Case Study

July 2012

European Liability Insurance Organisation Schemes

6. Bio-Material Insulation

Table of Contents

6.1 Introduction to the technology

Bio-material insulation exists in several forms, the common factor being that all are derived from natural, plant- or animal- based products.

Many forms of bio-material insulation have thermal conductivities on a par with mineral wool, and others have a higher conductivity yet are capable of bearing structural loads. All forms are non-irritant, and offer high levels of fire protection (either naturally or in combination with chemical fire retardants). Resistance to rodent, pest and fungi attack is, in most cases, provided by the addition of suitable chemicals.

Due to their hygroscopic properties, bio-based insulation products are frequently used as key components of 'breathable' buildings. Their embodied energy is normally low, and many products claim to sequester sufficient carbon to be classed as 'carbon-negative' over their lifecycle.

Bio-material products are available in a variety of formats (eg. fleece, slabs, boards, structural), and material costs are generally comparable to the equivalent traditional construction products.

6.2 Available types of this technology

The major classes of bio-material insulation are:

- Hemp
- Sheep's wool
- Wood fibre
- Straw

Various minority materials also exist but are not widely used in the EU, for example:

- Cotton
- Cork
- Soy oil or castor oil based polyurethane spray foam
- Flax
- Rice

The major classes:

Hemp. Available as fibre slabs or as ‘hempcrete’. Hemp fibre slabs are typically composed of 60% hemp fibre and 30% recycled polyester, and with a thermal conductivity around 0.04 W/mK are used for straightforward insulation between timber studs,. Hempcrete comprises hemp fibre mixed with lime, and can be used for structural walls and floors. Hempcrete is either poured or laid as pre-cast blocks, and has a conductivity between 0.06 and 0.1 W/mK. Because its compressive strength is only 1/20 that of concrete, however, walls and floors usually require a structural timber frame and the addition of aggregates respectively).

Sheep’s wool. Sheep’s fleece insulation is supplied in rolls and as slabs. Both forms contain approximately 15% recycled polyester fibres. Conductivity is around 0.039 W/mK in both cases. Sheep’s wool insulation has the ability to absorb and subsequently release large volumes of water with no ill effect, although it will degrade with prolonged contact with water or exposure to UV radiation (including sunlight).

Wood fibre. Wood fibre batts, the thermal conductivity of which is around 0.038 W/mK, are flexible and are therefore often used for internally insulating older properties with irregular walls. Some products incorporate a ‘mineral functional layer’ which encourages any condensation to occur within the batt, where it can be re-absorbed back into the room, rather than at the interface with the existing (cold) wall where it may collect and cause structural problems. Along with most other bio-based insulation materials, wood fibre insulation contains no VOCs or CFCs. When produced from Forest Stewardship Council (FSC) -certified sources or recycled timber it can be said to be truly sustainable.

Straw. While straw can be supplied as pre-compressed blocks or as a finishing board, the majority of straw buildings comprise normal field bales produced during food crop harvesting by a baling machine. Being extremely dense, straw bales provide no entry point for rodent attack and are extremely fire resistant. Straw bale walls can be load bearing to an extent, but often incorporate a timber frame to withstand extreme loading conditions (for example, snow). It is important to keep straw bale structures waterproof, so they are usually rendered (typically with lime render)

The minority materials:

Cotton is a relatively new insulation product, and because the raw material has to be imported from warm cotton-growing countries (notably the USA), when used in the EU it has higher embodied energy than other bio-materials. The manufacture of new cotton insulation also involves significant amounts of energy and chemicals, although recycled cotton insulation is starting to appear.

Cork bark is a useful natural insulation board, and granulated cork can be used in loose fill applications. Cork is particularly sustainable when used in countries where it is grown in abundance (for example Portugal).

Spray foam insulation can be produced using **soy** or **castor oil** to replace a proportion of the normal fossil oil derivatives and in some cases can also be blown with non-ozone depleting foaming agents. At the time of writing, however, soy- and castor- based spray foam only appears to have any following in Ireland and the USA, and even there has remained a ‘fringe’ product distributed by predominantly a single company for several years.

Flax and **rice** fibres can be used in similar insulation products to hemp and straw, with clear sustainability benefits where they are indigenous.

