

Episode 285

Developing plant-based building materials – with Judith Thornton

The show notes: www.houseplanninghelp.com/285

- Ben: My first question is just a bit about you. So, who are you?
- Judith: I'm Judith Thornton. I work at Aberystwyth University, within the Department of Biological, Environmental, and Rural Sciences. As a department, we've been working on plant breathing projects for just over one-hundred years now and my main interest is in plants as building materials.
- Ben: You were sent my way via a recommendation: George from Architype, who I personally feel has one of the best houses I've ever been to from numerous different respects in terms of the costs, the materials, the efficiency. Why has he sent me to you?
- Judith: George obviously lives in a house built from straw and there are lots of plant materials that are potentially suitable for building with but historically the natural building industry has been quite siloed into these are people that build with strawbales and these are people that build with hempcrete. Because they have to acquire such finely honed skills in their particular approach, there's been a bit of a tendency for each of these industries to be slightly separate.
- Actually, as with all things, there are advantages and disadvantages to particular materials. One plant might do well in a certain setting and another plant might do better in a different setting. So, for me as somebody who's interested in environmental building materials, to be in a department of plant science is an incredibly interesting space to be.
- Ben: Well, there are lots of avenues I could go from here. I suppose one of them is, are you looking for an ultimate set of criteria or, as you just mentioned, is it we need this criteria for this part of the building and this for that?
- Judith: That's an interesting question because plant breeding is basically a design problem. You need a set of criteria that you're aiming at.

When we domesticate plants, when we design a plant for food, we have those design criteria in mind, don't we? Whenever you eat an apple, somebody has put quite a lot of thought into the taste, the colour, the texture, and how well it grows in different environments.

So, one approach to plant-based building materials would be to have a list of design criteria and then it would be a case of saying do we have a plant material that actually fits those criteria already or is this somewhere that we should be looking at designing a new plant variety for that purpose?

For me, it's always about fitness for purpose and every part of the building envelope has a slightly different set of requirements and we shouldn't be assuming that we can build the whole thing out of plants or that one plant is going to do the job of each of those different building elements.

Ben: Can you give us some of those criteria? It doesn't necessarily have to be all of them, but just the key ones that pop into your head.

Judith: Walls, for example, are a bit of a classic. When we think about walls as building elements, the walls do several things. They provide some insulation value and they also provide some structure.

Depending on your approach to building, you might separate out those two functions. So, you might end up with a structural element which could be timber frame, steel frame, glulam, or something like that, and then provide the actual material of the wall that's doing the insulating function entirely differently. And given that those two functions are really quite different, it potentially makes sense to use different materials for them. Because wherever you're trying to get a particular product to perform multiple functions, you may well end up with some significant compromises.

So, with strawbale building, it's an absolute classic compromise. They have a fixed size of bale and that dictates the wall thickness, for example.

Ben: Presumably, it's going to change according to what that straw is because you can get different types, can't you?

Judith: Yes. Historically in the UK people have built with wheat straw or occasionally barley straw. Even within wheat there are a multiple variety of choices.

But strawbale builders, partly because of a very admirable approach to using left-over straw or thinking of straw as a waste product, they'll very often take what they're given. So, they haven't

really demanded a particular variety when in fact, even within wheat, various varieties of straw are available. But I have yet to meet a strawbale builder who even knew what wheat variety was in their building.

And then beyond that, hang on a minute, why are we building with wheat straw in the first place? Well, to roll it back a step, some people have built with barley straw and it only takes ten minutes conversation with an arable farmer and you learn that barley straw is far more prone to rotting than wheat straw is and they have to bale it and get it off the field as quickly as they can. To me, that's instantly a bit of a red flag for its use as a building product, the fact that it rots fairly easily.

At the other extreme, one of the things we've done here in Wales is we've built a strawbale house using miscanthus which is an energy grass that is native to Asia but has been domesticated for the UK and northern Europe. Miscanthus as a plant has evolved to grow to about three metres high so, as you can imagine, it's a much tougher straw than either wheat or barley. You can reasonably assume from that, that it would be more resistant to break down, which is kind of what you want in a walling material that you're hoping is going to last for a hundred years.

