HOUSE PLANNING HELP

Episode 52

Identifying Construction Defects by Using Thermal Imaging Cameras

The show notes: www.houseplanninghelp.com/52

Intro: My interview is with Lisa Ann Pasquale from Six Cylinder Limited. You'll hear how passionate she is about creating better buildings and trying to spot issues on-site before they develop into something worse. I got underway by asking how she got started in construction.

Lisa: Alright, I'm an architect by training so I have a bachelor's degree in architecture and after several years of working on site, supervising construction works in Boston I went and got a specialist masters in building physics and building performance from the Architectural Association. So I did about a year of heavy calculations into how buildings actually perform in terms of thermodynamics, energy performance and fluid mechanics in terms of air movement in the building. And because I had spent so much time working on construction sites, seeing where everything tends to go a bit off the rails, I was possibly my professor's least favourite student because I kept poking holes in his theories about how buildings should be built by saying: "Well, no, no, no. If the chippie does this wrong then that's not going to work and if the window installer doesn't do this right then that's not going to work and if you don't coordinate this, this and this all at the same time then that's never going to work," and just picking holes in all his beautiful theories about perfect construction.

He said at one point: "Well if you're so interested in how things actually get built why don't you go and be a post occupancy evaluator, a building performance evaluator, and forensically deconstruct why things do or don't achieve their performance goals?"

Lo and behold I went and did that and absolutely loved it because I could go and find faults with buildings, where things had gone a bit off, and then from my background knowledge understand where the mistake had happened and where the miscommunication had happened, and mis-coordination and whatever else, and then work with the teams to help resolve those issues so that they don't

happen again on the next project and ideally also help fix the building at hand as well.

So I mostly do forensic work into building performance and understanding why buildings do and don't work, and helping design teams and project teams actually fix the problems.

Ben: Well I approached you to try and find out a bit more about thermal imaging so let's just start at the beginning. What is thermal imaging?

Lisa: It's a type of photograph essentially. So you know the electromagnetic spectrum, which is what we see, we see part of the spectrum as visual light, the lights that you see every day. Thermal imaging is actually very, very similar, only it's not at the same visual spectrum we normally look at, it's at the infrared spectrum which is a slightly different wavelength. So that's specifically looking at the heat of objects.

If you point a thermal imaging camera at your hob when you've just cooked a meal, you'll see it glowing nice and red. Likewise if you open your fridge it'll be black or blue. So it allows us to see difference in thermal temperatures. Where it comes in handy in buildings is we tend to use them in winter to look at the thermal performance of the building envelope which is the walls, the windows, the roof, the floor - anything really that goes from inside of the building to outside of the building. We specifically look for what we call thermal anomalies, significant differences in temperature that you wouldn't normally expect so you'll expect a wall to be more or less a consistent temperature from top to bottom, so you'll expect that to be all the same colour.

If you point a thermal imaging camera at a wall and you see a big, dark spot on the top or the bottom or somewhere in between there's something obviously going on causing a cold spot somewhere on that wall. It might be a bit of insulation that's been missed out, it could be a bit of damp, it could be a piece of the structure that's bridging from front to back. There's all sorts of different reasons you could see that but what helps with the thermal imaging camera is that if you look at that same wall with just your eyes it looks like a normal wall. The only way that we can see the actual thermal differences is with the thermal imaging camera. So it helps us identify construction defects, design defects, general aging issues with buildings so it's quite good if you're doing a retrofit. Say an eave has developed a failure point and some water has started to seep into the building fabric and soak one of the walls quite heavily,

you'll be able to see where that is in the structure and be able to identify it so that you can remediate it, fix it, before you go installing anything further.

So it's quite useful to understand what exactly is going on with the fabric before you start engaging with it.

Ben: Does the cladding of a building ever stop us from getting a good view of what's happening?

Lisa: Yes, there are certain situations where, what we call, a rainscreen which is generally a bit of cladding that is a certain distance away on the outside from the rest of the building fabric. So there's a bit of an air gap in between the insulation and most of the structure, and the rainscreen. That does make it very difficult from the outside of the building to see if there's a problem. It will mask a lot of the issues. So with rainscreens it can be quite difficult to see exactly what's going on and if there are issues with the insulation or other things. That said, you can actually see quite well from the inside if there's a problem because the nice thing about thermal imaging cameras is you can see problems from either side of the wall, usually. So you can see them sometimes quite clearly from the inside, sometimes quite clearly from the outside, which is why when you do a survey you want to do it quite comprehensively - all the interior surfaces and all the external surfaces. So you might see a bit of insulation having been scooped out of a wall on the inside when you look at it from inside the home but if you stand outside and it's a rainscreen facade you won't see that same issue.