6.3 Strengths, weaknesses, opportunities and threats

This section outlines a discussion of the key drivers affecting paper-based insulation.

Strengths

- Similar insulative properties and capital cost to conventional insulation.
- Renewable. Often 100% new, naturally grown content, but never less than 75% (where the remainder is usually recycled material).
- Low embodied energy.
- Raw materials contain sequestered carbon, so products have negative global warming potential (GWP).
- Zero ozone depletion potential (ODP), because products are not factory-blown.
- Non-irritant, non-toxic and safe to handle, although face masks are usually worn during installation.

Weaknesses

- Liable to degradation with prolonged exposure to damp or UV radiation.
- Cannot, therefore, be used where the structure will be exposed to damp conditions or as external finishes; normally used as infill panels in timber framed buildings rather than in filled cavity construction.
- Most forms require chemical treatment to resist of deter rodent, pest and fungal attack.

Opportunities

- Increasing interest in 'natural products' and 'breathing buildings'.
- Growing concern about embodied energy of construction products.
- Increased legislation against competing insulants which are blown with ozone-depleting gases.
- Adaptable to local growing cultures (eg. UK would use straw where China might use rice-based products).
- Straightforward end-of life disposal.

Threats

- Possibility that aged-product research may reveal issues not currently known.
- Rodent or pest attack may transpire to be worse than predicted.
- Development of rival products with better price/performance ratio.

6.4 Building pathology, defects, and what can go wrong

6.4.1 Invitations to complete questionnaire

An invitation to complete the online version of the Elios II questionnaire was sent to 374 individuals in the following industry sectors:

TABLE 6.1 – Invitations to complete questionnaire

Sector	***Number sent***
Insurance	64
Certification Bodies	10
Accreditation Organisations	4
Builders/Installers	55
Manufacturers	74
Trade Associations	27
Professional Institutes	19
Architects	14
Quantity Surveyors	2
Other	4
Building Inspection Services	13
Government Organisation	22
Housing Associations/Commissioner	16
Consultancies	15
Merchant/retailer	5
Unknown	30
Total	374

In total 70 respondents completed some or all of the questionnaire. This is an 18% response rate.

6.4.2 Responses received

At the closing date of 1st October 2012, 9 responses had been received which related specifically to bio-material insulation, e.g. hemp, straw, sheep's wool, etc. This is 13% of the received questionnaires.

The industry sectors of the respondents were as follows:

TABLE 6.2 – Responses

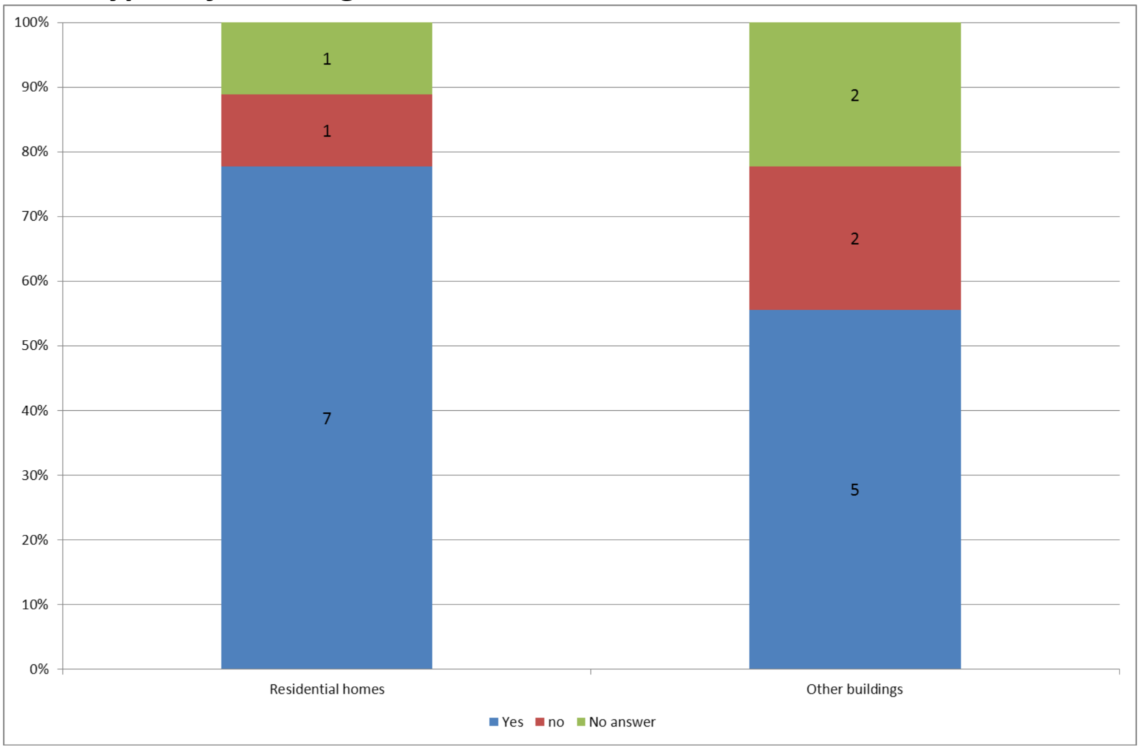
Sector	***Responses received***
Government organisation	1
Architectural practice	0
Housing organisation	0
Manufacturer	0
Retailer/merchant	0
Construction company	0
Installer	0
Building inspection service	2
Certification organisation	5
Insurance company	3
Trade association	0
Professional institution	2
Other (please specify)	3
Business in more than one	4
Total	***9***

