HPH325

Ben Adam-Smith 00:00
This is House Planning Help episode 325. Hello, I'm Ben Adam-Smith. And this is the podcast for you if you're interested in self build or retrofit. I'm exploring what houses we should be building in the 21st century and trying to break down the major roadblocks that may get in our way.

Ben Adam-Smith 00:17
Coming up. My guest is architect and Passivhaus Designer Mark Siddall. His practice LEAP - Lovingly Engineered Architectural Process - that's the acronym, operating in the North East of England. And today we're looking at air movement around insulation, it could be across insulation, it could be getting through insulation. It's all bad news, I'm afraid! But first.

Ben Adam-Smith 00:19
[Music sting] It's a bit dramatic for this podcast! Thank you to Stephen Miller in Oxfordshire. There is a reason I've played that. And he spotted this in the Journal of the Institute of Engineering Technology. They have this column called 'Dear Evil Engineer' which is a podcast and also a YouTube channel and villains write in for advice on their diabolical plans.

Villain 01:07
I have two fearsome pet leopards, and I was already considering buying more. How many would I need if I wanted to heat my pleasant two bed semi-detached entirely with leopards? Yours, a conscientious villain.

Ben Adam-Smith 01:22
Now you're going to have to check out the full video for all the maths behind this. It goes into quite some detail, but I'm very excited that they mentioned a Passivhaus and say that that would be the best way of going about this riddle. And then a normal building regs house. And do you want the answer for a Passivhaus? I think so.

Evil Engineer 01:43
For an average UK house with floor space of 96 square metres, that gives us 1440 kilowatt hours per year in heating. A single leopard can generate 392 kilowatt hours per year in heating. So 3.67 leopards, alright four leopards would provide all your heating needs in the most efficient house.

Ben Adam-Smith 02:09
I'm fairly confident that you wouldn't have put that on your choices for heating sources, a nice passive leopard. Thank you, Steve, once again, for alerting me to that one.

Ben Adam-Smith 02:19
Mark Siddall is a Passivhaus specialist operating in County Durham and Newcastle. He's also a technical adviser to the Passivhaus Trust and the AECB. And it's in that capacity that he's written a paper on thermal bypass risks for the Passivhaus Trust. And we're going to find out how that might impact us on a self build or retrofit. We start though, you might have heard of the performance gap before, so I wanted to ask him what exactly does this mean.

Mark Siddall 02:46
There's not necessarily one performance gap, there are a number of different performance gaps that could be considered and explored. When we're talking about Passivhaus buildings, the conversation has a tendency to focus on energy performance rather than air quality or other factors. And when we're dealing with energy, it's often the thermal performance of the building fabric. So that's the key area that we'd be focusing on in terms of thinking about performance gaps in this particular conversation, shall we say?

Ben Adam-Smith 03:13
Often we get told to insulate it's a very singular message. And I know that that's one of the reasons that I like Passivhaus is because I know, under the hood, there's all sorts of work going on. And that if you follow the formula, then that reduces things a lot. So if you're in a typical house, and you're using insulation, big question here, will it work?

Ben Adam-Smith 03:40
Maybe.

Ben Adam-Smith 03:42
Diplomatic. I like it.

Mark Siddall 03:44
Well, there's a number of different variables that will influence whether it works or not. And for the purposes of today's conversation, we'll just put things like thermal bridges, so cold spots, we'll put those to one side and we'll just talk about how the insulation properties actually work, and how that can impact upon performance. And in that particular context, it comes down to whether the material itself is specified sympathetically for the construction method that's been used, and also whether then it has

been installed properly. So there's two variables there that we really think well, three, I suppose. There's the material itself, the specification, and the implementation.

Ben Adam-Smith 04:23
All three of those right, and you're winning?

Mark Siddall 04:26
That's it. Yep. If we get all three aligned with one another, which we do in a Passivhaus design, as the evidence would show, then that's when everything works properly. It's when we deviate from that, that things can go wrong. We see quite a lot of case studies that show when it goes wrong. And there's... the Leeds Beckett University have got a good database where they did a co-heating test. I don't need to get into the intricacies of how it works necessarily, but basically, my metaphor is it's a bit like when you go and get an MOT and you put the car up on the chocks. You can test all the different variables. All this is trying to do the same thing for a house or for a building. And the evidence shows that even well-meaning projects that have tried to close performance gaps often fail when they're approached with a building regulations frame of mind, shall we say. Whereas when you compare that to the Passivhaus projects, they actually close the performance gaps and perform as predicted.

