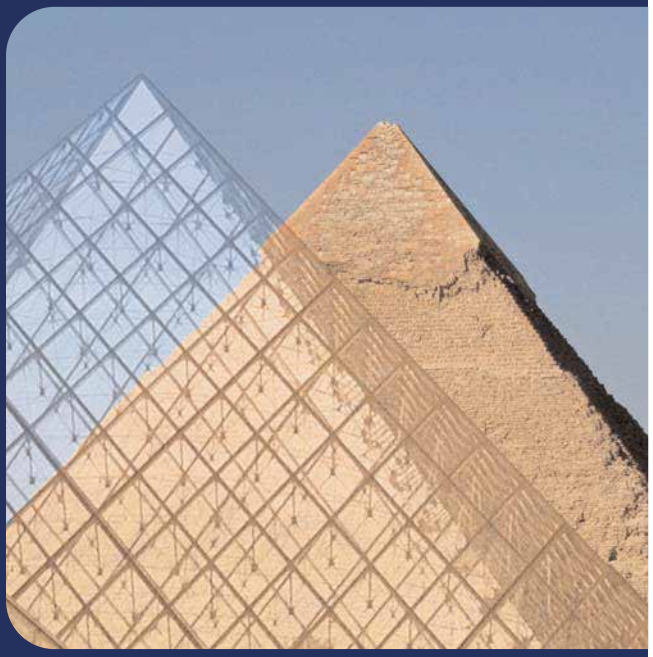
ENHANCING THE SERVICE LIFE OF THE ROOF

DESIGN CRITERIA



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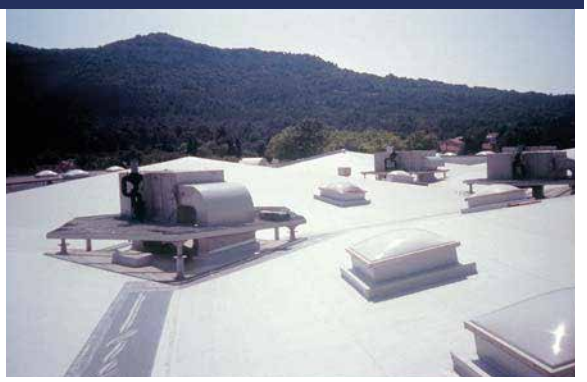


EXPANDED PERLITE INSULATION BOARDS: ENHANCING THE SERVICE LIFE OF BUILT-UP ROOFING SYSTEMS ON PROFILED-METAL ROOF

A new approach to assessing the mechanical properties of roof insulation

Flat roofs can be subjected to various types of foot traffic during and after installation of the built-up roofing system, which can have enormous consequences for the service life of the roof.

Once their resistance to ultra-violet rays was assured, the use of self-finished roofing membranes became commonplace on metal roof decks due to their lightweight.
This, in turn, has led to a certain fragility and damage of the membranes due to excessive foot traffic over insulation boards which have low compression resistance.

To assist building owners and architects in their choice of products, a study carried out by the CSTB in France has led to a new approach concerning the performance of the two main elements of a built-up roofing system: namely, the insulation and its waterproofing cover.
This study covered static and dynamic indentation tests, as well as several thousand cycles of compression/relaxation tests to monitor compression behaviour.

Is it possible to foresee the intensity of traffic on a roof ?

The building is in use: the requirement for the maintenance of the roof and roof-top equipment can generally be foreseen at the planning stage.This could cover the maintenance or replacement of equipment such as skylights and smoke outlets, air conditioning, ventilation, generators, transformers, neon signs, solar panels and photovoltaic roofing membranes, etc.

The building is under construction: roof access being limited, roofing contractors may need to use finished roof areas for access to other areas or for storage of materials.