Note that a respondent might have classified their business in more than one sector.

3 respondents collectively claimed to have data relating to 9 installations of the technology. One further respondent stated that he had no numbers but reported generalised comments about failures and defects.

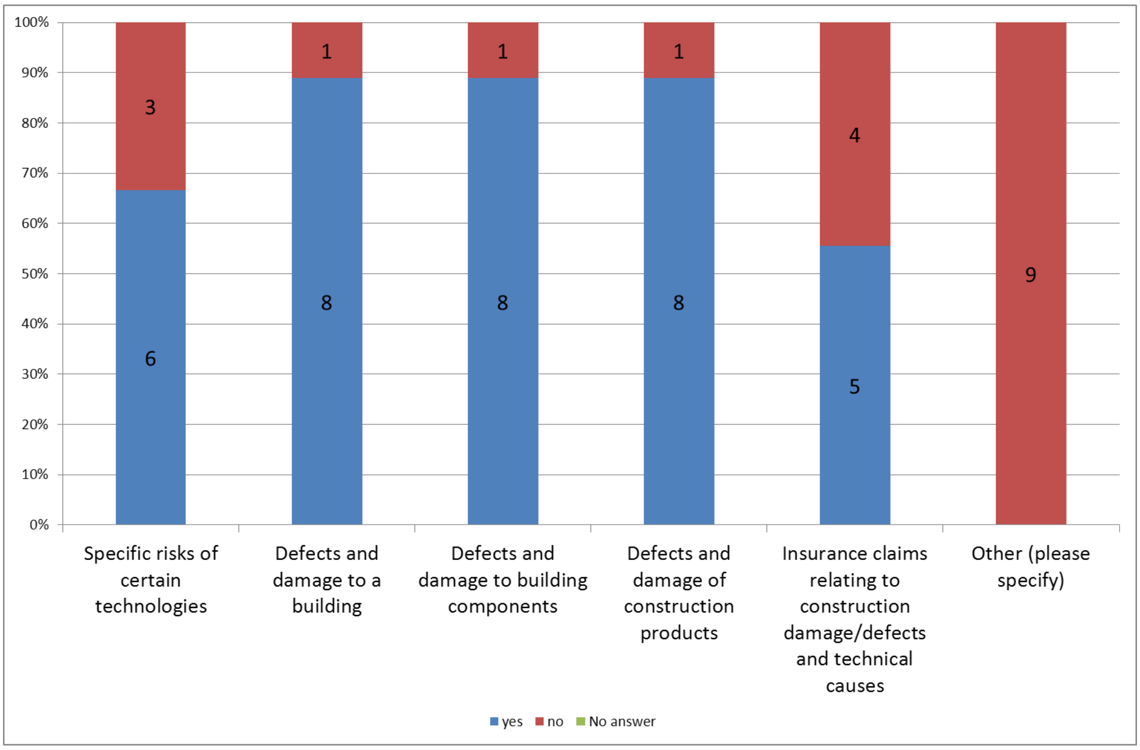
The following graphs and charts only relate to the people who responded about this technology.

