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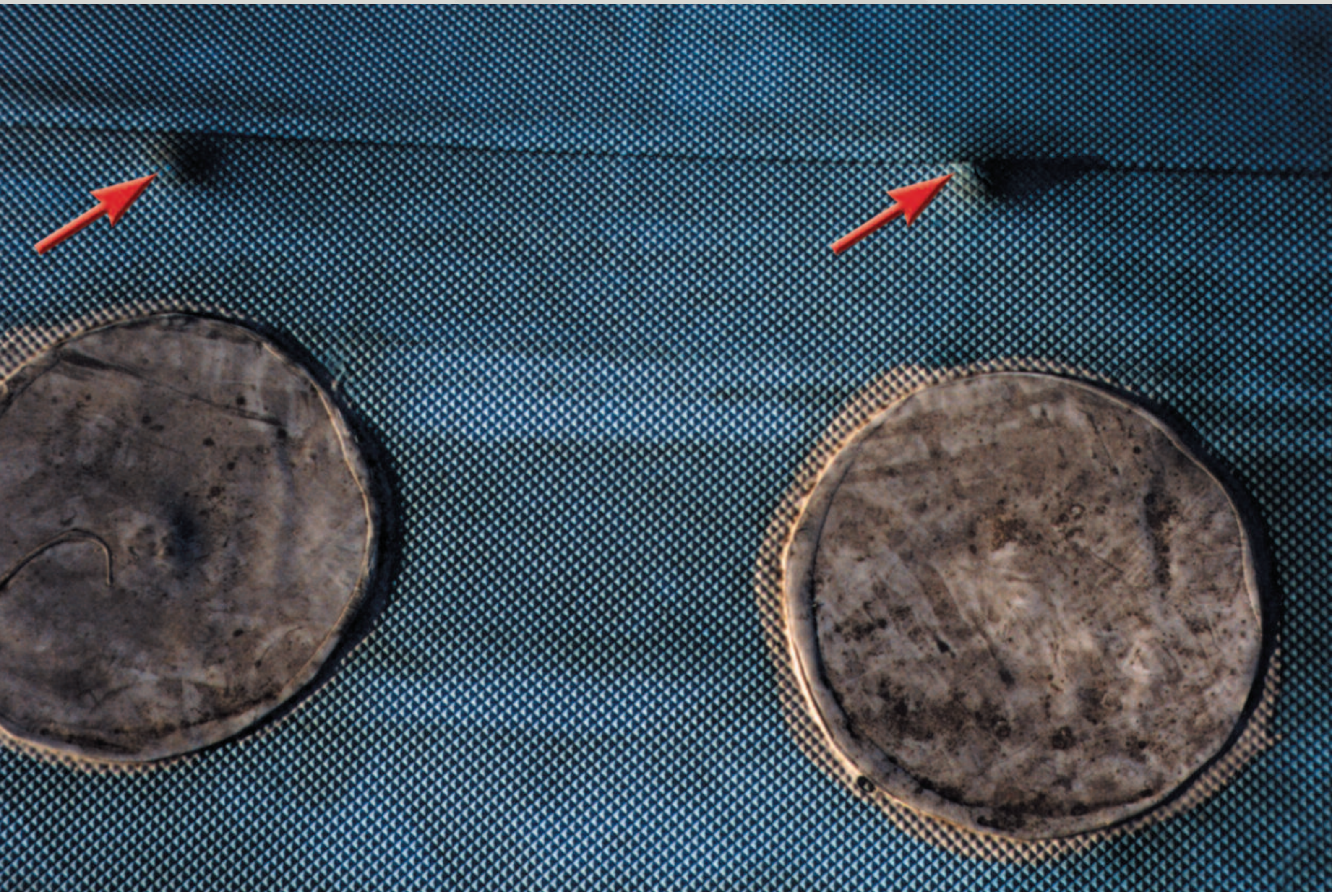
The Walkability of Rock Mineral Fibre Flat Roof Insulation – A White Paper

A STUDY INTO THE EFFECTS OF REPEATED PEDESTRIAN TRAFFIC ON TWO FLAT ROOF INSULATION MATERIALS



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1 Executive Summary

1.1 The BDA Marathon Man Test simulates the effects of repeated pedestrian traffic on a flat roof in order to classify flat roof insulation materials for suitability of use under a range of pedestrian traffic conditions.

