Episode 94

10 Insulation Types and When to Specify Them

The show notes: www.houseplanninghelp.com/94

Intro: Today's podcast is all about insulation. And if this were a 'money' podcast then today would be a bit like talking about tax! It's a topic we know is important. We're probably not going to be doing this ourselves, but what I'm hoping is we'll get a feel for an area that has so many variables.

I started by asking Brian to tell me a little bit about his background.

Brian: I'm an architect by training, a specification writer by choice which I did for about 15 years and I've been in the industry for 40 years. I've specified £2,400 million worth of work, predominantly larger projects but I'm more interested in smaller, greener projects these days so that's where I'm putting all of my efforts.

Ben: What do we mean exactly by 'specify'?

Brian: Well, it's like writing a recipe for a building. You have to describe every component, every material, how it's used, what the mixture is, how do you apply them, what tolerances and surface finishes you're looking for, so there's absolutely no doubt for anybody, including the people that price them, the people who build them, the people who buy the materials. Everyone has to know what's required so that there's no doubt and you write it once and there shouldn't ever be another question.

Ben: And in your time when you were doing different specifications, presumably you were learning too. Were there any surprises?

Brian: Yeah, my first freelance commission was the new British Library which was a bit of a challenge. £500 million first go. I was given a kind of part time post there for 14 hours a week, and it took me 3 months to realise that when we're used to writing, doing drawings, a single line is a single line in ink on paper, or in these days in a computer. But as I progressed I realised that any one line might be six or seven different processes. So it became quite daunting to do specification as thoroughly as I've had to, but it's a great way to learn how to do things and get better at what you do.

Ben: We're talking insulations today and we're going to look at ten specifically. Will there be lots of others that we don't mention or has this really got them in this list?

Brian: This is really the bulk of things. There probably are one or two other materials that. . . there's combinations and there's different mixtures of things. There's been a lot of playing around with blending of chemicals in making different kinds of plastics. I'm only going to talk about plastics as a single group. I'm not going to break them down into the many different plastics that I used in different applications. Because I kind of lump them together, and I shouldn't, I know that but that's the nature of the game.

Ben: Do all insulations do the same thing if there's enough quantity of them?

Brian: No. It's interesting that we're in the habit, and the building regs drives us in most respects. We're focussed on conductivity, and thermal resistance and U-values, the kind of total calculation for an external wall or a roof, and that's only one of at least three possibly four different ways that we need to think about thermal insulation.

I put them into groups. There's conductivity insulation, convection insulation and radiation insulation. And radiation insulation is probably the more important one because it's the one that we're going to engage with more and more as we progress to a hotter climate closer to Mediterranean climate in the UK.

Ben: Can you give that a little bit of an overview of those three that you mentioned and are we trying to get a balance sometimes, is that why this is changing?

Brian: I tend to see them as we're really focussing on one thing, most of the time. But in some cases we do have to have more than one characteristic in one place. For example, a pitched roof which is going to be subjected to the sun, it already is subjected to the sun. The sun, the heat of the sun and the warmth of the day is going to get progressively warmer as we move towards a European / Mediterranean climate. The solar gains are going to make rooms and roofs very much hotter and if we've got a good mixture of radiant thermal insulation protection stopping the heat getting in, and also some conductivity thermal insulation then we're going to stop the heat getting out. The risk is that if you let the heat in and you don't let it back out again you're going to overheat upper parts of the building. So there is a risk, and yes, we do need to start mixing the two types of insulation for two particular purposes.

Ben: Let's start off our list. At the top we've got glass, rock, mineral insulation. Is this at the top for a particular reason? Is it the most common?

Brian: It's usually the lowest price, and therefore it's used by the vast majority of people in the vast majority of locations. And it's a very good conductivity thermal insulation. It doesn't have a lot of decrement delay, the radiant heat thermal insulation. So in a roof it's the standard material that's used generally and projects like the Green Deal and other insulation programmes that the government have got in place, recognise glass wool and rock wool and unfortunately it's not the right material for most of the places. Particularly roofs.