Ben Adam-Smith 05:21
So maybe we do need to go into this a little bit, what is different about what the Passivhaus methodology is doing?

Mark Siddall 05:30
Well, the way that it's delivering a better standard of building fabric is it's got better quality assurance processes and mechanisms deeply rooted in the standard and within the brains of the people delivering these projects. So therefore, we're avoiding risks that might otherwise arise. So when we're thinking about how insulation is specified and used, we're using the right kinds of insulation that work with the particular method of construction that we're talking about.

Mark Siddall 05:58
To be a little bit less abstract, if we were taking cavity wall insulation as an example, you could go to any building site that happens to be around you, and you'll see probably that it's cavity wall insulation, that it's a foam insulation that's been used. And the question would, you know, a Passivhaus Designer will ask is, is that insulation really sympathetic with the method of construction? And the answer to that would be no, because you've got blockwork but you've also got mortar joints, and mortar is obviously squidgy when it's been installed. And that creates a mortar snot which projects into the cavity and then stops the insulation abutting the blockwork along its smoothest face. And that little air gap that we end up with is enough to completely undermine the thermal performance of the insulation.

Mark Siddall 06:49
Whereas for a Passivhaus side of things, we're looking at that and we're saying, okay, there may be mortar snots, we want to clean them off. We know it may not happen with one hundred percent confidence all the time, something like a mineral wool insulation is a lot more flexible, and capable of dealing with subtle undulations in surfaces. And therefore that's a much more appropriate insulation to

be using in a cavity wall scenario. And we can use mineral wool insulation to the full depth of the cavity, which also helps to reduce the risk of air movement. Because it's air movement within, and around, and through your insulation, which has a really significant impact upon its performance.

Ben Adam-Smith 07:29
So that's really interesting. You've mentioned all sorts of things going on here. Let's stick with this masonry example for a second. So when you're doing this well, can you take us through almost some of the layers because you're trying to do different things, aren't you? You've got the wind on the outside, you got the rain on the outside, you want to be warm on the inside, you've got to have this airtight barrier if we're talking Passivhaus, as well. So how do we make all of this work then if we don't want the air to just wick it away to the outside?

Mark Siddall 08:03
There's several different factors to go through there. You've alluded to them quite broadly, shall we say. If we start with the rationale for an air barrier in the first place. Building regulations only really gives us a numerical target for airtightness when we're dealing with heat loss. So Part L of the Building Regulations deals with heat loss, and it prescribes an airtightness standard of 8. Part C of the Building Regulations, which talks about moisture only really refers to that things should be fairly airtight, it doesn't really give you a numerical target. And there's a problem with that.

Mark Siddall 08:39
What we know from the Passivhaus standard, and the reason it's got its targets set the way that they are, and also other research that's been conducted in Canada. They both confirm the same thing, that we need to be achieving an airtightness in the order of 0.5 or 0.6 air changes per hour at 50 Pascals or a permeability of around about 0.5. And the reason we want to achieve that is so that we don't get moisture damage to timber structures. So within roof spaces or in a timber frame scenario within walls, for instance. Now, that sets the standard for why you want good airtightness, but that in its own right won't necessarily guarantee that your insulation will work properly. What we also want to be able to do is to make sure that the wind can't blow through the insulation because if it can get through the outer layer of the insulation because of gaps or cracks, or air gaps between or around and behind your insulation, then that air movement will wick away the heat and mitigate the performance of your insulation. So we need to get some sort of wind tightness on there. Now we can't actually test that on site but it's a really useful thing to understand the quality of workmanship that would be expected. And what we find when we start to do the more technical analysis is that the standard of wind tightness that we require is broadly speaking something similar to what we'd expect on our airtight layer as well. Certainly, from a visual inspection point of view, that's the rule of thumb. And then we've also got this insulation sandwiched between an air barrier and a wind barrier, we've really got to make sure that this insulation is properly encapsulated. So that means that you've got no air gaps anywhere in and around that insulation. Because you can imagine, if you've got a successful wind barrier and a successful air barrier, that insulation in theory could be suspended perfectly in the middle of a void space. And, again, there's risk of convective loops, which can arise just because of temperature differences between the warm side and the cold side of a wall, that could mean that that air movement would mitigate the performance of that insulation, or at least undermine it significantly. So we need to avoid that closed

loop thermal bypass by properly encapsulating the insulation between a notional air barrier and a wind barrier.

