HOUSE PLANNING HELP

Episode 76

Getting the Foundations of a Building Right

The show notes: www.houseplanninghelp.com/76

Intro: I don't think we've had a structural engineer on the podcast before. David Sharpe from Thomasons is not only one, he's a certified Passivhaus designer and that makes him an ideal person to help us understand foundations, and also explain whether we need to do anything differently when creating a low energy building.

I got our discussion underway by asking him to explain a little bit about his work.

David: Yeah, as you said, I'm a structural engineer. I work for a company, Thomasons, and basically I see my role as the one in the design team that is thinking about how the building stands up and how the forces that work on a building actually are transmitted right the way through the structure and down into the ground, so that the building stays where it should do.

Ben: It's not something we've really gone into in any great depth before, the foundations. So, let's start with that basic question, what are the foundations?

David: They're that thing in a building that all of the weight and wind forces are transmitted from the building into the ground. It's that simple, and it's probably not thought about when you think about a building design because it's the thing that's done first and is then hidden and you never see them again.

Ben: Are you always thinking, I want a flat piece of ground ideally?

David: It depends. It depends what the building is. The foundations have to be site specific and they also have to be relevant to the design but also if a structural engineer is involved early enough in the design and it is a tricky site that has slopes or difficult ground as we would call it, we can say well the foundations need to be this sort of thing, is that a way that can influence the way the building above is designed so you can get some benefits out of the things we've got to do in the ground. So, that's where we come from.

Ben: How many different types of foundation are there?

David: How many different types of ground are there? It's a bit of a "how long is a piece of string" question. It ranges from, for example in the United Kingdom, we'll have ground conditions that are based on very soft clay and then it'll range right the way through from therma clay, sands, gravels, then rocks that were formed by igneous action, so you've got granite, sandstones as well. So in the UK we have to deal with a whole range and it's going to be the same throughout many countries of the world, it just depends exactly where you are.

And the other thing that we have to worry about in foundations is that sometimes the ground will fight back. It's an earthquake. How that sometimes impacts on how the foundation's designed, is something that we think about. Luckily, I practice in the UK and we don't have them but sometimes you do have to think about the 'what if' scenario if you are looking at a particularly sensitive building or if you are building somewhere like parts of the United States or in Turkey or in other parts of the world, it is a factor that you have to think about when you're thinking about how the ground works.

Ben: How do you assess what the building is going to need so that it will be stable in its entire lifetime?

David: Well, as structural engineers we're used to thinking about things in the long term and start looking at things from a more scientific end of the spectrum. So, we'll first of all try and find out what information is already available for a particular site. Very rarely is there already that information readily available, but we might be able to get a sense of what's going on by looking at published geological maps and then start that as a basis of saying, well, we've probably got one or two options as to what the ground conditions are. So let's find out. Let's dig some trial pits as we would call them, or some boreholes and actually find a way to have a good guess as to what exactly is going to be happening across the footprint of our building. Just from little, if you like, windows into what's happening here and there. So that's what we try and do. Get information.

Ben: Is this why to a degree it's unpredictable what you might have in the ground, because you never know until you've started. You can do these trial sections, but you can't really know the entire area unless you've dug it all up.

David: Well, I often joke, the best site investigation is about the size and depth of the foundations you want to build! But unfortunately we

can't do that. We can't get perfect information, but engineers are used to getting good enough information and saying, well, on the balance of probabilities based on what we know, we think this is likely. This is the margin of error and this is the risk. So, and also we can then say, well, if you start to find in your first investigation something like this, then flag it up because clearly our assumptions are wrong. But if it's within this range of parameters, it's OK, our designs can cope with that. So that's what we do.

Ben: How can we avoid pouring all of our money, as self-builders, into the foundations?

David: You need to get a structural engineer involved early in whatever basis you can. If it's somebody that's practised in your local area, it's likely that they might know from their experience what the ground conditions are and they'll be able to say, well in this area say, this is soft clay soils, so let's try and spread the building footprint out a little bit. Let's think about instead of going for the mass heavy construction, see if we can go lightweight, so for example, timber frame and so on. And instead of going for four storeys, maybe we should try and restrict to two because then we can go for cheaper foundations. So, that is what I was saying earlier, try and let the foundations influence what the superstructure is, rather than forcing the ground to do something it's not good at and then spending lots of money, which is not going to be of any value to the homeowner.

Ben: I imagine then it's a really bad idea just to say we want this building on this plot?

David: I don't think that it's in anyone's interest in any sector of the design process to do that and engineering is no different. You have to respond to the site. You can build anything anywhere but do you have an infinite amount of money? No. So, you'd let the site influence things and I think that's true for architecture as well as engineering. But for us, yes, the foundations should guide your design in the right way and not fight the ground 'cause the ground will win.

