HOUSE PLANNING HELP

Episode 26

Achieving Airtightness in Low Energy Buildings

The show notes: www.houseplanninghelp.com/26

Intro: Let's get into the main content for this episode. We're talking about achieving airtightness and my guest is Paul Jennings from Aldas. I started by asking him for a little bit of background on his career and how he got into air testing.

Paul: I did an engineering design degree and started working for an energy charity in London and courtesy of Ken Livingstone, at the GLC at the time, we were provided with this test equipment from Canada, this is twenty five years ago now, to try and promote energy saving and better housing in London.

So we went round London for several years testing council flats, council houses, some private stuff as well, mostly public sector, looking at improving the housing because fuel poverty was becoming more of an issue. People were becoming concerned, quality of health, asthma, mould growth, all those things were coming around more so and with fuel prices going up, which of course is happening again now, it was thought it was a good idea to try to improve the UK housing stock, building stock, still the case because we have done very little over the twenty five years since I started but that's fundamentally how I got into airtightness.

Ben: For some reason I seem to think of airtightness and increasing it as something that's happened in these last few years but it's always been a requirement, has it, of building? Or maybe you can give us a bit of the history of how airtight buildings have been?

Paul: Well historically some buildings have been very airtight because of the nature of the construction. If you have plastered walls, lime plaster originally over stone, that's pretty airtight. One of the most airtight structures I tested was part of Gloucester Cathedral, which because it's six hundred years old, the roof has been sitting on stone and it's got plastered walls, was very airtight.

Whereas you can test modern housing, certainly housing built by developers in the seventies, eighties, nineties and it's disastrous. It's much worse and much less fixable than much of the stuff from Victorian, Edwardian going back. You know I've said for some time that we can fix up Victorian properties, we can make them airtight but for a lot of the more recent stuff it's too much to do, we'll end up throwing them away.

Ben: Maybe we can have a definition of airtightness then to kick us off.

Paul: There are two primary measures of airtightness. One is called air permeability which is the amount of air which flows through the fabric, the walls, the roof, the floor of a building per hour at a particular pressure and the usual pressure we work to is fifty pascals which is not a lot. Fifty pascals is five millimetres of water, it's not a huge pressure. If I'm doing a training course I say to people that you apply two thousand pascals if you have a milkshake in a burger bar or similar. That's two thousand pascals with your mouth. It doesn't hurt you, people don't need to worry about the budgerigars or the rest of it, so it's relatively a small pressure. That's air permeability and that's in the building regulations. That's what we use in building regulations for new build.

Then the other measure is called 'air changes per hour' which is what is says on the tin, really. It's a volumetric measure, it measures how much air passes into or out of a building per hour, again at the same pressure of fifty pascals. That's most appropriate for buildings that have heat recovery ventilation, that are conditioned buildings which will tend to be more airtight and certainly you want that air, warmed air, cooled air going through the ventilation system rather than leaking out around doors, windows, and through cracks, gaps and all the rest it.

So basically air changes is what we use for more airtight buildings, like the Passivhaus, which has a very stringent airtightness target down at point six air changes, whereas building regs is still at ten, maximum of ten air permeability, so that's about sixteen times more onerous and, of course, the closer you get to the lower yield you are aiming for the harder it is. It's diminishing returns. Getting air tightness down from ten to five is easy, getting it from one to point six is very hard generally, obviously this varies according to building design, building type, but above all it varies according to the builder and the quality of the builder and that's the biggest issue we face with delivering airtightness is how do we make our builders do what they need to do, work to the sufficiently high standards and it can be pretty onerous.

Ben: So where do we start then when we are trying to make, let's consider a new build, airtight, what is the process?

Paul: Well the first part of the process is to look at the design because there are things that you can do that make it easier to achieve airtightness. One of them is common in Germany is where your upper floors are concrete rather than suspended timber like ours. Wherever you have suspended timber you have voids which air can pass through and it's fascinating to do a test on say a three storey town house, and point out to the occupant the room thermostat that's on the internal wall of the mid-floor living room and there's air coming through it when you're testing it, because it's connecting through the voids in the walls and floors, so one thing we could have more of is solid upper floors. That would make a significant difference on the design side.