Ben: Can you give us an example of what decrement delay means?

Brian: Well what happens is that when the sun beats on the roof, the roof gets hot. If you've got a black or blue slate it's going to get hotter. That slate will then re-radiate the heat inwards into the attic. The attic gets hot and then, if you've ever been in an attic trying to get stuff out in the middle of summer, it absolutely cooks. It's just unbearably hot. So that heat will find its way into the rest of the building, so it'll go to the bedrooms, the upper floors soonest. And those upper floors will overheat during the summer. And if you've got a very well insulated roof with 300mm of insulation of the conductivity type, that heat will stop getting out again. So what you need to try and do is stop the heat getting in in the first place to stop it overheating. So then you need the decrement delay.

Ben: Getting back to glass and rock mineral insulation, it sounds like there's a lot of manufacturing that's gone into this?

Brian: Yeah. If you imagine trying to take a stone and melting it, it takes an awful lot of energy. Then they turn it into a fibre by blasting air over it, or dripping it and blasting air over it. So lots of energy to go in, but it's one of those manufacturing processes where they're producing millions of square metres of the stuff. They're producing it in the most efficient way imaginable compared with the kind of one man band making natural materials. So there is a degree of efficiency but there's still an enormous amount of energy that's gone in.

Ben: This may seem very generalised, but because of course there's so many situations when you might use it, but why might you use it and why might you not use it?

Brian: Well, the primary use is for conductivity thermal insulation so it's going to be used in roof construction, in timber construction, even in cavity wall construction, you know masonry cavity wall. So it's a fairly versatile material. It can be used for thermal acoustic fire performance. But the one characteristic it doesn't have is the decrement delay characteristic. It's got to be very dense in order for it to have that characteristic. So it's not the ideal material for use in roofs. The other important aspect is that it's hydrophobic which means it will reject water. It doesn't like moisture. But the other natural materials that we're beginning to see a lot more of are hygroscopic which is a completely different characteristic and one which we need to understand and get to make the most of.

Ben: Is there anything else we need to mention before we move on from glass and rock wool mineral insulation?

Brian: Well there are reasonably strong differences between glass and rock. There used to be slag as well which is a kind of by-product from steel production, but that doesn't seem to have the same market share that it's had in the past. So glass wool and rock wool, you'd use rock wool where you're looking for a fire performance and you might use glass wool in an acoustic performance situation, so although both have the characteristics they don't have the same characteristics.

Ben: Number 2 on our list is polystyrene and what you said at the beginning, other plastics!

Brian: Yes! The interesting thing is the plastics do have a range of characteristics. They do have, there's some products that have been brought into the market recently are recycled plastics which have a non-itch characteristic. So there's an interest, especially on the self-builder's part, to actually have a material where you don't have to have special suits, special breathing apparatus, so that you don't have the problems of itching afterwards.

The plastics that we're more familiar with are the polystyrenes, expanded, extruded, polyurethanes. They all have different characteristics. They all have different gases in them. Some are blown in, some happen as a part of the expansion process. But the blown in ones tend to have the chemicals that historically were ozone depleting and as time has gone on and as legislation has driven them, those gases have been changed to more benign gases, but they're still required to make the bubbles which make the material insulating. And it's about trapping air inside those bubbles, sometimes it's not just air, sometimes it's other gases like carbon dioxide and other chemicals, but trapping air inside plastics stops it from moving and stops the heat from passing through them.

Ben: I always think of this one as one that you'd use in the foundations, but again is it quite versatile?

Brian: Yeah, I guess it is quite versatile. Polystyrene is often used under floor slabs. It's also used in cavities underground. It's used in cavities at ground level and it's used in cavities above ground, so it's versatile in that respect. There's quite a lot of manufacturers who are making polystyrene for pitch roofs, flat roofs, in different situations, some of them with a kind of squeezy characteristic which means you can apply them into the gap between rafters, let go and they'll push outwards and hold themselves in place against the rafter sides.