Ben: I'm getting the impression that this is something that we do at the end. Particularly in your introduction you were saying you're a forensic going around spotting all the problems.

Lisa: CSI Buildings!

Ben: When ultimately should we be doing this or is it a checking tool?

Lisa: It depends on the project, exactly, as to when you do it. If you are doing a retrofit where you're going to have to start ripping into walls a bit, especially if you're insulating an existing property which might be a bit damp, I would highly recommend doing thermal imaging before you start applying insulation, before you start doing really anything to the facade or the external walls. Make sure you're quite certain you know exactly what's going on and if there are areas that are a bit of a concern, look into deconstructing them a bit and seeing if you need to remediate them because there's no good

reason to go sealing up some nice, damp building fabric inside of new insulation. [Lisa laughs.] It won't do you any good!

So on retrofit it is quite valuable to do it beforehand. For new build I would highly, highly recommend doing it if at all possible during the construction if you can get the right conditions. This gets a bit tricky because you do have to have the timing right. So if you can get the heat system commissioned and ready to go whilst it is still winter outside and still a bit cold, and then you crank the thermostats up, get the house nice and warm, turn them off for a couple of hours, let the building cool down a little bit and then go and do the survey. Hopefully before you've put the furnishings in, before you put drapes up, before you've lined your radiators with your socks and whatnot. [Lisa laughs.] Then you'll be able to see quite clearly what's going on with the building fabric. Once you start moving furniture in it becomes much more difficult to see it. That said, very few construction schedules happen to work exactly on that timeline, so if you can't do it before you move in but after the heat system has been commissioned you can do it the soonest winter while the building is still in defects and you're still involved a bit with the contractor. That does help you identity construction defects where just things have been accidentally missed out.

It's relatively rare that we see something that's blatant negligence on the part of a contractor. We do occasionally pick up things that you just think, *oh you really shouldn't have done that*, but it's usually just someone's forgotten to do something and they just have to go back and fix it. So it's very, very common to find in electrical sockets that the electricians have gone and scooped out insulation to install a socket or something behind a wall and they've just not put the insulation back in and just kind of slapped a plate over the wall and so you see a big cold spot right behind the socket. So you can just send them back and say: "You need to put some more insulation back there and fix it." Usually they're relatively minor fixes.

You can find some far more serious issues which are built into the design and that's really around detailing, where you've got sills or headers around windows which are very poorly detailed which then conduct heat directly from inside to outside. Those show up quite clearly. They are a risk, not just in terms of energy performance in that the energy is being transferred out of the house quite quickly, they are also a bit of a risk in terms of condensation because condensation is effectively caused by having a colder surface in contact with warm, moist air. So if you have warm, moist air in the house and you have a cold bridge, say above a window, that

surface is going to be a bit colder than everything else so water is going to tend to condense there. That's how you're going to end up getting bits of mould.

If you look at UK houses, quite commonly you'll see mould tends to form on the corners of party walls and external walls. That tends to be a very common thermal bridge in traditional buildings. It's always been there. They've been building them that way for centuries. [Lisa laughs.] That is the bridge that tends to cause the most condensation and in modern buildings we, as much as possible, try and design that out.

Ben: Who is the person who does this? Because I know you can get thermal imaging cameras but then perhaps you're not going to know what to do with them. Or is this the architect? So who is the person who controls this process?

Lisa: I'd say it's not, at the moment, it's not a particularly well-established practice. It's not super common to do it. It's becoming more common which is really positive.

Ben: With low energy buildings?

Lisa: Yes, with low energy buildings and some architects are becoming very proactive about getting a few people who understand how to use the camera out there and doing this quite regularly on their buildings. I'd say they are by and large probably the minority.

There are people who are certified in doing this as a service. I've had mixed experience [Lisa laughs] with contracting to some of them. One of the concerns is when you subcontract this out to, you know, a guy that shows up with a camera and takes some pictures, if he's not really invested in the process and the construction and the client and the product, you tend to end up with a drive-by survey. They stand outside, snap a few photos, stand inside, snap a few photos and they don't really take the time to understand what's going on and look for specific details that might be an issue.

The person that you want to hire would be someone who understands the construction or takes the time to understand the construction, look at all the details, look at the site pictures and see how the building has been constructed, talk a bit to the architects and the contractors to see how things were done and then who takes the time to do the survey in a very, very proper and methodical manner. So the conditions of the survey should be done in very specific weather conditions so you don't want a nice sunny

day like today, unfortunately, because the sun will heat up the external wall of the building, that will show a bit differently and cause different patterning that you expect from a normal . . . an overcast day.