Ben: Can we talk about a couple of different types of foundation? Let's start, I always think, concrete. If you are going to have a foundation, well of course it will be a concrete foundation.

David: Well, structural engineers actually think a step further because you can build a strip footing, basically a footing that transmits the load along the ground, with any material. So, it's actually thinking about

what the systems are and then how you build it comes second. So, is the ground good enough that the load can be spread? So, you've got spread footings which will be pads or strip footings I mentioned earlier. Or if the ground's poor, do you need to actually drill down, so that you're getting to better ground? So you're thinking about piled foundations. Or, is the ground variable, but in some parts OK but some parts not? So, you have a large spread footing which we would call a raft, which I think's probably the thing that people think of a raft as something that floats on the sea, it's doing the same thing. It floats on the ground and spreads the load around.

So those are the three broad types: strips and pads, rafts and piles. And you can do piles with timber, or steel, or concrete, so you can then see what's appropriate to the particular local construction market as to how you might do things. And then that might influence things. Technically, you might be able to do a raft but for the materials you've got locally, it might be better to do piles. So, it depends again.

Ben: This may be a really bad way of looking at it but is it almost getting a grip for your building, because if the earth, if putting a foundation quite shallow is not going to get that basis, you're just looking to get that nice and sturdy?

David: Well yes. For example the city I work in most, where I live, is Birmingham in the United Kingdom. And there, in the city centre, at some depth or other there's usually rock, a sandstone. And the saying goes there well, if you just go deep enough, you'll hit the rock. Well if you're building a ten storey office development and you put in a basement, you'll hit the rock and you'll get the best ground going possible and then you can build whatever you want on top within sensible limits.

So sometimes you can find out things about the ground that will actually help you say, well, I can dig a basement here, it's really soft ground and then I'll get to the stuff that I can put in a conventional foundation and I'll get extra benefits out of the work that I might've had to have done anyway to make the foundations work.

So, I think it can just inspire your design to go in a different direction and use the money that you have to spend on foundations in ways that actually do things for you rather than just putting money in concrete in the ground.

Ben: If things do go wrong, perhaps you haven't done your work upfront, is there any way to pull things back, perhaps by changing the design of your building if you discover… I visited one property that was on more or less a forty-five degree slope for example, and it was incredible how much had gone back, and as you were saying the ground won on that occasion.

David: We do some work, the company I work for, in looking at when things go wrong. It's typical where a house might have been built on one foundation solution that somebody extends it using another and they didn't realise that they needed to use the first type.

Ben: So what, you need to have a standard foundation the whole way along?

David: Well, for example the house could've been built on piles and then somebody extended out just on spread footings and the spread footings fail and the part of the house on spread footings moves too much and it causes problems, cracking, and doors won't open. It just ends up being to the homeowner a bit of a disaster. But it is possible to actually retrofit the right foundation solution. Now, it's always best to start off knowing what you think's going to be there and putting in a reasonably robust solution because that'll be cheaper than building the right thing and then finding out you're wrong, and spending more money trying to put it right. But it is possible.

Historic buildings also have found... the thought process that I've outlined is fairly twentieth century. So, if you got a nineteenth century building and you try to do things with it, you might then have to take a slightly more conservative approach and improve the foundations. So retrofitting older buildings with better foundations is quite common. There are techniques around to do it, but it's always best to try and get it right the first time. It's cheaper that way.

Ben: Is there anything different when we come to think about low energy buildings?

David: In principle no, because the building doesn't know it's low energy. Gravity still obeys the law that things weigh the same, except when it comes to thinking about thermal bridges. And often the things that in any construction market are normally done in foundations often incorporate a direct thermal bridge. So sometimes you end up, effectively double up the foundation solution so you can separate the foundation from the superstructure by some robust insulation materials. That's the thing that... I'm also a certified Passivhaus

designer and that's the thing that I see where most structural engineers struggle to get their minds around. And if we're struggling, we're the professionals, I imagine homeowners are also saying, well what do I do here?

But there are lots of solutions out there for all types of foundations now. So, it is possible to talk to somebody who has done one before, whether that's a structural engineer or an architect and say, hey, how did you get around this one? And it's possible. That's the main bit I think, in the foundations. Otherwise, no, it's pretty much the same.

Ben: So, this is something that they haven't done up until very recently, insulating under whatever your foundations are. Is it always under?

David: Well, yes. It is trying to think about from, for example the Passivhaus approach, of getting a continuous thermal envelope, and you want to have that continuous line through. And yes, that means you need to have the insulation going underneath. And yes, it's relatively recent.