Ben: Why might we specify polystyrene based insulation?

Brian: Interesting one. I guess because they are water resistant, durable. Another application is in an inverted roof situation where you put them above the waterproof membrane and then weigh them down with paving slabs, so they are waterproof in both locations under the slab and above the roof. And so that's one of the reasons why you'd pick that material.

Ben: So are there any other applications that we need to look at for polystyrene or plastics?

Brian: Yes. You're probably familiar with the term SIPs - Structurally Insulated Panels. They use polyurethane usually between two sheets of OSB usually, sometimes plywood. And OSB is kind of a wafer board which is somewhere between plywood and chipboard. It's a material which has some of the characteristics of both and an economic price in between them. So SIPs panels are structural. You can make whole buildings with them, you can make panels, you can make up panels which are for self-build. You can make up panels which are larger, whole buildings even. You can even have whole pods, modules, half a house, a quarter of a house, an attic, all pre-fabricated and delivered to site, assembled, craned into place sometimes and they have a lot of the characteristics you need in terms of conductivity thermal insulation but very little of the radiant protection from solar gains. So I suspect there will be some SIPs buildings which will be overheating too.

Ben: We'd better get moving on our list, because that's the thing about a list of 10, it takes a little bit of time, but cellulose fibre.

Brian: Yes, so cellulose fibre. It's recycled newspaper turned into flakes, so it's shredded and flaked and available in bags, sacks, delivered to site, put into a machine that's then blown into the cavity of timber frame construction normally.

So there are two approaches. One is blown in dry, another one is blown in wet so it's a bit like papier mache at the end of the day. It's rigid, it's not going anywhere. There are fears that the cellulose fibre flake blown in dry can settle, but it's about setting the density on the machine so that it makes sure they're solidly filled cavities. Some are spray applied from an open face onto an open cassette and sometimes they're blown in through a hole and that time they'll all be blown in with a particularly powerful, I think they're called turbojets, where they're blown in and blown into every corner of the cavity so that there's very little risk of heat loss at the edges where in the alternative situation, if you got a board material or a quilt, you cut it, fit it. If there's any gaps you've got the high risk of condensation occurring where those gaps are.

Ben: In terms of insulations, as we're looking at this whole list, is there any benefit over a rigid one compared to this that's just little bits? How do the two compare?

Brian: Well, usually a rigid material would be applied on the outside face or the inside face of a stud frame construction, whether it's a metal stud, a timber stud, even traditional timber post and beam construction. So you would apply them by applying them on the face, fixing them through the face with a special fastener into the timber construction or the metal construction. So they're designed to span and then they can carry things like roof tiles, battens, felt.

Ben: And this is also a good one in terms of moisture management?

Brian: Yes, that's right. We briefly talked earlier about glass wool and rock wool - they're hygroscopic, they hold the moisture in the air space and any moisture in an air space stops the air space from insulating. When you get to a cellulose fibre, any moisture that gets into the material gets absorbed into the fibre itself, leaving the air space to do the insulating as it was intended. So it can accommodate a fair amount of moisture in the construction and still perform to its best.

Ben: Next up we've got sheep’s wool, which is obviously a nice renewable one, so long as you've got lots of sheep around!

Brian: Yes, and of course one of the great things about the green and the violet industries as I call them, the two halves of the sector, is that they're always kind of telling you porkies about what's wrong with the other guys. The one thing that the guys will tell you about the sheep is the methane from the sheep. As sheep eat grass they poo, they make methane and of course the methane has a higher global warming potential than carbon dioxide. And there's even discussions about do you put devices on them to catch the methane, all kinds of silly stories going around but the important thing is that sheep’s wool itself has some interesting characteristics. It has the normal conductivity characteristic, but it has an interesting one. You think of sheep in the rain, especially in the UK rather than New Zealand, somewhere like that. Sheep seem to be quite happy wet and that's because there's a characteristic of the insulation warming up when wet and cooling down when dry. So there's a very strange characteristic which I don't really understand thoroughly. A friend of mine did a PhD on the subject and he doesn't like to talk about it because it's not one that people engage with very easily. So, yeah.