CHART 6.3
Question asked – *"Does your organisation collect or collate its own data on these types of buildings?"*



This chart shows the number of reporting organisations that collect data on each type of property. This is only for this eco-technology. Organisations may collect data on more than one type of property.

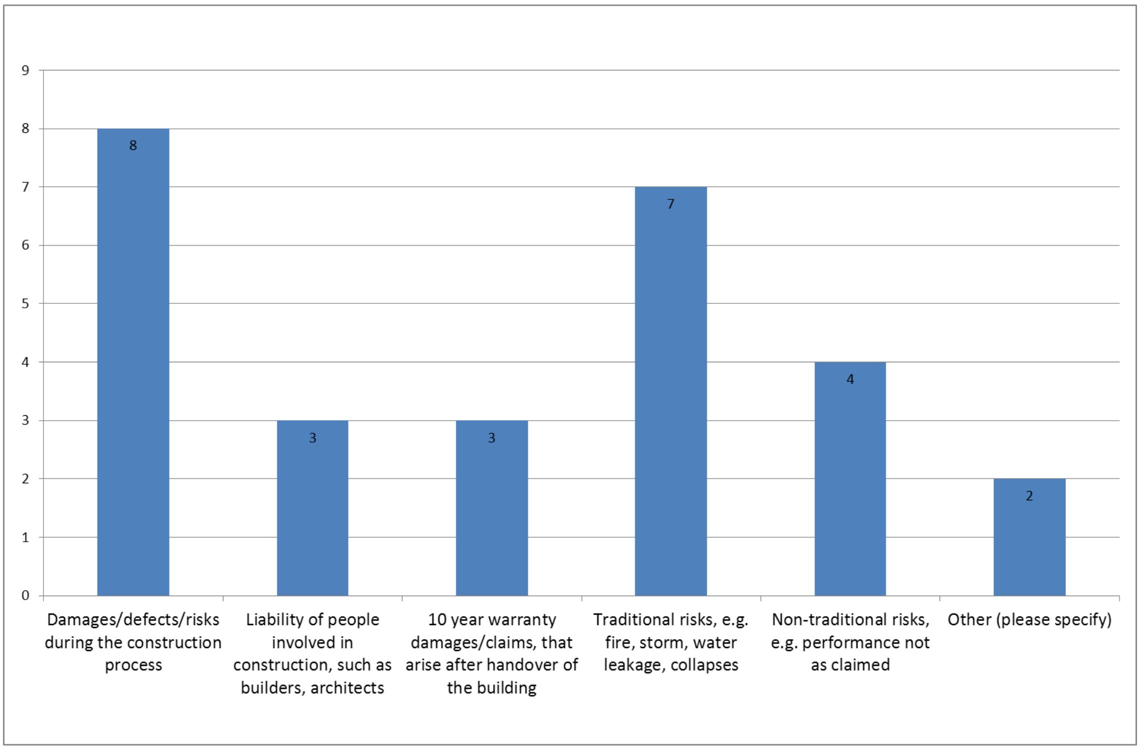
CHART 6.4
Question asked –*"Does your organisation collect its own data on these issues (please tick all that apply)?"*



This chart shows the various reasons that the reporting organisations collect data, and the number of organisations that gave each reason. This is only for this eco-technology, and not for all 10 technologies. Organisations may collect data for more than one reason.

