CIM
Centre for Infrastructure Management

Sheffield Hallam University | Materials and Engineering Research Institute

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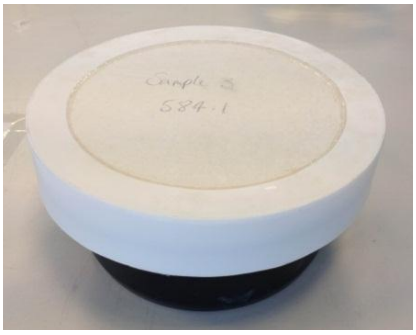
Determination of Water Vapour Permeability of hardened Fibrelime^{TM} mortar



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Executive Summary

The Centre for Infrastructure Management at Sheffield Hallam University was requested by Singleton Birch Ltd to measure the Water Vapour Permeability of a mortar produced with their Fibrelime™ product. The water vapour permeability was determined using a methodology based on BS EN 1015-19:1999. The test specimens, consisting of three mortar discs of 185 mm diameter and 12 mm thickness, were manufactured and cured by the client. Upon delivery to the laboratory, the samples were sealed on the open mouth of circular test cups in which the relative humidity was maintained constant at 93.2% by means of a saturated solution of potassium nitrate (KNO_3). The samples were then placed in a fan-assisted environmental chamber maintained at 20^oC (±2 ^oC) and 50% RH (±5%) and weighed every 24 hours until steady state vapour transmission was achieved. The water vapour permeability of the tested mortar, calculated as the mean of the three individual samples, is equal to 1.44E-11 $kg \cdot m^{-1} \cdot s^{-1} \cdot Pa^{-1}$.

Content **page**

1. Background

The Centre for Infrastructure Management at Sheffield Hallam University was requested by Singleton Birch Ltd to measure the Water Vapour Permeability of a mortar produced with their Fibrelime™ product. The water vapour permeability was determined using a methodology based on BS EN 1015-19:1999.

2. Test procedure

The test specimens, consisting of three mortar discs of 185 mm diameter and 12 mm thickness, were manufactured and cured by the client. Upon delivery to the laboratory, the samples were sealed on the open mouth of circular testing cups containing a saturated solution of potassium nitrate (KNO_3). The sealing was obtained by means of a plastic sealing ring and a silicon sealant (Fig. 1).

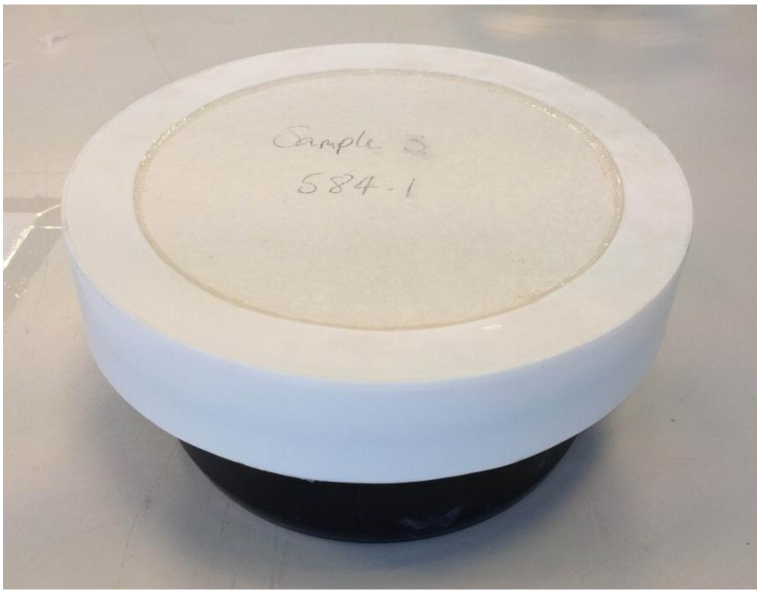

Figure 1 Test cup with mortar specimen and sealing ring

The testing cups have a diameter of 192 mm at the top and 160 mm at the bottom. The area of the open mouth is 0.018 m^2 and the depth is 70 mm.

The saturated KNO_3 solution was prepared by mixing 400 g of KNO_3 (Sigma-Aldrich ACS reagent, ≥99.0%) with 1 L of distilled water on a magnetic stirrer in a laboratory environment (≈ 20°C) for about 3 hours. The solution was then placed to a depth of 24 mm (±1 mm) in the bottom of each testing cup, making sure that each cup received approximately the same amount of undissolved salt. The air gap between the base of the samples and the solution was 46 mm (±1 mm). It was assumed that the KNO_3 solution generated a relative humidity within the air gap of 93.2% at 20°C. The samples were then placed in a fan-assisted environmental chamber maintained at 20°C (±2 °C) and 50% RH (±5%) and weighed every 24 hours. Table 1 contains the weight and weight loss of each cup as well as the average weight loss of the three cups for each measurement. The steady state vapour transmission was considered achieved when a plot of the average weight loss of the three cups versus time produced a straight line with at least three points (Fig. 2).