Ben: It's quite interesting – I'm imagining its our human minds thinking if we can use the waste products from the fields and if they're near to us as well, then that's got to be preferable. And I'm assuming there's another aspect as well that if I were going to build with strawbales, I'd go to a strawbale expert who would be able to say, 'we've done this for however many decades and we know it's going to work'. Are those dangerous things to be thinking?

Judith: Well, I think it's a completely legitimate approach. If your dream is to live in a house built out of straw, then that's great. That's a wonderful dream to have. I think the difficulty comes if that dream is based on false assumptions.

So, there's an assumption that strawbale buildings are inherently low energy and that's not necessarily the case. If you don't build them as well as George built his then they can be leaky and rot easily, not very airtight and have high heating bills in the same way that any other building can.

I think similarly with hempcrete, if you've got a desire to build a house out of hemp, that's fine. But it's a case of making sure your reasons for choosing a particular material are sound. And if those reasons are emotional ones, that's fine. I have no problem with that.

Ben: I think what you're suggesting here is almost having that combination like George had on his project, which in my mind seems strangely rare. I don't see it that many times. With my own build, I know I went down the Passivhaus route and almost forgot about the materials for a moment. And I see the reverse happening, the materials leading the way and like you're saying, perhaps losing the low energy side of the building.

So, is it entirely possible and why is it not being repeated?

Judith: To build with low impact materials and to Passivhaus standard do you mean?

Ben: Yes.

Judith: Lack of incentive, I think really. In the UK, we don't value building as a trade. It should be an incredibly skilled profession and there are some really good artisans about. But the bottom line is if you want to be a builder, you buy a white van and write 'builder' on the side and that qualifies you as a builder in the UK. So, amongst the public, builders are not necessarily held in sufficiently high regard. And yet actually, to build to Passivhaus standards is an incredibly challenging undertaking.

I think coupled with that, we've got a regulatory system where we've got a fairly ineffectual stick and absolutely no carrot. So, 'this will comply with building regs.' and people will say that as if that's a good thing. Well, complying with building regs. is as bad as you're allowed to be before you get prosecuted. That isn't an aspiration, is it? So, we have a lack of aspirational standards like Passivhaus.

We did used to have a standard called the Code for Sustainable Homes which had a lot of shortcomings but nevertheless did provide some carrot as opposed to just a fairly ineffectual stick approach of building regulations.

Ben: Well, living in a passivhaus, I just feel that there are so many benefits which unfortunately you immediately take for granted when you're living in it. Even just silly things like drying your clothes becomes so much easier because the moisture is dealt with and extracted from the right rooms. And when other people are switching on their heating, they'll always say in September, 'I think I'm going to switch on my heating' and it takes you another six weeks or so to even slightly have it on.

So, it does seem to make sense. And I, having only learnt in fairly recent years, would find it hard to reverse back and think I don't want to go this far to get this comfort.

Judith: I think you're absolutely right. And particularly with the concept of climate change, we need to be building houses now that will see us well past 2050. So, we need to be building houses that don't have high energy demands and we should be building everything to Passivhaus standards by now.

Ben: What are the challenges then, just going back to these materials? Let's say that is our goal with plant-based. What generally doesn't happen when people go down that route?

Judith: As you'll know with Passivhaus, one of the key things is airtightness. And the key thing with airtightness really is the junctions between different materials. That can be problematic for all sorts of manmade materials as well as plant-based materials. But particularly junctions between timber and straw, for example, where you might get a little bit of shrinkage of plaster when it's butted up against a timber frame. So, there are all of these construction details which, as you'll know, just actually take a little bit more care and design in order to reach the Passivhaus standard. But those design details for most plant-based materials that you might come across are already there. It's just that they're not widely promoted.

I think there's also this huge misunderstanding and conflict within the environmental building movement about what people understand by airtightness and ventilation.