Ben Adam-Smith 11:07
So all sorts of technical terms there, but it's interesting to see how powerful that air movement is. And we talked about designing it out, and then the workmanship on site. So yeah, let's just stick with masonry. On the technical design side, you will have had cavity wall construction projects going through your architecture practice. What would those layers look like? If you just you start on the cold side, the outside, and go through? What layers have we got? Can you just talk us through that quickly? And then I've got another follow up question.

Mark Siddall 11:44
Sure. Okay, so you'd have your brickwork or your stonework on the outside face, you'd then have a, often, a 300 millimetre wide, fully-filled cavity, mineral wool insulation that's built up in, often, two or three different layers. And then you would have your blockwork on the inner side, on the warm side, and on the surface face of that, then you've got your plaster, and the plaster is acting as the air barrier. And the masonry on the outside is acting as the wind barrier, because we've fully-filled the cavity, we have encapsulated the insulation, and we've got no air gaps around that.

Ben Adam-Smith 12:27
So let's chat about moisture now. So if I understand this correctly, and I could easily be wrong. But the cavity part of the invention 100 years ago, or however long it was, was that that was stopping some of the moisture coming in. So are we expecting moisture to enter that insulation that we've got? And because I had a chat with Bill Butcher a while ago, and I remember him saying something about the weaving of this insulation helps to keep the moisture out. Would that be a fair comment?

Mark Siddall 13:00
Yeah. Okay, so we've got moisture from two different sides. We've got moisture from the inside and from the outside. Now the most dominant moisture problem is the rainwater, the moisture on the outside. When it was first invented, shall we say, when it was introduced in the 1920s or so, the idea was that we were able to then use the air gap as a capillary break. So therefore the moisture wouldn't, from the rain, wouldn't be drawn through the wall. And any moisture that got through the brickwork would then drain down on the inside face of the cavity on the weathering side, then we could direct that out at the bottom through something called a weep hole.

Mark Siddall 13:39
Now, there are certain critical dimensions to the width of a cavity. If you've got a very narrow cavity and you fill it full of insulation, then you've got quite a high risk that the rainwater that could be running down on the inside face could then bridge through to the inside. But the wider that cavity gets the less risk that you have of that rainwater tracking across. So when we're dealing with cavity widths that are in the order of what's supported by a Passivhaus design, then that driven rainwater risk is pretty well mitigated as long as we've got the quality of the workmanship right, there are no mortar snots sitting on the beds of the insulation. And also when we're thinking about the insulation itself, and this is getting onto Bill Butcher's point, that the weave of the mineral wool is such that if it's built up in different

individual layers, a bit like strata, when you've put the insulation in place, all of those layers are really like sheets of paper from the top to the bottom. So that means you've got successive layers of the book, to keep that analogy going, running through the depth of the cavity. And that means that if any water did get through one layer, it can then still be pushed down and back towards the outside. Rainwater would have to have worked very hard to get through all of those different layers, those different lamellars of the mineral wool itself. So that's how we keep the rain water out. And even if that does mean that there's a little bit of the outer face of the insulation that becomes a little bit redundant, because it's got a little bit damp, that's okay. We can accommodate that, we know that the building will still work fine. But because we fully fill that cavity, we haven't got the risk of this air movement taking place, which would also undermine the thermal performance.

Ben Adam-Smith 15:24
And you often have these Teplo ties and things going across. So none of these things are affecting the thermal performance?

Mark Siddall 15:32
Well, the Teplo ties, they're dealing with what's known as a repeating thermal bridge. So we're using a Teplo tie instead of a stainless steel tie. A stainless steel tie has got a much larger physical dimension and a much higher conductivity. And again, that would undermine the thermal performance if we use them at large. So therefore, we use Teplo ties instead, because they're thermally broken.