1.2 Kingspan Insulation Ltd. commissioned BDA to conduct a series of Marathon Man Tests on rock mineral fibre flat roof insulation materials.

1.3 As a result of these tests, the **rock mineral fibre** samples tested could be classified as **"not suitable for roofs with pedestrian traffic"**.

1.4 BDA has published the results of other Marathon Man Tests, on rigid urethane and rock mineral fibre flat roof insulation materials, carried out for another company.

1.5 As a result of these tests, the **rock mineral fibre** samples tested could be classified as either **"not suitable for roofs with pedestrian traffic"** or **"suitable for incidental pedestrian traffic during inspection and maintenance of roofing"**.

1.6 The **rigid urethane** samples tested could be classified as **"suitable for daily pedestrian traffic (galleries, roof terraces)"**.

1.7 If an unsuitable insulant is chosen for the prevalent level of pedestrian traffic on a particular flat roof, this could lead to the collapse of the insulation material. Rock mineral fibre flat roof insulation could be regarded as being more likely to cause such failures because of its lower Marathon Man Test performance.

1.8 This is corroborated by industry experience of some existing flat roofs. A case study of one such example is contained in this White Paper.

1.9 If rock mineral fibre flat roof insulation collapses then this could exacerbate the formation of ponding water on a roof which will also add to the load placed on the structure of a buildings roof and could accelerate waterproofing membrane failure.

2 Introduction

2.1 In warm deck flat roof construction the flat roof insulation layer plays a key part in the integrity of the roof, as any compressive load applied onto the roof will be distributed through the insulation layer.

2.2 Flat roofs are often exposed to dynamic compressive loads, e.g. pedestrian traffic. These loads occur during construction of the building and during regular maintenance of plant installations on the roof post-construction.

2.3 Industry experience shows that, despite good static compressive strength, certain flat roof insulation materials can be susceptible to damage from repeated pedestrian traffic. Some materials can lose much of their compressive strength after a few load cycles. This can result in the deeper imprint of a pedestrian's feet into the top surface of a flat roof. If the insulation material is unsuitable for common dynamic compressive loads, such as repeated pedestrian traffic, then this may have an adverse impact on its lifetime performance.

2.4 There are no normalised test methods for the assessment of the effect of dynamic compressive loads on the long term performance of flat roof constructions. Often the static compressive strength and/or point load resistance of an insulation material is used as an indication, but this method only applies a load once, and thus can not test deterioration due to repetitive loads at the same point on a flat roof.

3 The BDA Marathon Man Test and Walkability Classification System

3.1 A new test method has been developed by the Dutch test institute BDA to simulate the effects of repeated pedestrian traffic on a flat roof in order to predict potential damage due to repetitive loading. The phrase “walkability” has been coined for this practical phenomenon. This test method, which is now known as the BDA Marathon Man Test, enables the walkability of insulation products to be classified.

NB: the Marathon Man Test is not as yet a normalised test method though there is a body of opinion that it should be.

NB: BDA is a Dutch test institute and European notified and accredited laboratory, similar to BBA in the UK.

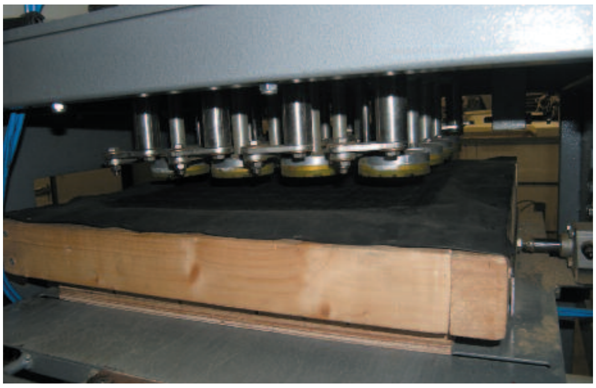

Figure 1 The current BDA Marathon Man test device

3.2 The test simulates the repetitive foot fall (with a shoe or boot) of a man weighing 75 kg carrying a 25 kg roll of waterproofing membrane. The number of load cycles can be adjusted thus simulating the repetitiveness of the loading of the flat roof.