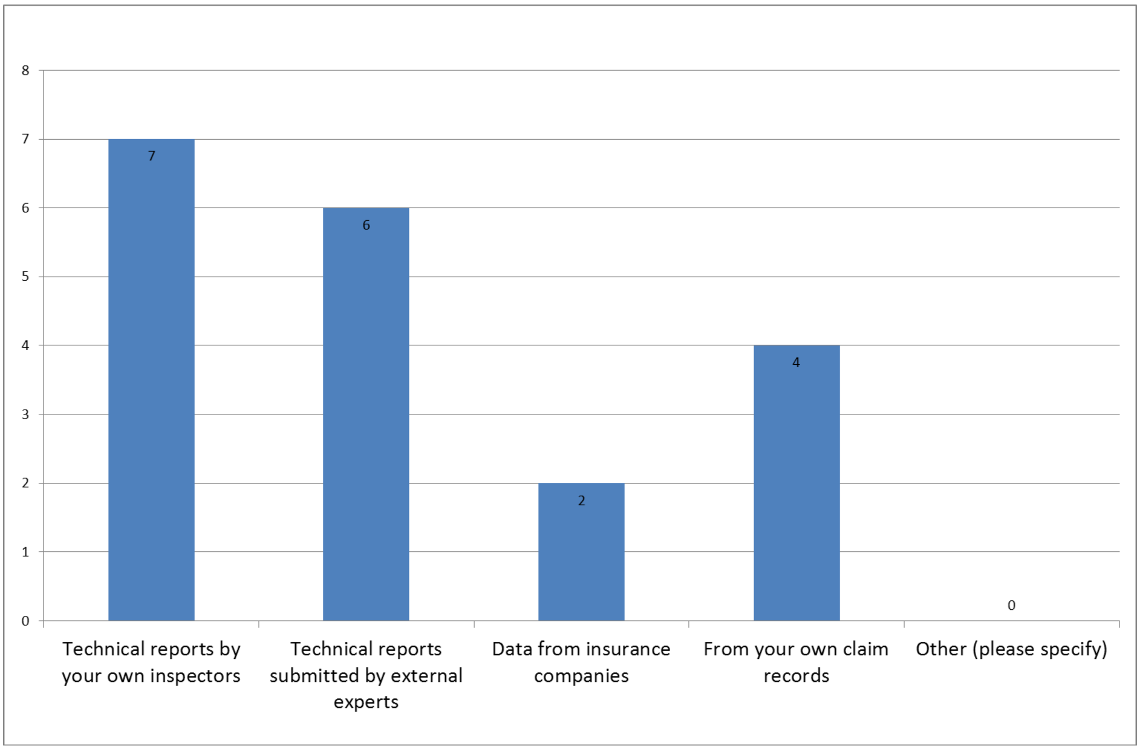
CHART 6.5

Question asked – *"What kind of damages/defects do the data refer to (please tick all that apply)?"*



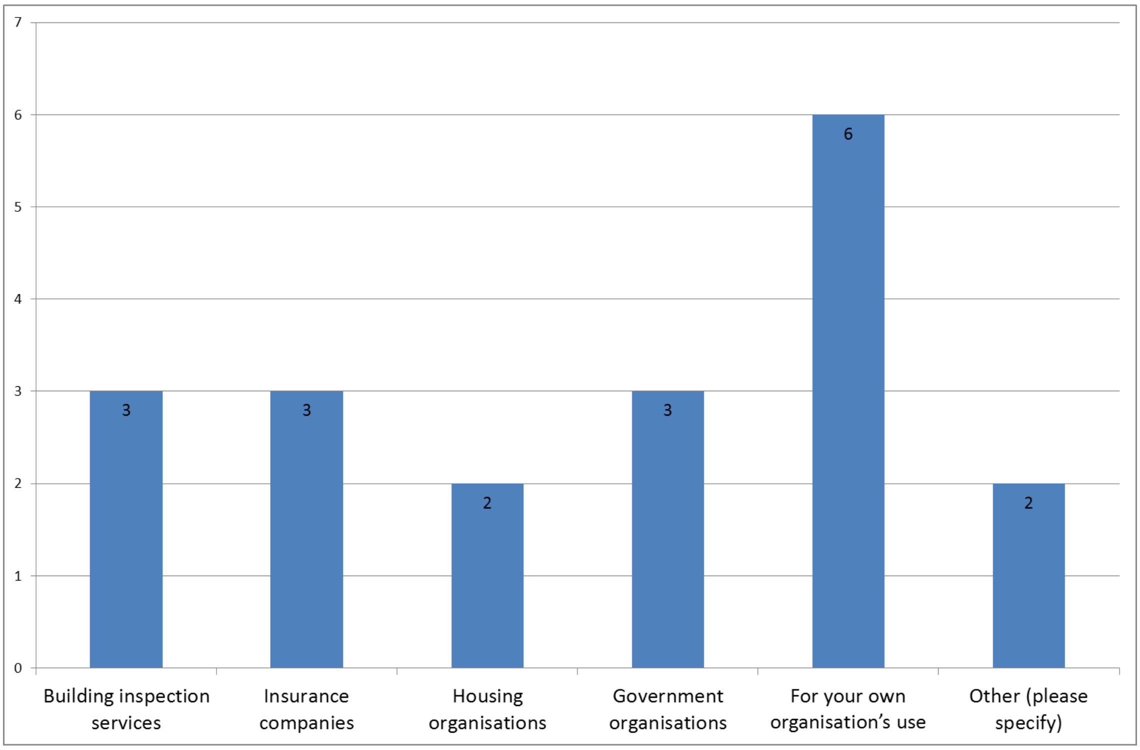
This chart shows the number of organisations that reported each kind of damage on which they collect data. Each column represents a different type of damage. This is only for this specific eco-technology, not overall. Organisations may collect data for more than one reason.