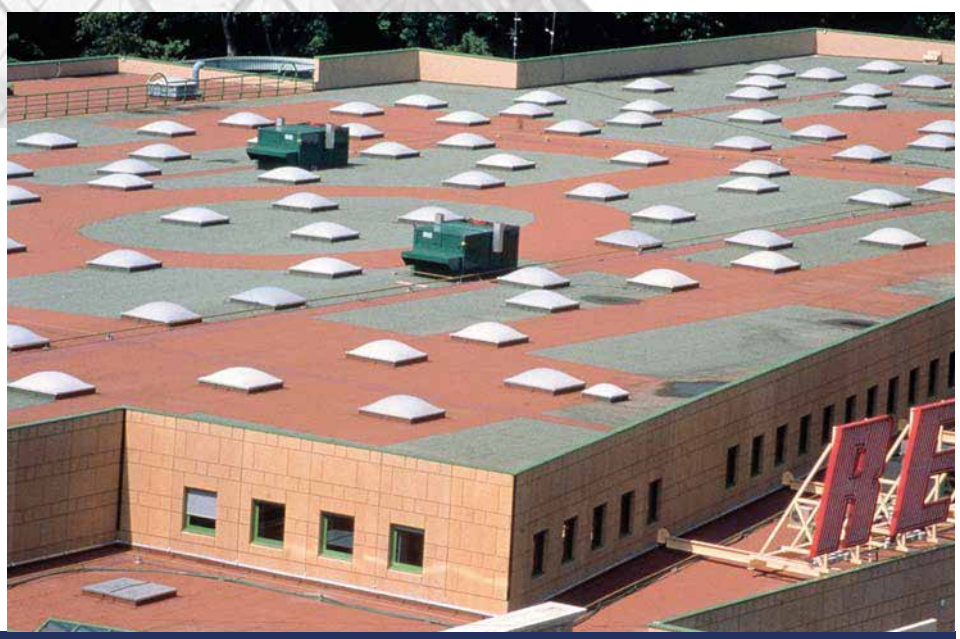
The change in use of the building leading to greater need for roof accessibility should be planned for at the outset.A relatively small extra cost at this stage can save expensive roof reinforcements later on.

What are the risks?

Damage to the waterproofing layer is very often the consequence of foot traffic over the roof and the principal effects are:

- the appearance of cracks along the joints of the insulation boards leading to an eventual breakdown of the water-proofing,

- the perforation of the roofing membrane caused by the screw heads of mechanical fasteners used on metal roof decks.



CONVENTIONAL TRAFFICABILITY TESTS

Generally speaking, Agrément Certificates for insulation products indicate:

1. the compression resistance at 10% reduction, according to norm EN 826 and expressed in kPa (1 kPa ~ 0.01 kg/cm^2)

2. the compressibility classification B, C or D based on the UEAtc test method i.e. less than 5% reduction after 7 days under loads of 20, 40 or 80 kPa measured at 80°C when used under a self-protected water-proofing membrane.

Neither test method reflects the effects of regular foot traffic on a built-up roofing system:

• in the first case because the level of crushing is too great and is non repetitive,

• and in the second instance, corresponding more to an object being laid down on the roof.

Furthermore, Agrément Certificates for roofing membranes give values for static and/or dynamic puncture resistance based on results of tests using a substrate of expanded polystyrene (EPS).

Thus, the contractor or specifier can only judge the mechanical performance of these two vital elements of the system based on non-representative test methods and taken separately.

NOTE
It should be noted here that experience of damage to built-up roofing has led to a number of rules being applied when low compression resistant insulants are used.
For instance, mineral wool boards must be:

1. used in conjunction with water-proofing membranes having a minimum puncture resistance class I3,

2. used only on non accessible roofs if the compressibility class is B,

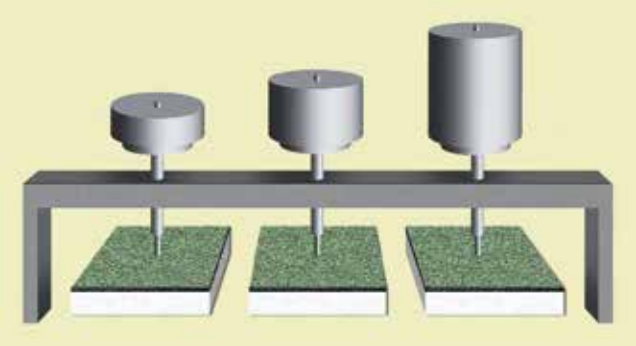
3. fastened using only one-piece (screw and washer) fixing systems if the compression resistance at 10% is inferior to 100 kPa,

4. installed fully supported at the roof perimeter,

5. covered with a temporary protection against foot traffic during work on site.