So you want an overcast day, which is at least 10 degrees colder outside than it is inside. You can artificially boost the temperatures by just running the heat system for a few hours, nice and early in the morning. Get it nice and toasty warm inside and then switch them off. So you let the radiators or the underfloor heating cool down for a few hours before you go in with a camera. The trick is, because I've seen quite a lot of flyby surveys where they've had the radiators still running and the slight problem with that is the radiators kick off so much heat you can't see anything that is going on, on the wall above them. All you can see is what the radiator is warming.

Yeah, you want to have the right site conditions. You can't have a rainy day. You can't have an overly windy day. Sometimes the best way of doing it is to just go to the building very late at night, so show up at 11 o'clock at night. The nice thing about thermal imaging is because it's infrared spectrum instead of visual light spectrum it doesn't matter whether it's completely dark outside. You can still see the building just fine. The only problem is you can't then take visual photographs to show what you're looking at! [Lisa laughs.] But yeah, going to the building quite late at night is one way of doing it. Also I tend to go very early in the mornings, so in the dead of winter showing up to site at 6am which is a bit tough but [Lisa laughs] you get a very good picture of what the building is doing because it's been out of the sun for a least 12 hours. It's normalised to its temperatures. So yeah, you want someone who takes the time to do the work properly.

You also want to make sure that they understand how to calibrate the images properly. The images are actually calibrated photographs so you can put a crosshair on the image and see the exact surface temperature of what's underneath that crosshair. Now most building materials emit heat at a particular range, which is actually quite high. There's different materials which emit at different rates. For building materials if you're looking at bricks, woods, concretes, those sorts of things, they're all in the sort of 0.9 plus range. They go from about 0.9 up to 1. You can generally lump those all together in one range and calibrate those images just fine. However, if you have a facade that has quite a lot of shiny metals on the outside, so if you happen to have a zinc facade or something really nice and exotic that has a very, very different emissivity. If

you put the crosshairs on a material like that it's going to give you a false reading. This did happen on one occasion with some architects that were looking at the thermal performance of a building fabric before it had been clad. So they were looking at the nails that had been driven through the sheathing on the outside. When they looked at the image they saw these bright, glowing nails and they said: "Oh my gosh! The nails have all these thermal bridges." I said: "No, no, no. You have to calibrate the wood separately from the nails." We went through and re-calibrated a couple of images and I showed them, no the nails are the same temperature as the sheathing.

So you want to make sure you take the time to calibrate the images right so you don't get false readings and sort of send someone down a blind alley.

Ben: What are we wanting from the report at the end?

Lisa: From the end what you want is, one, usually a little bit of a fix list for the contractor. Where things have gone a little bit off and they've missed bits of insulation or things like that, they can go back and remedy it. So that's one thing. It's a bit of a quality assurance process to make sure that they've ticked all their boxes and done things properly, because there are instances where things just get covered up on site quite quickly and you can't always pick up where something's been done not quite . . .

Ben: Sorry, what do you mean there? They cover something up and then you can't tell with the thermal imaging?

Lisa: No, you can't see visually so generally when architects do inspections of sites they do visual inspections, so we look around at the sheathing, we look around at the insulation, we look to see if things mostly look fine. Usually they do. One particularly fantastic example was a courtyard of a children's centre. We were walking around, just actually having a play with the thermal camera. We hadn't even told the contractor we were going out with it that day. We were walking around and we swung the camera in front of a wall out to the courtyard and there was something seriously wrong with this wall. It looked like it was haemorrhaging cold air into the space. The architect and I were both standing there staring at it, going: "Oh my gosh. What's going on?"

He pulled the site manager over and he really quickly realised what had happened and he'd had a guy who had been supposed to be sealing up around the windows and doors, and putting sealing tape

in between the frames and the walls. Apparently he hadn't done it. So the guy had just slapped some trim around, slapped some cladding on. The whole facade just wasn't really airtight. So as soon as we showed the picture to the contractor and said: "Okay, we're going to have to take this apart a bit and fix it," he immediately said: "Absolutely. Yeah, that's fine." And they fixed it in the next couple days.

Those sorts of issues, had we just been standing there without the thermal imaging camera, we could not have seen what was going on. And the problem with, especially an issue like that, is where there was quite a lot of ceiling missing there was quite a lot of cold air that was getting pulled into the building, you're going to end up with a lot of condensation inside that wall had it not been fixed. So we would have ended up with mould on the inside of the wall, condensation, rot, because it was a timber cladding. It would have degraded that facade very, very quickly because of that pretty substantial construction defect and it was not something that we could see at that point in the construction. We could have seen it two weeks earlier before he had clad it but not after.