Ben: Can we stay on things like airtightness tapes? At the moment, a lot of them are plastic, for example – I know you've written all about this as well – and then I've got a fair few amounts of insulation that are petrochemicals.

Where is the trade-off then, with it would've been better to put that aside and have a slightly less performing house versus just going all the way to Passivhaus and including a few petrochemicals? Or is it just a matter of time and you're going to tell me there's a great plant-based tape I could be using?

Judith: I'm not aware of a great plant-based tape and I think it's absolutely insane to be trying to – it's the law of diminishing returns. To be trying to build entirely out of plants is a ludicrous aim because there are some materials – and tapes are a classic example – where a small amount of very, very high tech material provides an enormous benefit.

And there are other bits of houses where we wouldn't dream of building out of plants. You're not going to build a glazing unit. We

don't have see-through plants. We don't try and make glass out of plants. So, to be obsessing about whether your strawbales are tied with polypropylene string or sisal or whether your airtightness membrane has got formaldehyde glue in it or not, I just find it really bizarre.

Partly because it makes almost no difference to the total carbon in the building and partly because it's based on this completely false premise that natural things are safe and manmade things are dangerous. That simply isn't true. But it's a very commonly held environmental world view.

Ben: I can sort of understand it as well. There's the side of me that says the waste angle – we chatted to Emily Penn a little while ago who's sailed around the world and it's amazing how much plastic ends up in the seas. And although I'm not basing this on any fact – you'll probably hate me for it because you love all the facts and stuff – it does make me wonder that all the plastic that we have around us, how do we know it's not fragmenting all the time, very tiny bits of it, and then getting into the water supplies and so forth?

Judith: I guess the short answer is that we don't. But the threats to marine life from ocean acidification due to increased CO₂ and warming from CO₂ are orders of magnitude greater than threats to the oceans from plastics.

We do this weird moral balancing in the UK where we say, 'I'll fly abroad on holiday, but I did do my plastic recycling'. The whole plastic debate for me is seeking to shift blame to manufacturers as an alternative to examining our own behaviours.

It's not rocket science. As individuals, we need to eat virtually no meat, we need to stop flying on holiday, and we need to insulate our houses.

Ben: Yes, we can be drawn down a rabbit hole there. I think I'd definitely like to explore that more but let's get back to the materials then.

Let's say you're doing your research and you discover you're going to make a great new product. What does that process look like? What will it have had to go through? Is it what you're doing, looking at these plants for a long period of time and then testing it in a laboratory, then testing it out on site? What happens?

Judith: My choice really is to start with some industry pull. So, what is there a demand for within industry? Because academics have just got this incredible tendency to dream up solutions for problems that didn't necessarily exist. So, I think for me there's this interesting middle

ground between what the building industry needs and what is available off the shelf in terms of plant-based materials.

So for example, in Wales we need to be insulating solid wall houses and we need to do that with vapour permeable materials and hemp lime or another material mixed with lime is an excellent way of achieving internal wall insulation whilst minimising risks of interstitial condensation. So, then it becomes a question of saying what is it that the plant material is doing in that hemp plus lime mixture, and seeing what other plants are available and then testing.

Ben: Do products go through this rigorous analysis or not always? Is there some way of keeping an eye on what they're actually doing? Because as self-builders, I have to say we're probably not going to research it to the nth degree.

Judith: No, I think you're absolutely right. It never ceases to amaze me how much eco bling there is on the market. You see it at trade shows all the time. A couple of extra bullet points on the end of the functions of this amazing miracle material. And everything these days is eco, isn't it?

Ben: And that probably gets about ninety percent of the people, just writing, 'this is incredibly eco'. 'Oh right. Well, there we go. We'll forget about eco now. What else? How much does it cost?'

Judith: Absolutely. And that's incredibly frustrating. There's a complete lack of regulation on any of that sort of product claim which is really baffling if you're a self-builder and you're genuinely wanting to make the best decisions.

You've got a massive and unwieldy project and a lot of variables to consider and then you've got six different types of roof insulation all of which you're being told are eco. It's an absolute minefield.