3.3 The Marathon Man Test is carried out with a vertical load of 750 N combined with a radial (torsional) force of 250 N. 600 mm x 600 mm square samples are covered with a non-reinforced EPDM waterproofing membrane and surrounded by a wooden frame. Table 1 shows the BDA walkability classification system for these test conditions. The number of cycles per class is determined by a safe estimate of the number of times the roof will be walked on in the usage category concerned. The pass criterion (no more than 15% reduction in compression strength) is based upon BDA’s practical experience.

Class	Number of Cycles	Compressive Strength no More than 15% Lower than Initial Value	Walkability	Suitability
0	5	No	Not walkable	Not suitable for roofs with pedestrian traffic
1	5	Yes	Limited walkability	Suitable for incidental pedestrian traffic during inspection and maintenance of roofing
2	10	Yes	Good walkability	Suitable for frequent pedestrian traffic during inspection and maintenance of building services equipment
3	30	Yes	Intensive walkability	Suitable for daily pedestrian traffic (galleries, roof terraces)

Table 1 Classification of walkability of insulation products for tests conducted with a vertical load of 750 N combined with a radial (torsional) force of 250 N.

3.4 A comparison, commissioned by BDA from independent consultants, of the results of the new test method with the damage observed on real roofs shows that the test results correlate well with reality.

4 Results & Classification

4.1 Kingspan Insulation Ltd. commissioned BDA to conduct a series of Marathon Man Tests on rock mineral fibre flat roof insulation materials using the test method described in Section 3. The results are discussed below.

4.2 The rock mineral fibre flat roof insulation materials comprised 105 mm thick boards, purchased in the UK by BDA, with an average initial compressive strength of 66.2 kPa at 10% compression.

4.3 Significant changes in compressive strength were observed (Table 2 & Figure 2). The reduction in compressive strength was more than 28% on average after 5 cycles, more than 41% on average after 10 cycles and more than 71% on average after 30 cycles. The best results achieved by any of the samples were a reduction of more than 16%, 34% and 64% at 5, 10 and 30 cycles respectively.

Insulation Material	Compressive Strength (kPa)			
	Initial	After 5 Cycles	After 10 Cycles	After 30 Cycles
Rock Mineral Fibre Sample 1	63.5	42.7 (-32.8%)	37.3 (-41.3%)	11.9 (-81.3%)
Rock Mineral Fibre Sample 2	64.4	53.5 (-16.9%)	32.3 (-49.8%)	18.7 (-71.0%)
Rock Mineral Fibre Sample 3	70.7	46.2 (-34.7%)	46.5 (-34.2%)	25.2 (-64.4%)
Average	66.2	47.4 (-28.4%)	38.7 (-41.5%)	18.6 (-71.9%)

Table 2 Results from BDA walkability testing conducted on rock mineral fibre flat roof insulation materials using a vertical load of 750 N combined with a radial (torsional) force of 250 N.

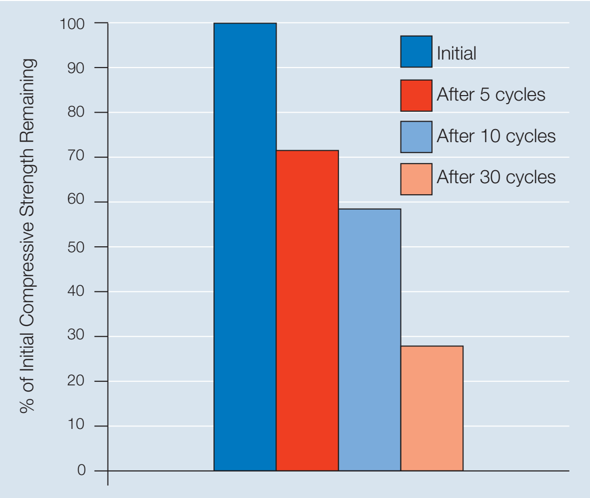

Figure 2 Loss of compressive strength after test (average of all 3 samples)

4.4 These results would lead to a classification of "not suitable for roofs with pedestrian traffic" for the rock mineral fibre specimens tested.