Ben Adam-Smith 15:55
And joining the inner leaf to the outer leaf?

Mark Siddall 15:59
Correct, yes, to help provide structural stability against wind loads and the likes.

Ben Adam-Smith 16:05
So why then have major developers not got around some of the science that we've been talking about?

Mark Siddall 16:14
There's commercial interests at play. Just to point directly to Grenfell, we can see that there are different manufacturers that have helped to try and steer things to suit their own ends, rather than necessarily acting for the greater good. And within that, though, there's a slightly more subtle duplicity that's going on, whereby an architect, for argument's sake, most architects out in the regular world, shall we say, away from the Passivhaus context, they'll phone up a manufacturer and ask them to do a U value calculation for them, that will let them understand the performance of that particular piece of building fabric. Now, what the manufacturer never does is actually say, and what quality of workmanship are you specifying? Because if they did, that would inherently mean that you'd have a lesser performing wall. What they actually do in their calculations is they assume that the insulation has been installed perfectly. What the industry doesn't recognise is that that means that we then need to have certain construction tolerances on the building site to reflect that. So therefore, when you put your theoretical foam insulation in a wall, and it's installed perfectly, then you can get the U value that was predicted in the calculation. But when it's less than perfect, which is what you see on every single

building site, because no one ever talks about the quality of workmanship that's required, or the specification of the materials to make sure that they're working sympathetically with one another, then you've got this scenario whereby things won't perform as we intended, because of these air gaps that will then start to crop up.

Ben Adam-Smith 17:58
If we're the client coming in here, and we want our Passivhaus built, I would come to you and I'd be fairly confident, yeah, you know what you're talking about, you're going to do all your side of things in the designs. But what about on site? And I've seen this on a couple of Passivhaus builds. Let's mention my friend Mike Coe who, he was out on his masonry construction, after the builders had gone home, pulling out the insulation and putting it back in after he'd got all the mortar snots off, and so forth. So is there anything we can do, short of what he's doing, to keep an eye on that workmanship for our Passivhaus? Or is it time to look at other ways of building that are not masonry?

Mark Siddall 18:42
Yeah, well, I think there is plenty of reasons to choose something other than masonry. It was a starting point in our conversation, because it's widely used. There are other technologies that are preferential, timber frame being the obvious one, because it's easily adoptable, it's widely used, familiar in different ways and we can address performance gaps very well using that mode of construction as well.

Ben Adam-Smith 19:06
Is there an obvious wall build-up of timber frame that we like to use for Passivhaus?

Mark Siddall 19:11
Yes, I think there is a generalised approach that seems to be working fairly well. And if we go from the inside to the outside, we'd have plasterboard, we'd have a service void, that may or may not be insulated, ideally not insulated because of the time and labour and material costs associated with it, but sometimes, in the North East for instance, often we might have to insulate it just to try and get the U values that we're looking for. You then have an airtight layer, you'd then have an engineered I-beam and between the engineered I-beam we'd then fill it with the cellulose insulation, for example. Then you might have some wood fibre insulation on the outside and a wind barrier membrane on the outside face of that and I'll come back to that in a moment. Then we have a drain cavity, which works as that capillary break and then we'd have a rain screen on the outside face.

Mark Siddall 20:02
Now some of the more recent information that I've been reading geeking out on research from places like Sweden, and in Canada, they've observed the putting the wind barrier membrane just on the warm side of that wood fibre insulation I mentioned, which might be just 20 millimetres thick, by moving the wind barrier onto that warm side significantly reduces the risk of condensation, because of radiant cooling, so night sky cooling that can happen. So there is still refinements that we can do in the Passivhaus timber construction that would make it even more resilient than it already is. I'm not suggesting that in the UK climate, putting the wind barrier on the outside is going to cause any significant risks, but there's just a little tweak that we could do to make it even better.

Ben Adam-Smith 20:51
So the performance gap in timber frame then, where does it occur? What is the typical place that we might find the air moving?