Ben: What are you hoping to do with all of this ongoing research? How does it filter on from the work at the university?

Judith: I think my main aim really is to try and have the conversations between the building industry and plant scientists to work out the appropriate niches that need new materials and how the plant science community can contribute to that. Because at the moment, as I say, we've got people who are obsessed by hemp, people obsessed by straw, and actually there's a whole range of other plant materials that are available.

My other aim really is to look at some of these plant materials with a quite critical eye because whenever you're incorporating a

biodegradable building material into a building, one of the key things you have to do is stop it biodegrading. There are quite significant differences between various plant materials in how easily they biodegrade and that has huge impact on the longevity of a building.

Ben: What is it that stops these plant-based materials from breaking down? What is the protection that it has, as you say, if you put a hammer to it and start exposing it to rain?

Judith: The key thing to stop degradation is to avoid moisture getting in. Building details are full of how to avoid moisture getting into places where it might cause damage and those points of damage are very often at junctions between two different parts of the building envelope.

In a more specific sense in relation to plants, they have got quite variable amounts of silicon and lignin in their cell walls. Both of those are very protective against breakdown. Both of those are materials that microorganisms find quite difficult to break down.

Even within wheat straw, for example, there are quite different amounts of lignin in different varieties of wheat straw and that in turn will impact on how quickly an individual piece of straw would rot if it were exposed to moisture.

Ben: We also, I think, have moisture transfer through buildings, don't we? Would that be a fair thing to say in plant-based buildings?

Judith: Absolutely, yes. One of the initial decisions that you make when you're thinking about your building is how are you going to handle moisture? Are you going to have a vapour-permeable construction where any moisture that's in the internal air of the house is allowed to diffuse into the wall and diffuse out? Or are you going to have a completely sealed envelope and rely entirely on mechanical systems or window opening systems for moisture management in the building?

They're two quite fundamentally different approaches and it's all about managing vapour. And unfortunately, these two approaches get called breathing and non-breathing whereas actually they don't really have anything to do with air, they have everything to do with moisture.

Ben: Yes. It does get quite complex. I've certainly been in lectures and things before where they go deep into moisture, which I'm sure you'd be happy with but goes a bit too far for me.

What exactly would you build if you were going to think about a self-build?

Judith: It's going to sound a bit strange, but I have absolutely no ambitions to build my own house. You're probably going to kick me off the podcast, aren't you? For not wanting to build a house.

Ben: No, it's fine. No, no.

Judith: I guess in one sense I think it's an incredibly skilled profession and if I did have that dream, I would definitely be getting somebody else to do it rather than me.

Some people find that process of acquiring the skill themselves and doing it themselves really fulfilling but I wouldn't dream of trying to maintain my own car. Mechanics have had years of training and lots of useful skills. It's the same with builders.

And again, in terms of the design, I'm always taking the mickey out of architects, but actually there is quite a skill involved in designing a house. So, I'm not actually that demanding, I don't think.

Last year I did some retrofit on my house and got someone in to do internal wall insulation with miscanthus and lime. That's considerably improved the thermal comfort of the rooms that's been done in. But I don't have a dream to build a house, I'm afraid.

Ben: That is allowed. One final question. Given the finite supply of fossil fuels unless we're going out into space and mining out there, are we expecting to see more plant-based buildings in the future, just because there's no other way?

Judith: Absolutely. Before fossil fuels we had a plant-based economy. And in the future, we're going to have a plant-based economy because we are going to have to make everything out of natural feedstocks. So, this fossil fuel age that we're in in the middle is hopefully relatively short-lived.

A project that I'm involved in within the University is called BEACON, which is looking at plants as products. So, it's this whole discipline of biorefining. When we have to move to a natural feedstock-based economy, everything we use on a day-to-day basis, be it building materials or plastics or everyday items, is going to need to be made out of plants and it's a question of how we do that.

So, yes, absolutely. More and more buildings will have to be built out of plants.



Ben: Judith, I really enjoyed this today. Thank you very much.

Judith: Thank you. I've enjoyed it.