Certainly where I practice in the UK, it's not yet thought of as a standard thing to do, but in some parts of the country they've been doing it for 20 years or so. There are experiences that can be borrowed from other parts of the world and will work in others. And there's nothing wrong with that because as I said, the laws of gravity, they change a little bit from place to place but usually things weigh the same wherever you are in the world. So, if it works in one place, and you've got the same ground conditions in another part, you can use the same solution.

Ben: EPS, expanded polystyrene, is what I think I've seen under slabs for example, but what other types of insulation work beneath a building?

David: I think EPS works because it can cope with getting wet. You can get various grades of it that control how much it compresses depending on how much load it is. And most other things that are around don't satisfy those two criteria. So, really the separation membrane between ground and building, I would tend to always default to EPS. There are other choices available out there but I tend to treat them with... well are you as good as EPS? Usually the answer comes back, no, not really. And the other beauty about EPS is it's not expensive. So, if it works, it's the technically right solution and it does the job and it's the thermal insulation as well, well it wins.

Ben: How interested are we in terms of the embodied energy that goes into all of these things? We'd like something that's a nice sustainable material and is a good strong foundation, what do we have to think about?

David: As a structural engineer, that's a particularly hard question because sitting here now, I'm not sure there's enough data on the whole life consequence of picking one structural material over another. There's a little bit of intuition that has to be involved and I think if you're able to create a really well insulated building, and try to use as little material as you can to achieve it, then in the round that's probably going to be better.

There's also a rough metric that if something is expensive, unless we're talking gold or other precious material, usually it's because an amount of effort has been required in its production. And that effort usually has included a certain amount of energy. So, if you're coming up with a solution that's more expensive than another, it's useful to see, well is there a cheaper alternative that does the same thing because there's a chance that that might also have an embodied carbon impact.

It's one to be applied with a little bit of caution and it's probably worth getting some professional assistance. But I would say that it's difficult to get robust data so, try and build well and get a low energy building. And that's probably much more benefit than worrying too hard about something that the industry as a whole hasn't got an answer on yet.

Ben: Does every project need a structural engineer?

David: I would argue, yes. Even if it's a simple shed, if you check it out with a structural engineer, and he looks at it with a professional eye and says, yes that's just a simple outbuilding, you can just build it to standard techniques and that's fine. Well you've bought him a cup of coffee and you know you're doing it right. So I think, yes. What's worse to find out that that shed is on top of a big hole in the ground and you wake up one morning and it's disappeared? If you'd had that chat with a structural engineer, who knew that it was over a sinkhole say, then you've saved yourself the money of a shed.

So I think that every project should involve a structural engineer. I know that's not necessarily a comfortable thing, because our thinking time has to be paid for, it involves a fee. But, that's where you need to think about well, the value of actually having a little bit

more certainty of what's going to happen, I'll be able to pick the right solution and save money that way. So, it's worth it I think.

Ben: How do you find a good structural engineer?

David: Talking to them. Hopefully I've demonstrated that I might be one, in the fact that I've been able to communicate what I'm trying to do in language that's fairly intelligible to average people. That I think is a useful mark. But then you can also talk to the people that he's worked with or she's worked with, and find out whether they think that they're a good structural engineer. So, I think communication and reputation are usually a good measure as to whether you've found yourself a good structural engineer.

Ben: And checking out their previous buildings and making sure that they're still standing?

David: Well, usually that's a good thing because the structural engineer should not be around by the time the building isn't there! You know, design life for a structure should be sixty, a hundred years and well, I'm forty and hopefully some of my buildings will last a hundred years but I won't be around to see it!

Ben: If we're working with a structural engineer, is that more the architect who does that? Or how much does the client get involved with a structural engineer?

David: It depends how involved the client wants to be. I know some clients that I like working with and will appoint us first before they've even thought about who the architect is. There are some clients that I've got to know because I have an ongoing relationship with an architect. We understand each other, so whenever they've got a new project they'll recommend and put my name forward. So it very much depends. If you've found through a social function, or you happen to know somebody in another field who is a good structural engineer, no other professional is going to be too upset if you say, hey, I found this person, I think they're good. Because the architect who might not know them but if they're good, they're good and everybody likes a good engineer!

Ben: Is there anything else in this discussion on foundations that we should be mentioning?

David: Well, it's a principle of, "look before you leap." You can't guess about something, so try and found out. So, I think, don't build a foundation and then be surprised that it's not the right one. Find

out, get a bit of data and then see if you can mitigate your risk by doing a design. That's what I would say.

Ben: David, thank you very much.

David: Thank you.