CHART 6.6
Question asked – *"How do you collect the data (please tick all that apply) ?"*



This chart shows the method by which each organisation collects data; each column represents a different method of data collection. This is only for this eco-technology, not overall. Organisations may collect data for more than one reason.

CHART 6.7
Question asked "*For whom do you collect the data (please tick all that apply)?*"



This chart shows the number and type of organisations that reported that they collect data about this eco-technology. Organisations may collect data for more than one type of organisation.

6.4.3 Summary of responses about databases

About their database:

- 8 people answered this question , and of them 7 have a database, 1 did not respond;
- 4 provided a date when data collection
  - 1 in 1967,
  - 1 in 1970, and
  - 2 in 1990
- 4 carry out statistical analysis of the data;

About data publication:

- 3 make data available on the web;
- 1 in newsletters;
- 2 in other publications;

About the availability of data, of these 8 respondents:

- 5 publish summary data only;
- 2 publish raw data in any form;
- 1 publish raw data, even anonymously;

Only 1 comment about data was passed, as follows:

- *"Confidential to ourselves and the providers - used to inform various services and policy"*

Finally, note that this question was answered in general about all 10 eco-technologies and may not apply to the specific technology.

6.4.4 Reasons for failures and defects

No firm numbers where provided for these technologies.

TABLE 6.8

Reason for failure/defect	Number	% of total
Requirement management		
Change in client's requirements	0	0.0%
Misunderstanding of the effectiveness of the technology	0	0.0%
Poor project management	0	0.0%
Inaccurate engineering or architectural data	0	0.0%
Delivery		
Late delivery	0	0.0%
Storage issues	0	0.0%
Awkward packaging	0	0.0%
Poor transport of product	0	0.0%
Installation		
Incorrect design for installation	0	0.0%
Incorrect installation documentation	0	0.0%
Failure in installation	0	0.0%
Commissioning failure	0	0.0%
Operational failure		
Product failure once installed	0	0.0%
Incorrect user documentation	0	0.0%
Misuse of product by end-user	0	0.0%
Performance not as claimed	0	0.0%
Other		
No other reasons were given for failure		
Total		

No specific counts were provided.

6.4.5 Failures/defects commentary

The respondents offered the following general comments and suggestions on the ways in which the failures and defects might be avoided in future:

TABLE 6.9

Reason for failure/defect	Commentary
Requirement management	
Change in client's requirements	
Misunderstanding of the effectiveness of the technology	
Poor project management	
Inaccurate engineering or architectural data	It is another product which requires more attention and application in practice than the traditional insulation blankets or sheets.
Delivery	
Late delivery	
Storage issues	It requires dry storage.
Awkward packaging	
Poor transport of product	

3. Installation	
Incorrect design for installation	This is another material like normal insulation. A correct airtight execution is very important in order to provide <prevent?> internal condensation. Internal condensation can have disastrous consequences for this material.
Incorrect installation documentation	
Failure in installation	Not following the application requirements
Commissioning failure	
Operational failure	
Product failure once installed	Thermal resistance value is often not attained. Sometimes product damage by internal condensation.
Incorrect user documentation	
Misuse of product by end-user	This could happen when the occupier of the house damages the air tight barrier of the insulation layer.
Performance not as claimed	
Other (specified)	

One general comment was made:

- *"Damp, fire and degradation"*

6.4.6 Key findings

In summary:

- It is hard to draw firm conclusions with such small samples, and so little data
- This is well established technology with a range of solutions available and tested.
- There seems to be a general conern about keeping the products dry both before and after installation.

Lessons:

- Appropriate storage, and more warning to installers and project managers, may help with preventing damp.