As you can imagine, had the wall degraded, had it rotted, had it had mould issues and whatnot the client would have been obviously quite justifiably upset. It would have cost a heck of a lot more money to go back and send someone to fix it after that had all happened whereas fixing it then and there it was just a matter of pulling a few trim pieces out and putting some tape back in place and putting it back together. So it was a relatively inexpensive fix compared to had it waited for eight months. Then also we didn't have any issue with the client complaining that something was right.

Ben: Is there any other factor about thermal imaging that we should be drawing in here?

Lisa: I think one of the most important things is understanding that it's a tool. It's not an 'end all, be all' tool so you still need a bit of intelligence about interpreting the images and that's one thing I've found people tend to overestimate what thermal imaging can do. You still need a person who understands what's going on to interpret the image properly. Otherwise it will just tell you, *there's an issue here*, but not exactly what it is. There are instances where we do have to deconstruct to understand what's going on. That can tend to be more of an issue around roof joints with walls, eaves and whatnot, because it's sometimes difficult to tell whether you've got moisture ingress coming in through that area because there's

something wrong with the moisture barrier or if it's just a bit of a thermal bridge because there's a beam up there or something like that.

So sometimes you'll see an anomaly on an image and not be able to see it clearly enough to know exactly what's going on. If it's a concern where you start having mould in that area or something else, then it tends to be worth actually taking a little bit of the wall apart and having a quick look and seeing if something else is going on.

But no, it's a pretty interesting tool that's quite useful, both in terms of finding construction defects and understanding the state of an existing building but also I've found that it's quite useful for design teams as well to understand what they've done. You do occasionally have instances where they've done a detail that, okay, could have been a bit better and they just think, *oh well that's fine, it's good enough*. Then they see the thermal image with the big glowing thermal bridge under a window or over a window and they're just absolutely shocked at how horrible it looks and very quickly spend the time to figure out a different way of detailing that kind of a wall section.

Ben: What would happen if we decide not to do any thermal imaging?

Lisa: It's a bit of a risk. You would tend to know about it. You will find condensation. That's the thing it tends to pick up the most is areas where you're at risk from condensation, mould, rot and that sort of thing, so you will find out about it eventually but unfortunately you'll find out about those issues after they've become a problem and started damaging the building.

More importantly it's really a matter of quality assuring the construction so it's about making sure that what you've paid for is actually what you got. The trick with building performance is really it's all in the details. It's about little issues that can go a bit wrong, which end up causing, actually, some pretty catastrophic problems a couple of years down the line and this is one of the tools that helps you identify those problems before they've become serious issues with the fabric or the structure or anything else. So it's a way of just double and triple checking that things are working the way they should.

Ben: And one final question. If we actually have to go out and find the people to provide this service, are there any tips on how we choose

someone who's going to do a good job? You mentioned some of these people who take some snaps here and there!

Lisa: Yeah! [Lisa laughs] I'd say that's one thing to talk to your architect about before you hire them is if they're familiar with doing this process. It's quite a useful discussion point when you're interviewing them. Are they familiar with doing a thermal imaging survey? Do they do it in-house? Do they work with someone who can do it? If this is something that is completely foreign to an architect I would be a little bit hesitant about working with them to design a low energy building. If they've never put a thermal imaging camera across their building then they're going to learn some bad lessons the first time they do it! [Lisa laughs.] Or some rather harsh ones at least.

So that should definitely be one of your interview questions with your architect. There's other people that can do it. I'd say there's a handful of Passivhaus and specialist architects and consultants that can do it. I would be a little bit hesitant about people that do this solely as a service day in and day out because it does tend to be a bit of a factory, that I've seen at least, of people that drive by, snap a bunch of pictures, hand you a report and then walk away.

It is quite useful to have someone on the team that actually has a camera to hand because it can be useful at different stages of the construction as well. If they have a camera to hand and they can bring it to site once in a while rather than just a one-off survey it's actually quite useful to maintain a constructive dialogue with the contractor as well. So there's been a handful of times where I've used a camera where I've never produced an actual report. I've just taken a handful of photographs of things that need to be remedied and just sent them to the contractor and said: "Okay, here's where we've found the issues. Can you have a look at these?" And he's just gone off and done it. So we didn't have to produce a formal, comprehensive report to get the issues resolved. I think really that's sort of the sensible way of approaching it. It should be a bit like when the architects normally go out and take pictures of site. We don't go then handing a report of all our photographs back to the client usually. We just pick out the ones where there's clearly an issue and we talk to the contractor and we resolve it that way.

Ben: Well, I'd like to thank you very much for your information today and I'm hoping we'll be able to get a few of these photos into the show notes because of course it would make sense. Lisa, thank you very much.

Lisa: You're welcome.