Also just going for warm roof construction. Any cold roof has, often a very tricky detail at the eaves where you have to try and maintain airtightness but you also want ventilation into a cold loft space, so trying to have those two things in what is becoming a tight space in that angle in the eaves, often becomes difficult for people and one of the places it goes wrong.

Ben: What materials do you use to achieve the airtightness? I'm assuming that if you have a wall then that is quite easy because it is one solid space and let's assume there are no windows in there but it gets more complicated, doesn't it, considering what the space is?

Paul: Yeah, fundamentally most building materials are pretty airtight. Glass is airtight, plasterboard is airtight, solid timber is airtight. Blockwork varies a lot, there's some blockwork you can blow through. I've had blockwork walls you can blow through and, you know, it varies.

One of the things we say for new build if you have blockwork coming off an external wall into the dwelling you have to make sure it is airtight for at least a metre into the dwelling. So you basically have to plaster, if you are doing a wet plaster system, on the return internal partition walls as well as on the inside of the external wall and even then we've had cases where they are using recycled power station ash, fuel ash, in the blockwork, they can be very very porous and a metre is not enough.

We've had air running through internal dividing walls by up to four metres, which goes beyond what you are expecting, it goes outside the design and then becomes a problem and so often with this it's where you have variations, where people move a duct, people change a window size, people discover that blockwork is leaking where it is not, it goes wrong. If you've got a programme, and if you are smart for airtightness you have a programme, because it doesn't happen by accident, good levels of airtightness which you are getting down below three say. I would tend to say that three is the minimum standard you are going for and three is the silver standard from the Association for Environment Conscious Builders which tends to be the minimum I would work to and then obviously going down to Passivhaus at point six.

So if you are in that band you want to deliver airtightness, you have to plan for it, you can't just specify the target, you can't even just specify the materials, you have to specify the process, you have to specify is the design getting reviewed, check who's doing it, making sure you have a set of what we call air barrier drawings, which most people think of as a red line drawing. So you have a drawing, plans, sections, details with the red line showing what the airtightness is, where it is, with notes saying it's this material here, it's this package of works, because you need not only to know what the material are, you need to know who is doing it.

Then there is the process of going through checking that, what we call a design review, of making sure that it all joins up. So you've got the airtightness in the walls, you've got the airtightness in the roof and you've got the airtightness joining the two at the eaves and I've had occasion where it is missing. I did a design workshop on a building society headquarters and we were sitting there and the main contractor says: "This is the part of the package that the roofer does. It joins with an EPDM membrane. It's joining the roof to the top of the blockwork walls." And the roofer said: "No we are not". And that was it, that was the value of that half day workshop straight there because that building would have been problematic for years.

Ben: So is this a learning curve for a lot of people? If you want to start becoming more airtight there have got to be mistakes or how do you avoid making these mistakes?

Paul: Well I think there will always be mistakes. It's very difficult to get perfection and part of the problem with UK construction is that we hide our mistakes, we don't deal with our mistakes, so I've had this before where something's been put in the wrong place, a hole for a boiler flue, a hole for a heat recovery duct or an extract fan and it's put in the wrong place and instead of being owned up to and acknowledged that yeah we put it in the wrong place now let's fix it, it gets hidden, and then suddenly weeks or months later you're doing a test and it's like why is there a huge air leakage into this void, oh that's why!

One of the things people don't understand is as soon as you have voids, so as soon as you have a cavity wall, air can go anywhere so you may not see a hole on the outside of the building but if there is a hole in the inner leaf connecting to the cavity that's as good as to outside. And it's not just even with new build and cavity walls. I've had this several times with old buildings where you have basically a stone wall a thick, even half a metre thick in churches and stuff, and you think of it as a solid stone wall but actually it's stone, rubble filled cavity. Stone and rubble will not be airtight and it's amazing the amount of air that comes through those walls. Now as soon as you stick lime plaster on the inside it's gone, it's dealt with but then you usually have an issue at the top, coming into window reveals or coming into the roof joint, but again it's something that people just have no expectation of, people do not expect buildings to leak where they do leak. They don't expect air to transmit into the inside of a building.