A NEW APPROACH TO PERFORATION RESISTANCE

Using these existing test methods but replacing the EPS with other insulation substrates, under the same type of waterproofing cover, the results were significantly different from one insulation material to the other.



The table below shows the difference in behaviour between a mineral fibre board and **Fesco** under a two-layer, modified bitumen, glass fibre reinforced waterproofing. The results shown are after 15 cycles without perforation of the waterproofing.

Perforation resistance (board density ~ 150 kg/m^3)	**Unit**	**on mineral fibre**	**on Fesco**
- static (NF P84352)	kg	5	10 Twice as resistant
- dynamic (NF P 84353)	J	11	18.5 1.7 times more resistant

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CYCLIC COMPRESSION TESTS

The criteria used for this new test were :

- sample size of 30 x 30 cm, which represents a big proportion of a board,

- choice of only one loading i.e. 40 kPa, instead of a given level of crushing,

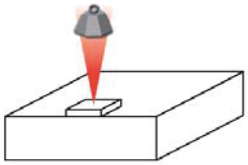
- instead of applying an instantaneous load, cyclic loads 0 - 40 kPa - 0 were applied several thousand times to simulate continuous foot traffic over a roof,

- the load was applied over an impress of dimensions 10 x 10 cm, representing a size something between the heel and the sole of a shoe,

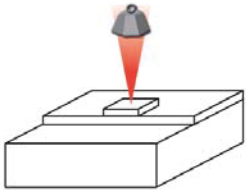
- the load is applied on the edge of the board, this being the weakest point for the roofing membrane,

- if necessary, a combination of several insulation boards,

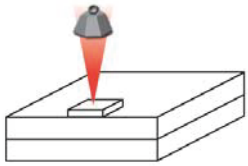
- testing at ambient temperature.



Compression/relaxation test on single layer insulation (curves I, III, and V)



Compression/relaxation test on mineral fibre + Retrofit 13 mm (curve II)