Mark Siddall 21:00
The research that's been done by the Building Research Establishment (BRE) looked at industry standard timber frame. The difference between what we've just described before for Passivhaus versus regular industry timber frame is that you wouldn't have the wood fibre board, you would not be using engineered I-beams, you'd be using a standard timber stud that might be about 140 mm deep or so. And you're less likely to have that service void that we discussed there as well. So you've probably got services penetrations through your air barrier that will allow moisture from inside the house to get into your timber frame, potentially causing moisture damage within the structure.

Mark Siddall 21:39
So there's moisture performance gap in this particular context, when we're thinking about that and why we want to have good standards of airtightness. In terms of thermally, the research has shown that more frequently in the UK, what we find is that timber frame has worked quite well. The U values that are delivered in a timber frame construction are more reliable than they are in a standard build cavity wall construction. And the reason for that is if you're using a 140 mm stud, often the insulation ends up being 150 mm. And therefore the insulation, because it's that little bit bigger than the timber it's going into it gets a little bit of compression, and it ends up being snugly sandwiched between your air barrier and your wind barrier. And therefore you've got less risk of these convective loops. You know the warm air rising and cold are falling within that zone between the air barrier and the wind barrier. So timber frame just inherently tends to work a little bit better within regular UK construction. When we move into the Passivhaus context, when we're using blown fibre insulation, that fully fills the gaps between the air barrier and the wind barrier, so again, mitigate this risk of closed loop thermal bypass so that these walls perform as predicted.

Ben Adam-Smith 22:59
Looking across other build systems, particularly ones with low embodied carbon, is it still air movement that's causing the main problem?

Mark Siddall 23:11
Yes, air movement is a key feature that all construction technologies will have to address, shall we say? Basically, the physics remains true. We've just got to understand how we can adapt the construction technologies to address those key issues of the building physics. Whether that's preventing moisture getting into the construction to help preserve it, so there's a good standard of airtightness. How do we do that for a straw bale for instance? Well, a lime plaster on the inside, or a clay plaster, that can provide the airtight layer. How we think about interfaces and other things, other subtleties and complexities which are another conversation. But it is a case of limiting that airflow and that air movement through and across and within the wall construction so that the building can perform as predicted.

Ben Adam-Smith 23:57

One thing we haven't talked about is roofs. So I don't know whether that's opening up another whole conversation that may confuse us. But how does this affect the roof space?

Mark Siddall 24:09
The broad principles that we've discussed so far all carry through to a roof. What we can then start to talk about is what kind of roof are we talking about? Are we talking about a warm roof construction? In which case it's very similar to the timber frame walls that we've just discussed. We can just crank it through an angle and carry on. We just change the rain screen that we had. We just change to tiles or some other suitable roofing material. Where we start to deal with the cold roof, which is perhaps your standard attic roof, where you've got the insulation running across the ceiling level, and then you've got the roof space up above. That's quite a risky space to deal with from the moisture perspective, which is one of the key reasons why again Passivhaus looks to have that high standard of airtightness because that's where we've got that risk of air movement through. So for example, if we've got a two storey house and we have a one millimetre wide gap that's one metre long, we can have two Pascals worth of pressure being applied to that ceiling. Now, what's two Pascals worth of pressure? Well, if you've got your good quality photocopy paper, that normally weighs about 100 grams a metre square. That's basically one Pascal worth of pressure. So we were talking about two layers of photocopy paper pushing upwards rather than downwards, pushing upwards against your ceiling. Over the course of 24 hours through that one millimetre wide, one metre long gap, around about 360 grams worth of moisture can be transferred through that. And broadly speaking, from the information that I've seen, around about a third of that could condense into your roof construction. So that's why we want good standards of airtightness. Whatever moisture does get through into the roof space, we've got to be able to then remove, so we need a vapour permeable underlay on our roof construction. We can also ventilate that roof space. There's arguments and reasons why that may or may not always be preferable, or you may not be able to do that. But if you can ventilate that roof space, then you can remove moisture. But the question then becomes when we start to look at an eaves detail, what's the risk of this wind-washing taking place? Again, you know, when the air is coming into the loft, it's coming at a higher speed, higher velocity, and therefore we need special details around that eaves detail to help protect the insulation at those vulnerable edges from that air movement.