I did a test on Saturday on a refurbishment of a nice four storey Edwardian town house and we had a pillar in the basement which had been lime plastered and it had a switchbox on it and air was coming through the switchbox. This is yards away from the outside surfaces, so where is that air getting to it? We think it's connecting to a flue, to a chimney flue from the existing chimneys, that's why so often we are finding if people want to deliver good air tightness in refurbishment they do tests to find out what is going on, because you have to know, because apart from anything else you may find you are wasting your efforts if you have a leaky building and you don't tackle it because you don't appreciate it. You spend thousands on a heat recovery ventilation system and it's all a waste because the air is leaking out through the walls or around the roof joists or wherever else it is.

Ben: How do you test for airtightness then?

Paul: Essentially you have a calibrated fan. Small fans, big fans and very big trailer fans and you mount it in an open doorway or an open window and that could be mounted on a piece of wood or we have various adjustable door systems and the fan's calibrated. It will have varying ranges of how much air it will blow from small to very large and normally we start by sucking air out of the building. It's called depressurisation so the building is at lower pressure so atmospheric pressure forces air back through the cracks, the gaps, the leaky dampers, the windows that the draught seals are not quite right, whatever else there is, and if we can get it above about twenty five pascals then effectively we have created a strong draught, a permanent draught while we are testing and we can go around and find it.

You can often just feel it with your hand; if you are not sure you put your eyeball next to it because your eyeball is even more sensitive. We can use different sorts of chemical smoke, stage smoke, we can use acoustic testing, we can use little extending anemometers, so you have your little extending tube that you stick next to where you think the hole is. We can use infrared cameras to help us find things because, especially in the very airtight buildings, it can be the coldness where the air's leaked that shows you where the leak is rather than feeling the leak itself because it's so small, at any one instant, but after ten minutes of cold air it starts to show up on the thermographic camera.

Ben: So these tests, how often do we have to them when the house is being constructed because I've seen them happen quite a few times and I'm still unsure, and even afterwards they keep on testing?

Paul: Well for most construction testing is required under building regulations and basically for non-domestic it's required for all building above a minimum size. For houses it's sample testing so you wouldn't normally have to test every house although the sample size does increase as the target gets a lower value for the airtightness and one of the issues that's being talked about at the moment is the fact that the building regulations say if you do a test and it fails you not only have to fix it and retest it you have to test another one of the same type as well - the sample size goes up. Yet there have been no failures or almost no failures reported, and why is that? Well we know why that is because any builder, sensible builder, says actually let's make this a leak location exercise not a test and we'll fix it and then you can test it again, which is basically, it's legal but it is definitely against the spirit and we definitely I think as a nation are building in problems for the future with poorly performing houses where we have small sample sizes on large volumes, large numbers of houses and especially where they are timber frame. Because one of the fundamentals underlying this is where air moves it takes water and water concentrates around the points of leakage. So for example if you have a socket box in a wall of plasterboard it'll be the socket box where almost all the leakage is and probably all the moisture ends up in the wall, so you can very easily get to a point where you are getting interstitial condensation, problems with rotting of timbers in walls and I know I'm a pessimistic cynic but I am expecting there to be another wave of problems with condensation in walls showing up in the next five or ten years.

Ben: How long does this airtightness last, presuming as with any building material you expect degradation over time?

Paul: The fundamental truth is that we don't really know because the UK is abysmal at research so we are not doing the research to go back and find out. Obviously the suppliers of materials, especially the better airtightness materials, do accelerated ageing and they say oh yeah we've proved that our product will last for fifty years but it's not in a fifty year old building. You know it's been in a laboratory with accelerated weathering blah, blah, blah, to demonstrate it has a robust life. Having said that most things are fairly stable, it's the joints, the interfaces, the penetrations that move.

Obviously mastic varies from very good high quality mastics which have a bit of give and will allow the building to move, to shrink, to thermally change over time and then you get at the other end of the scale you get the absolutely very cheap builders calk which I've seen crack within weeks of being applied. So between doing a preliminary test on a building and then an acceptance test six weeks later say, when the services have been installed, this mastic has failed, this builders' caulk has failed. And anybody doing airtightness should understand the difference because it's a very significant difference.

Ben: Now I may be opening a can of worms for myself here, when we talk about vapour open airtightness I don't think I understand this at all, how you can have both those things an airtight barrier that is vapour open. Do you want to try to explain that one?