Ben: Is it the case that with sheep’s wool and all of these things, that there's not much to do to it? So you're saving in terms of processing as well?

Brian: Yeah, there are. Historically we've always dipped sheep. In Switzerland they tend to keep their flocks small enough that they don't need to dip them. There's a much lower risk of disease transfer. So in the UK historically the dipping process has meant there have been nasty chemicals in the wool which have to be processed out. There is a combing exercise which is traditional with any wool product. Sorting it out in such a way that it can be turned into cotton fibre whatever it is.

There is another issue with sheep’s wool in that it can settle. And some of the products that are on the market are sheep’s wool on its own. Others are sheep’s wool with plastic fibre that's built into the material so that it maintains the loft, the thickness of insulation to keep it the same thickness it was when it was manufactured. And that enables the insulation to keep on doing its job when it's in an attic for example.

Ben: Number 5 is cellular glass.

Brian: Okay, so we probably know this one as Foamglas® which is one of the proprietary names. Foamglas® is used in places where people can afford it. It has special characteristics which are rot resistance, fire resistance, animal resistance, rodent resistance. There's a lot of interesting good characteristics. It's got vapour resistance, it's got fire resistance, it's got conductivity. And it also has decrement delay characteristics, the radiant heat resistance.

And the first time I discovered this was on the British Library when we were doing roofing, where this thermal insulation material was being applied to concrete slabs. Now concrete would normally take the heat out of asphalt if you were laying it direct on the concrete. The Foamglas® was actually stopping that heat from escaping from the asphalt and instead of going into the concrete it was going into the insulation. So the insulation was keeping the asphalt warm and the asphalt was floating down the slopes, so it had to be pushed back up the slopes by the men who knew how to lay asphalt. Okay, until such times as it started to set. So that was a small complication that none of us had ever experienced before.

But it has strong decrement delay characteristics so it protects you from the solar gains and it's a very good watertight material / vapour tight material, so it's ideal in roof construction. Ideal in gutter construction. Ideal in foundation construction.

But there have been some examples where I've actually had a sample in my hand which was fully saturated. Now for that to happen it had to be frost damaged. Moisture gets in by frost damaging the outer layer then the next layer, then the next layer, and then the next layer. This is layers of bubbles so it gradually works its way through. And that should never ever happen because the insulation should never be allowed to get wet, and the thing is that you should always wrap it up in a waterproof membrane. If you do anything else you're in trouble.

In most constructions you'd use it in a flood coat of bitumen so that it's fully encased and you'd flood coat the surface that you're applying it to. Put the board into the insulation, squeeze it into a corner. The bitumen would ooze out through the joints up onto the surface, squeegee the top surface and it's a nice waterproof construction. Or in the basement you'd wrap it up in a waterproof membrane and apply it in situ. If you follow the manufacturer's recommendations you should never have a problem.

Ben: And how does this one compare in terms of cost?

Brian: Well, sadly it's a very good material, it's incredibly versatile but it's a very expensive material. And I would always say use it where it's needed in wet conditions. That's the ideal way to use it. If you can afford to use it in many other places, you know sometimes you may want to use it in a roof construction where you need solar protection but otherwise where you need it. Damp places.

Ben: Halfway through our list and at number 6 we have dense wood fibre. Tell me about this one, Brian.

Brian: Well, I think this is one of those magic materials that it's got a lot of interesting properties that apply to many different requirements.

