance frequency changes took place in the course of the 300 freezing and thawing cycles. This gives evidence of a very good quality as well as long frost resistance of this ceramic tile type, from which a long service life may therefore be predicted.

From the results we can also see that the frequency inspection method is a useful non-destructive testing method being applicable to the evaluation of the ceramic tile structure condition and allowing predicting the frost resistance and service life of these products.

This research was supported by the Grant Agency of the Czech Republic under Grant 103/06/1711.

References

[1] ČSN EN ISO 10545-12 Ceramis tiles- Part 12:Determination of frost resistance

[2] Kořenská, M. - Chobola, Z. - Mikulková, P. - Martinek, J.: *On the application of impact-echo method to assess the quality of ceramic roofing tiles*. In: Proceedings of IV. Conference MATBUD`2003`, 2003, Krakow 2003, pp. - 239 – 244

[3] Mikulková, P. - Kořenská, M. - Martinek, J. - Chobola, Z.: *A study of the burnt roofing response vs. pick up location and transmission medium dependence*. In: Proceedings of International Workshop Physical and material engineering 2003, Bratislava 2003, pp. 145 – 148.

[4] Martinek, J. - Chobola, Z.: *Computation of Decay Coefficient of Acoustic Signal*. In: Proceedings of International Workshop on Physical and Material Engineering 2003, Richňava, Slovakia: Bratislava, Slovak University of Technology, 2003, p. 149-152. ISBN 80-227-1924.