Paul: It's the difference between allowing air through and allowing moisture through fundamentally. Moisture will wick through materials so will soak into a surface, pass through the material and come out the other side. That doesn't require a hole that will let air through and that's the fundamental we have buildings which we call vapour permeable, they used to call them breathing wall but that's a misnomer because it's not, but vapour permeable buildings will allow moisture to pass, some of them have these recent, what they call intelligent materials which vary according to temperature and pressure in which direction they allow moisture to move, but again they are airtight and nobody should be under the illusion that if they want a vapour permeable building they have to make it airtight because it's absolutely ludicrous you have this vapour, supposedly vapour permeable building with a one millimetre wide crack for a metre and that's letting through ninety nine per cent of the moisture.

Ben: OK that sorts that one out. A couple of questions as we come to the end here. I know that airtightness is one thing and obviously we know about insulation but people forget ventilation. How does it work as we crank up the airtightness we need to think about ventilation?

Paul: Well they are two different things and what's true at the moment is most UK houses have too much ventilation if the wind blows and not enough ventilation if the wind doesn't blow. So basically we have the worst of both worlds and as we move to more airtight, indeed very airtight with Passivhaus buildings, you have to have ventilation, you know you can't do without it, you don't need very much. People worry about this but you don't need very much movement of air to give you the oxygen you need to breath. We reckon about thirty litres per second per person for moisture control and for breathing, depending on exercise levels, two three or four, it's an order of magnitude difference. You will be getting black mould growing out of your ears before you suffocate in an airtight house.

Ben: OK and also indoor air quality, how does that fit into this equation?

Paul: Well it's another part of airtightness. When we are doing air tightness we have to think that there is less dilution of pollutants happening, so you have to avoid paints that are going to give off volatile organics for example, so you basically need to be careful about specification of paints, of furniture, things like new computers giving off lots of toxic materials, all of these things become more of an issue in an airtight house, but of course the big one is moisture, and especially during construction because if you are doing an airtight project very likely you will have much more wet plaster than plasterboard. An easy way to do airtightness is having wet systems but of course that means there is more drying out that has to happen and one of the things that we are seeing in some of the Passivhauses, the airtight properties, is mould during construction because they are not drying out because, of course, the heat recovery system isn't operational for a long while later in the build, the walls are up, the plasters on and it's starting to try to dry out.

Ben: What are the key challenges then of achieving airtightness? As a client I know that I want something that is energy efficient so this is going to be important to get an airtight building but what do I need to bear in mind?

Paul: Well, if you are a client wanting airtightness first of all, assuming you are not doing it yourself, assuming you are employing contractors and architects.

Ben: I will be.

Paul: What's their track record, what have they done? Have they done it elsewhere, what have they achieved, what's the best they have achieved, because if they are just a bog standard builder without any knowledge of airtightness then you'll be paying for their learning curve?

Ben: OK, alright.

Paul: So first off experience, then of course the whole process and then again it depends what level you are working to. It's much more onerous working at Passivhaus than working at a target of three, the AECB silver standard. It's horses for courses. If you are targeting the very airtight property then you've got to pay more attention, and you have got to plan, you've got to think it through, you've got to avoid variations so everything is specified, designed, planned. Review the airtightness so that you are very clear and the contractor's very clear what's going where and when. You know, making sure the contractors are doing the toolbox talks so that everybody on site has bought into airtightness. It takes very little time for one plumber or one anybody to completely compromise airtightness.

Ben: Do you want to leave us with a final thought then or perhaps something I haven't asked that you think I should be asking you?

Paul: I mean fundamentally we need to be delivering better quality airtightness particularly in refurbishment. We are not bad in new build, or potentially not bad in new build, but in refurbishment we've really got to learn a lot. We've got to get the skills base enormously improved, we've got to be doing much more testing of refurbishment projects so that people understand what the issues are and they see the difference before and after, because not only are we talking about energy efficiency but also talking about we want buildings to last.

Sustainable construction means construction that is not rotting from interstitial condensation five, ten or fifteen years down the line. We want it still there fifty or a hundred for our great great, whatever, grandchildren to be able to live in it and use it so we want that property to be airtight so it's protected against moisture damage and it lasts and I'm afraid all this eco-bling, all these solar panels, all rest of it, there is a place for it but you've got to get the building fabric right first. That's the fundamental, fabric first and it's a crying shame and it's the whole or most of the UK construction industry needs to be taken to task for the poor quality it does in refurbishment around airtightness and quality control generally.

Ben: Paul, thank you very much.

Paul You're welcome.