4.5 BDA has published* the results of a different series of tests, on various insulation materials, carried out for another company, using the test method described in Section 3 and the results relevant to this white paper are shown in Table 3 below.

Insulation Material	Compressive Strength (kPa)			
	Initial	After 5 Cycles	After 10 Cycles	After 30 Cycles
Rock Mineral Fibre Sample 1	57	20 (-64.9%)	10 (-82.5%)	-
Rock Mineral Fibre Sample 2	74	64 (-13.5%)	-	-
Rigid Urethane	194	-	-	193 (-0.5%)

Table 3 Most relevant results from BDA walkability testing conducted on several flat roof insulation materials using a vertical load of 750 N combined with a radial (torsional) force of 250 N.

4.6 These results would lead to a classification of "not suitable for roofs with pedestrian traffic" or "suitable for incidental pedestrian traffic during inspection and maintenance of roofing" for the rock mineral fibre specimens tested and a classification of "suitable for daily pedestrian traffic (galleries, roof terraces)" for the rigid urethane specimen tested.

** Hendriks, N.A. De beloopbaarheid van daken opnieuw bekeken. Dakenraad, Number 62, October 2004.*

NB The variation in initial compressive strengths of the materials tested is assumed to be a reflection of the normal distribution of compression strength of these products.

NB Different waterproofing membranes will give different results but single-ply membranes are the predominant waterproofing membranes used in the UK with rock mineral fibre.

NB This test program was conducted on a small number of samples and normal caveats regarding the statistical confidence of small sample sizes apply.

5 Case Study - Swindon

5.1 Building Sciences Ltd undertook a visual inspection of a large warm deck flat roof in Swindon. It was said to be suffering a number of weathering defects, which had been addressed with localised repairs. These defects had occurred in areas which had endured repeated pedestrian traffic by maintenance workers (by the main roof access hatch and walkways).

5.2 The construction consisted of a profiled metal deck, vapour control layer, rock mineral fibre flat roof insulation and a single-ply waterproofing membrane. The insulation had been fixed down mechanically with metal disc topped fixings. The single ply membrane was bonded to the top surface of the metal discs.

5.3 In the areas where heavy trafficking had occurred the insulation layer had been permanently compressed (collapsed) and the fixing discs, together with the membrane bonded to them had been forced downwards leaving the fixings protruding up into, or indeed, through the membrane. This had already resulted in a number of the fixings piercing the membrane which had, as a result, been patch repaired (see Figures 3, 4 & 5).

5.4 Building Sciences Ltd commented that punctures of the membrane would almost certainly have resulted in water penetration into the roof system prior to patch repairs being carried out.

NB The type of mechanical fixing used on the Swindon roof, which was constructed in the 1980s, is seldom if ever used on roofs constructed today. The risk of modern fixings penetrating a roof's waterproofing membrane is small to negligible. However, the type of fixing used will not have any material effect on the walkability characteristics of the flat roof insulation, only the consequences thereof.