Dense wood fibre is one of those materials which comes in two forms. It's a soft material or it's a dense, rigid material so it's pretty versatile. And sometimes it's supplied with a rigid face and a soft face so there's some very special characteristics which can be applied. The important thing is this is a material that's new to the UK market. It's been around in Europe for quite some time. They know how to use it. It's been tried and tested. We have no idea how to use it so there are people like Natural Building Technologies have been promoting it for quite some time and a lot of the other manufacturers have been beginning to bring it into the UK market.

It has moisture management characteristics which we talked about earlier with cellulose fibre, with the cellulose flake, but this comes in a rigid or soft material. It has acoustic performance, it has conductivity performance, and it also has these moisture management characteristics. The hygroscopicity characteristic which allows the moisture to be absorbed into the fibre, allowing the insulation to continue to do its job when conditions are moist.

So it's used as an internal lining, an external lining, used on timber construction, on masonry construction. It's used in roofs, it's used in walls, in floors. It can be used as an acoustic underlay.

It's an incredibly versatile material and it's manufactured in two different ways, either a wet process or a dry process. The wet process inevitably there's a drying action that needs to be carried out and so there's a lot more energy goes into the production of the material. The dry process, a lot less energy goes in but they are very clever materials.

If you wrap your building up in dense wood fibre you can forget about fireworks. You won't hear them anymore. These are very good materials. They have to be installed properly. They have to be made airtight joint construction and overlapping boards is one way of achieving that. You can use them for external insulation with or without render, weather boarding timber frame all kinds of other materials on the outside. You can use them as an internal dry lining. You can use them on solid wall construction, in cavity wall construction. Not in the cavity, on the inside face or the outside face.

You can use them for retrofitting old properties which need to continue to breathe. The one thing that we are putting ourselves at risk at is using plastic insulation in old buildings. The two are completely incompatible. Dense wood fibre as an internal lining with a soft surface on one face can apply itself and touch the inside face of the wall no matter how nobbly that wall is. And make sure that any moisture coming in from the outside can transfer to the inside and evaporate inwards should it need to. If conditions demand that then it can happen. If you've got any kind of cavity between the insulation and the inside face of the external solid wall, you've got a risk that the moisture can't jump across that cavity and can't escape inwardly when it needs to.

Ben: You mentioned retrofit in that which I guess at the end it might be interesting to look at the two, new build and retrofit and how all these materials fit into it, but the next one that we're coming to I suppose has a use in retrofit. It's aerogel.

Brian: Yeah, aerogel is an interesting one. It was invented by NASA. Guys who were bored because there weren't many space flights. *What shall we do? Let's see if we can get some water out of jam and leave the jam behind.* Okay, interesting weird and wonderful places the NASA guys get to. And then somebody came up to them and said okay, you know that thing you did with the jam, can you do it to make a thermally insulating material for the spacecraft that are going to go and come back and go and come back. They'll have a ceramic surface to protect them but we need some thermal insulation. And it needs to be thin. So what can you do for us?

So they created aerogels. And aerogels are significantly better performance than the foamed plastics. It's microscopic bubbles inside a matrix and they're very high performance. They add into them some fibres to kind of hold that material together and then they usually bond them to a board and that board could be a dry lining like a plasterboard. And these become very important when you get to things like window and door jams where there's a very high risk of conductivity, thermal bridging across between the stone or the brick outer-face, bypassing the window and coming in through the jam. So there's a high risk of cold condensation mould in that position. So if you've got a very thin insulation which can go through the around the lining of the jam, you can deal with the risk. And so that's a very popular material used with other materials for dry lining the rest of the walls.

Ben: I'm imagining expensive and probably not great for the environment as well?

Brian: It's clay based so it's not that bad in that respect, but there's probably an awful lot of energy gone into making it. It is an expensive material and because the vast majority of it was coming from America then when the Americans discovered thermal insulation and then they discovered aerogels, okay it became expensive. So yeah, it's an expensive one and you use it in the special places you need it. In those condensation, mould risk problems.