Ben Adam-Smith 26:30
It always seems that it's very complicated. We're talking about houses, which must be one of the simpler things to do. But are we on a path to simplifying things? And what would that route be?

Mark Siddall 26:44
There's a lot of thought, shall we say, there's a lot of things to consider when developing a detail. But that doesn't mean that the detail has to be complicated. To make it buildable, the art of the design is actually simplifying those details so that they are very easy to replicate from person to person, site to site, project to project, it takes just as long to design a good detail as it does a bad one. I don't think it takes me any longer to design those details. Because once you've got in the right frame of mind, certain things come effortlessly. So therefore you're just designing the detail and addressing these things more automatically. So it's not that there's more time, from a design perspective, that has to go into it when you've got the experience.

Ben Adam-Smith 27:32
Is there anything else that we haven't mentioned in this conversation that would be appropriate to a homeowner, either buying or going for a self build journey, some parting advice to try and avoid these issues that we've been discussing?

Mark Siddall 27:50
Yeah, without getting sucked into too many details it is keep it simple. And it is to remember to make sure that you have an air barrier, that you have a wind barrier, and that you encapsulate the insulation. And as long as you do those three, four things, then you're on the right path. There's all sorts of levels of detail that you could go into as to how you deliver that. But those are the basic principles, the key takeaways in this particular context.

Ben Adam-Smith 28:16
So Mark, for anyone who wants to dig deeper into this paper, can you tell us where it is and what it covers?

Mark Siddall 28:24
The paper is on the Passivhaus Trust website and it's entitled 'Thermal Bypass Risks.' And it's also packed full of solutions, and tips and tricks that designers and architects can use to help mitigate thermal bypass within their building projects. It could be picked up by a brave self-builder, shall we say? It's broken down into sections so that at the end of each section, there are some takeaways presented in a fairly accessible format. So I think your listenership should benefit from that.

Ben Adam-Smith 28:57
Mark, always a pleasure. I'll chat to you next time.

Mark Siddall 29:00
Wonderful. Well, thanks a lot, Ben, you look after yourself. I'll speak to you again soon.

Ben Adam-Smith 29:04
Get a summary of today's session at houseplanninghelp.com/325. We've got links to Mark, to LEAP his architectural practice, and to the Passivhaus Trust where you can download his paper - all at houseplanninghelp.com/325.

Ben Adam-Smith 29:23
We've got a couple of new reviews that have come in to the Apple Store. Hello to Buzz941. The title of this is 'fantastic resource.' "I'm considering a self build and House Planning Help has been a fantastic resource for getting me up to speed across so many different aspects. Keep up the great work." Thank you very much for that one. Also, thank you to Tom in Aberdeenshire who says "excellent series, really well put together and loads of useful information." If you're thinking I like this podcast. I wish there was something I could do to help Ben. Well look, this is your moment please! Whatever you're listening to us on, whichever app, often they give you the opportunity to review what you're listening to. So please put in a review, try and explain what the podcast is all about for others, and that will help us get to more people.

Ben Adam-Smith 30:12
Finally, today, my call to action is to check out The Hub, which is our very own bootcamp. It's primarily for UK homeowners, self-builders or people looking to retrofit. But obviously, a lot of it just applies wherever you are in the world anyway. We try to use video as our main learning tool. And so we often follow entire projects. Our current one is a retrofit story. It's actually nearing the finishing stages now and they're on site doing an airtightness test. This is quite an interesting one, because it illustrates a key point in a retrofit. So it's taken almost a year, all the structural changes have been made. It's watertight once again. And it's just the small matter of the airtightness. So there are lots of pressures. It's been a year since they've lived in their home, they want to get back in there. The builder wants to finish the project. But quite often, you want to almost pause the project to just fiddle around with that last bit of airtightness. And on this project, there were just all sorts of things. There were labour shortages, there were material shortages and the sequencing, it all clubbed together to make this very, very difficult. So check that one out as our new one that we've added into The Hub houseplanninghelp.com/join. All the other things in there, our courses, our office hour calls where you can chat to me, our live training sessions and our members-only forum. Get involved at houseplanninghelp.com/join.

Ben Adam-Smith 31:41
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