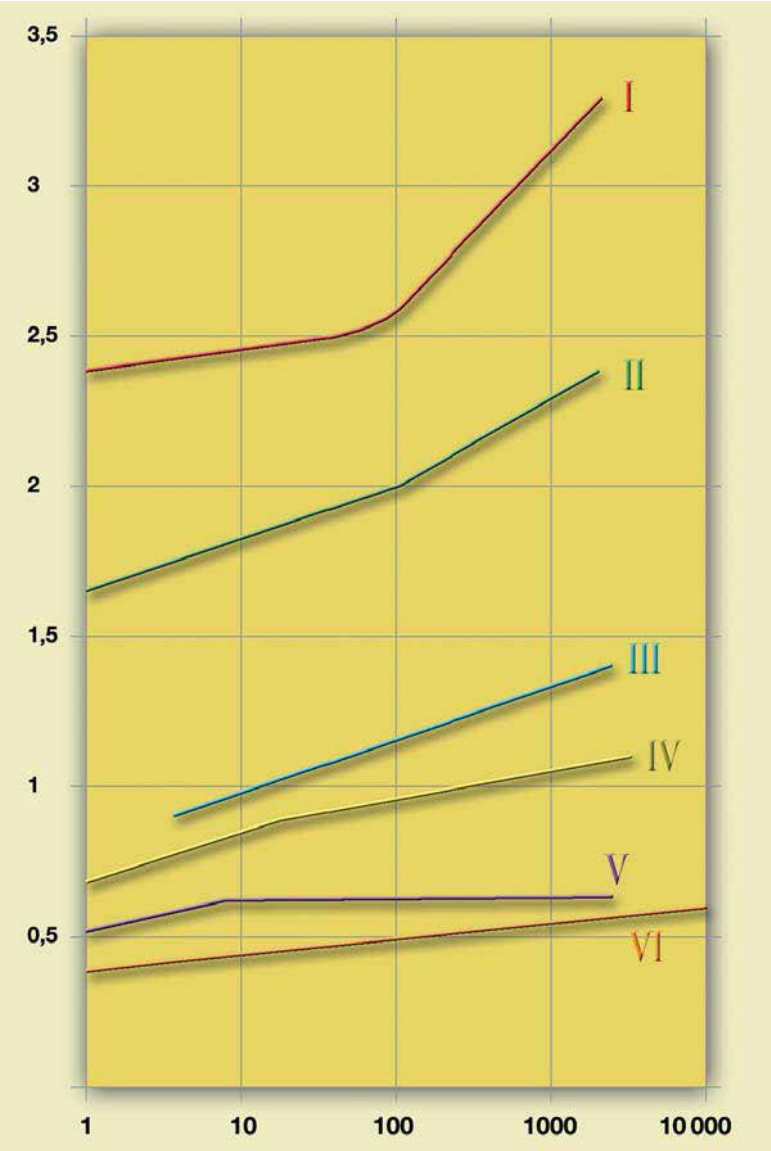


Compression/relaxation test on composite insulation boards (curves IV and VI)

The choice of insulant and the different combinations highlight the influence of the impress (which is 3 times smaller than the sample boards) in distributing the load; standard test methods, applied over the whole surface of the sample, do not allow this to be measured.

	Boards and combinations tested	Thickness (mm)	Nominal density (kg/m³)	Compression at 10% crushing (kPa)	Compressibility classification
I	**Mineral wool type 1**	75	150	60	B
II	**Mineral wooltype 1 + Retrofit 13 mm**	75 + 13	150 et 200	not applicable	
III	**Mineral wool type 2**	80	190	90	C
IV	**Mineral wool type 1 + Fesco 50 mm**	50 + 50	150 et 150	not applicable	
V	**Fesco**	100	150	300	D
VI	**Phenolic foam + Fesco 20 mm**	60 + 20	40 et 150	not applicable	

The graph below shows compression values at various stages of the cyclic testing procedure.



OBSERVATIONS

- mineral wool type 1 (curve I) shows, as expected, the highest initial crushing with a sharp increase at 100 cycles, which demonstrates a breakdown of the fibre content. At the end of the test the crushing exceeded 3 mm,

- the combination of mineral wool type 1 with Retrofit (curve II) crushes down less than in the preceding case, with a slight break at 100 cycles to finish at less than 2.5 mm at the end of testing,

- high density mineral wool (curve III) shows a constant increase in deformation upto 1.5 mm at 2 300 cycles,

- the composite of 50 mm of Fesco on 50 mm of mineral wool type 1 (curve IV) results in crushing that barely exceeds 1 mm at the end of testing,

- the Fesco insulation board (curve V) is crushed by only 0.6 mm at the beginning and stays at this level upto the end,

- the composite of 20 mm of Fesco on a phenolic foam board (curve VI) is compressed slowly from 0.4 mm to 0.6 mm at 10 000 cycles.

WHAT LESSONS CAN BE DRAWN?

• The tests carried out in this study result in a classification of roofing products corroborated by field experience. For many years Sitek has recommended that this type of testing should be incorporated in Agrément Certificates for roof insulation, waterproofing support boards,

• The cycles represent the intensity of foot traffic both during installation and over the life of the construction,

• When used together with the maximum authorised compression limits for the waterproofing, these results give a good indication of the service life to be expected for a given roof construction.

RECOMMENDATIONS

1. The roof has no or very little roof-top equipment and no change in the use of the building is envisaged. Furthermore, the amount of foot traffic during installation is limited:
   all the solutions listed above are suitable.

2. Due to the size of the project, frequent and heavy foot traffic can be expected, and mineral wool by itself could well suffer damage as a result:
   *using **Retrofit** as an overlay board on standard mineral wool offers a permanent and economical solution.*

3. Large industrial and commercial buildings tend to have a considerable quantity of roof-top equipment that needs regular maintenance. Heavy foot traffic can be expected during roofing work due to the size of the roof and the installation of this equipment:
   ***Fesco** by itself or, where very high insulation values are required, **Fesco** + foam insulation board + **Fesco** are recommended solutions.*

4. The constraints are similar to those in paragraph 3 above except that the intensity of traffic is less, allowing the possibility of combining the economic advantages of mineral wool with long-term reliability :
   *the ideal solution is to apply a layer of **Fesco** over a mineral wool board, both boards being of equal thickness.*

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