Ben: Number 8 we've put calcium silicate.

Brian: Okay, calcium silicate has come from places like Germany where it's been invented. Particularly invented for historic buildings. And they tried lots of different recipes to find the optimum material for working with historic buildings and they've been used as an internal dry lining, thermal insulating material.

So it effectively makes its own lining board and sometimes that would be skimmed with a material for decorative purposes. But it's an incredibly lightweight material. It's probably a waste product from some process, don't really know the details of that. But a very good high performance material with moisture transport characteristics which mean you can use it on the inside face of a solid external wall and any moisture that gets in from the outside face works its way through the brickwork and comes to the inside face. It has a way out internally through this moisture transport thermal insulation material. And you bond it to the inside face of the external wall to make sure that it's in contact, there's no cavity, no risk of the moisture not being able to jump across.

Ben: We're getting close to the end of our list here. At number 9 we've got vacuum insulating panels, which sound very technical.

Brian: They are a bit, yes! What it is is a steel cassette which is a hollow steel panel. They then suck the air out of it and as we all know, insulating a vacuum is a very good thermally insulating material that's used in flasks for keeping drinks hot or cold.

In this case, as you can imagine, if you've got a vacuum panel, if you've got to kind of fit it into a construction and the construction is all kind of different sizes and shapes, you're going to have to start cutting things. You can't cut vacuum insulated panels. They leak. They hiss and blow and lose their properties. So they're ideal in a modular design but if we're kind of using them in a retrofit situation you just don't have that. So you'd have to use them in combination with another material and the best combination that I can come up with so far is either an aerogel side by side, or a dense wood fibre. But it's about getting the right thicknesses to make sure that you've got kind of level surfaces for following trades.

Ben: And does this one put itself at risk of failing in certain circumstances, or is that what you're saying about the modular design for example, that it's much safer then?

Brian: Yeah, if you use the modular design and everything is made to suit or bespoke, it can be bespoke or modular. So bespoke would be purpose made to a specific size. The risk is somebody sticks a nail through it. Somebody drills a hole to fix something to it so you've got to put them in places where no one is going to be likely to do that in the future.

Ben: And at number 10, insulating render. We've made it.

Brian: Yeah. Okay, so insulating render, it's a fairly new material in the market and I'm not talking about insulation plus render on the outside of a wall. I'm talking about a render which is insulating throughout its thickness. So it's a material which is clay and other ingredient based material and it's had special ingredients added like a cork aggregate, which is just part of the mix.

It's applied as a render, it's applied as a plaster, it's applied as a screed and it will accommodate all of the lumps and bumps of an existing surface including chasing out for conduits and everything else. Pretty versatile and applied by specialists or possibly applied by a self-builder, you would need to investigate that one a little bit more to kind of find out. And because it's a through and through thermal insulating material you don't have the risks of condensation. You don't have to have vapour barriers and other special membranes applied to the construction. It's just applied like a render and off you go. Fairly thick, probably talking about 100mm and maybe more. Can be applied relatively thick and occasionally if the walls are really lumpy and bumpy you might have to apply a first coat and then apply a second to build up the thicknesses that you need to achieve the U-values that you require.

Ben: Well Brian, we've made it through the list. I'm probably going to ask a very stupid thing here, but if we want to try and be environmentally friendly are there any that we should pick out of here or is this just swings and roundabouts?

Brian: Don't try to be green and friendly for the wrong reasons. Choose the right material for the right properties of the right application. Once you've made those decisions then you're going to have a solid, sound building that if you invested well in and you're not going to have any risks later on.

Ben: And my final question, is about retrofit. Is it again a similar approach?

Brian: Yes. You've got to pick the right material for the job, so it's got to be hygroscopic. It's got to be moisture transport capability and it's got to be compatible with the existing building fabric.

Ben: Brian, thank you very much.

Brian: Okay, pleasure. My pleasure. Thank you.