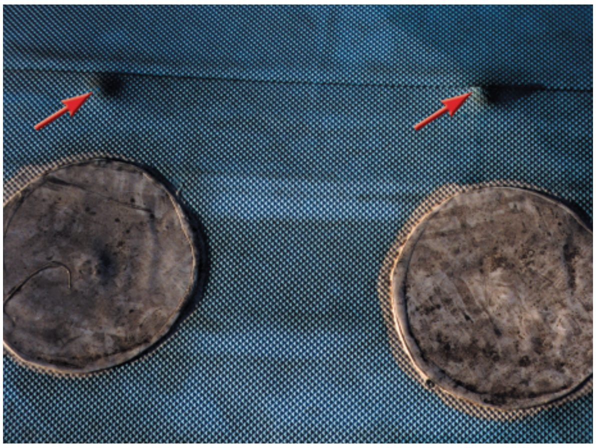

Figure 3 Two screw heads are pressing against the waterproofing membrane. Two previous penetrations have been repaired

Figure 4 Arrows show where screw heads are pressing against the waterproofing membrane. A number of previous penetrations have been repaired. A pond of water is visible in the affected area

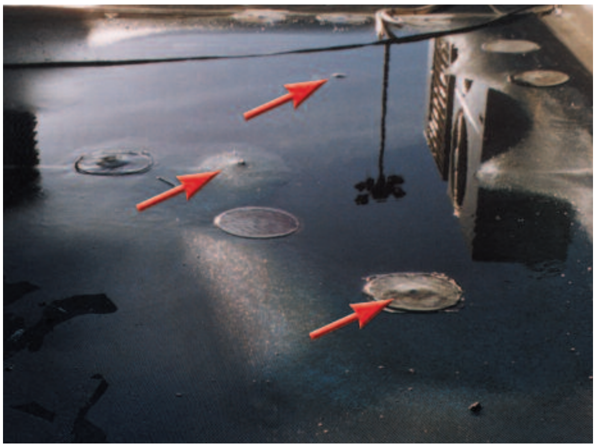

Figure 5 A different view of the area shown in Figure 4. The pond of water is more obvious and the roof plant is visible in the reflection

6 Conclusions & Potential Consequences

6.1 In the tests reported herein, the performance of rigid urethane flat roof insulation is superior to that of rock mineral fibre with regard to cyclical loading.

6.2 The BDA classification system would indicate that the rock mineral fibre specimens tested may only be suitable for roofs with limited pedestrian traffic, if any at all, if unprotected.

6.3 This is consistent with the findings of the roof survey case study reported herein. The roof surveyed is not unique.

6.4 The BDA classification system would indicate that the rigid urethane specimens tested would be more than adequate for use where repetitive foot traffic is likely.

6.5 Careful consideration should be taken when specifying the insulation for a warm flat roof. The insulation must be able to withstand and exceed any level of expected pedestrian traffic, not only when the flat roof is under construction, but any further access after the roof has been completed.

6.6 If an unsuitable insulant is chosen for the prevalent level of pedestrian traffic on a particular roof, this could lead to the collapse of the insulation material. Unprotected rock mineral fibre flat roof insulation could be regarded as being more likely to cause such failures because of its apparent lower performance.

6.7 If rock mineral fibre flat roof insulation collapses then this could exacerbate the formation of ponding water (as shown in Figure 6 below) on a roof's surface.

Figure 6 Patterns of deposits left by water pond evaporation can be seen. The polka dot pattern is due to individual ponds forming round single fixings which have been installed in such a way as to dig into the compressible rock mineral fibre insulation. They are not caused by collapse from foot traffic.

6.8 Ponding water will in turn add to the load placed on the structure of the buildings roof.

6.9 Ponding water can speed up waterproofing membrane failure because:

- the freezing of ponded water may cause damage by expansion and contraction effects;
- it may encourage the build up of silt deposits which support the growth of plants, moss and algae which can cause damage; and
- the edges of ponded water may create local sharp temperature gradients which could impose significant stresses on membrane materials*.

6.10 Mineral fibre flat roof insulation manufacturers recommend that additional protection be used to overlay their insulation products in areas of a flat roof that will be used as walkways. However, this recommendation could be regarded as futile because it can be hard to predict where all foot traffic on a roof will occur. In addition the problem may be caused by the repetitive foot traffic of the contractors installing the roof insulation, waterproofing membrane and plant, before any durable covering can be laid..

*BFRC & CIRIA. Flat Roofing Design and Good Practice, p54. 1993.

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