Time (hrs)	Sample 1		Sample 2		Sample 3		Average wt loss (g)
	Wt (g)	Wt loss (g)	Wt (g)	Wt loss (g)	Wt (g)	Wt loss (g)	
0	1410.62		1348.16		1362.22		
24.00	1408.72	-1.9	1346.44	-1.72	1360.32	-1.9	-1.84
47.50	1406.15	-4.47	1344.04	-4.12	1357.98	-4.24	-4.28
70.75	1403.57	-7.05	1341.59	-6.57	1355.55	-6.67	-6.76
96.00	1400.76	-9.86	1338.91	-9.25	1352.89	-9.33	-9.48
120.00	1398.06	-12.56	1336.38	-11.78	1350.39	-11.83	-12.06
144.00	1395.43	-15.19	1333.86	-14.3	1347.86	-14.36	-14.62
168.00	1392.76	-17.86	1331.3	-16.86	1345.34	-16.88	-17.20
192.00	1390.10	-20.52	1328.89	-19.27	1342.96	-19.26	-19.68
216.00	1387.27	-23.35	1326.21	-21.95	1340.30	-21.92	-22.41
240.00	1384.53	-26.09	1323.59	-24.57	1337.74	-24.48	-25.05
264.00	1381.82	-28.80	1321.09	-27.07	1335.21	-27.01	-27.63

Table 1 Measured weight and related weight loss for each cup and as average of the three cups.

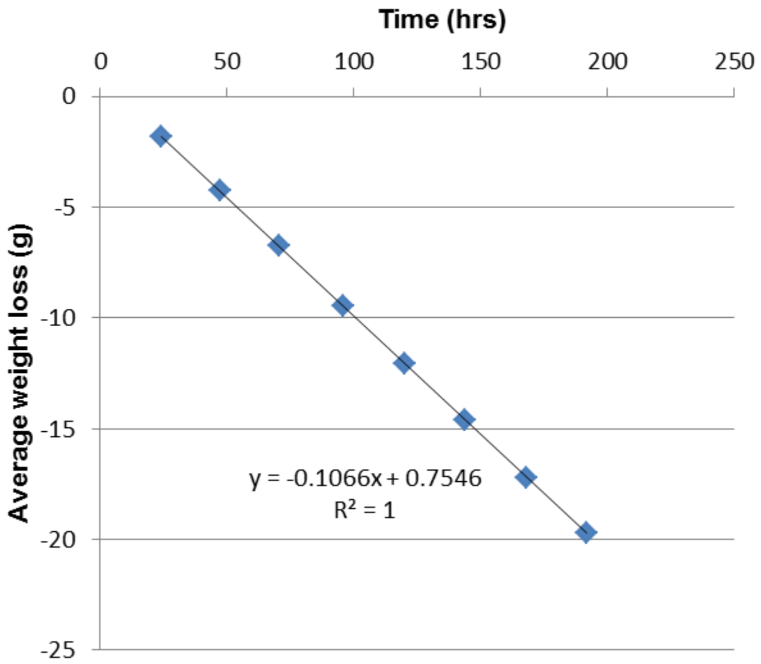

Figure 2 Average weight loss of the three cups versus time

3. Calculation and expression of results

The WVP was calculated using the following formulas (1) & (2):

$$W_{vp} = \Lambda . t \qquad (1)$$

$$\Lambda = \frac{1}{(AD_p)/(\mathrm{DG}/\mathrm{Dt}) - R_A} \qquad (2)$$

Where:

W_{vp} = water vapour permeability ($kg \cdot m^{-1} \cdot s^{-1} \cdot Pa^{-1}$)

Λ = water vapour permeance ($kg \cdot m^{-2} \cdot s^{-1} \cdot Pa^{-1}$)

A = area of the open mouth of the test cup (**0.018 m^2**)

D_p = difference in water vapour pressure between the ambient air and the potassium nitrate solution (**-1010 Pa**).

R_A = water vapour resistance of the air gap between specimen and solution (**$0.2208 \cdot 10^9$ Pa m^2s/kg** per 46 mm air gap).

DG/Dt = water vapour flux (kg/s)

t = specimen thickness (**0.012 m**)

The water vapour flux DG/Dt was determined from the plot of the average weight loss of the three cups versus time shown in Figure 2: DG/Dt = 0.1066 g/hr which corresponds to **$2.961 \cdot 10^{-8}$ kg/s**. The mean water vapour permeance, calculated from (2), is equal to **1.20E-9 $kg \cdot m^{-2} \cdot s^{-1} \cdot Pa^{-1}$** and the water vapour permeability, calculated from (1), is **1.44E-11 $kg \cdot m^{-1} \cdot s^{-1} \cdot Pa^{-1}$**.

4. Conclusions

The water vapour permeability of a hardened mortar produced with Fibrelime™ was determined following a procedure based on BS EN 1015-19:1999. The calculated value (1.44E-11 $kg \cdot m^{-1} \cdot s^{-1} \cdot Pa^{-1}$) is very similar to those determined for a number of previously tested lime render mortars with the tendency for the Fibrelime™ mortar to be at the top end of the scale.