**Episode 95**

# The Saskatchewan Conservation House

The show notes: www.houseplanninghelp.com/95

Intro: Today's podcast is slightly different to what we normally do because we're meeting Passivhaus pioneer Harold Orr and hearing how the construction of the Saskatchewan Conservation House changed the game in the late 1970s. So it's more about history and context in this episode.

I started by asking Harold to tell me a little bit about his background.

Harold: Well I'm a carpenter by trade. My father was a carpenter, my grandfather was a carpenter, my great grandfather was a jointer so we were in the building trades. So when I was growing up, about the age of 12, I was going with my father and I was the gopher. Go for this, go for that. And so I learned building right from the bottom, and as I was going through high school I was working every summer in the building trades, and when I started university I actually contracted and built a house by myself for somebody else.

And I got into engineering and I was going to go into chemical engineering, but my marks were not the greatest and so I went the next step to go to mechanical engineering. And I was at that time getting very interested in a girl and of course that presents problems when she's 150 miles away! And so I wasn't getting my work done, and so at the start of the third year I dropped out because I was going to fail if I didn't.

So we got married and I went into carpenter work and I did carpentry. And we were working on a 320 unit project in Regina and I was working on this 320 project as a carpenter and they worked me up until I was one of their most valuable employees. And I saw an opportunity then to go into architecture so I applied for the job, got it and worked then for almost 4 years as an architectural draughtsman working towards an architectural degree. But the architect I was working under came to a situation where he didn't see the way I liked to see and I didn't see the way he liked to see and I thought it was time for a parting of the ways.

So I applied to go to take architecture at the University of Manitoba and architecture was a 5 year degree and they would not accept any of the 2 years of engineering that I already had. Not a single class. And I could go back to, now that I had a family with 2 children, I could go back to Saskatoon to complete my degree in 2 years and so we decided that was the thing to do.

So we moved up to Saskatoon, went back into engineering, mechanical engineering, graduated in the top of my class and the university suggested you really need to go on and get a masters. Here's a man with a wife and 2 children, no 3 children now, and I should go on to get another degree. So I did. Fortunately I had a bursary from the National Research Council that paid some of the way. My wife was working. And I got in and took my degree, and my thesis work was - I'd selected to work - on air barriers.

Ben: Why?

Harold: Because basically at that time if we were doing the calculations, the engineering calculations, on heat loss for houses we could calculate the heat loss through the walls and through the ceiling and through the windows and the doors, but when it came to air leakage you wet your finger and held it out and see which way the wind blew and grabbed a number out of the air. Literally that's what you did. And you hoped you were in the right ballpark because there wasn't any data on how to do this.

So we worked on an instrument. I'd developed an instrument to measure, actually what it was measuring was the percentage of helium in air and a mixture of air helium. And we were using helium then as a tracer gas. We put 100ft$^3$ of helium in the house and then we would measure and see how fast it disappeared and we'd assume that the helium disappearing would disappear at the same rate as the air and this would give us our numbers. Unfortunately that's an incorrect assumption. When you put a high concentration of helium in the space, the helium goes into closets and cupboards and spaces and so on. And so it artificially disappears from what you're measuring.

Ben: How extraordinary!

Harold: So it appears that the infiltration rate is very high, and then as the concentration goes down the helium comes back out of the woodwork and so now it's artificially low. And so what are you measuring? Well you're measuring the concentration of helium but that really doesn't tell you anything.

So anyway I got my second degree on that and when I got my second degree I went on staff at the National Research Council working on the same problem. I just continued on so for the next several years, and so what we did eventually then was to change from helium as a tracer gas to sulphur hexafluoride as a tracer gas.

And the advantages of sulphur hexafluoride was we had a measurement system that we'd put it through a gas chromatograph, and the gas chromatograph would separate out the sulphur hexafluoride and it would come through as a separate peak from the air. And so then we could measure the sulphur hexafluoride separately from the air peak. We knew what size the air peak was and we now measured the sulphur hexafluoride peak. This would give us the concentration and instead of using 100ft$^3$ for a test we could do the same test with 5cm$^3$. One teaspoonful.

And so we were using very very much less material to do our tests and cost wise that was great, and the other thing was since we were doing this now we could use constant concentration mode. We would pick a concentration that we wanted, for say 15 parts per billion, and we would dump some sulphur hexafluoride in the space, measure it and if it wasn't 15 parts per billion we could calculate how much more we needed to inject to bring it up to that and we'd just keep doing this every minute, take another measurement and keep measuring with a computer, one of the first computers that were available.

This worked very nice but the problem was in order to measure the infiltration in a house, we had equipment that today would be about $10 million worth of equipment. [Ben laughs.] We had 2 men that were needed to put the equipment in the house and get it connected and so on, that's at least half a day's work. And then somebody had to come into the house and monitor this every day for a week or a month or whatever period we were doing, and when we got that then we could see what had happened in air change over the thing or we could average out or whatever you wanted to do with it, but it gave us the numbers. But, it's not a practical system to do every house. You can't put this into every house and do it.

And so our people in Ottawa were using pressurising houses to see how much air was leaking. And they had a very cumbersome system. They had about a 12 inch diameter duct and it's 20 feet long. They put a fan on the end of it and then they would go into the thing with a pitot tube and measure the pressure on an anemometer in 10 equal spaces around the duct. And you had to precisely position this and each measurement. And I said well that's stupid because it'd take you an hour to make 1 measurement and you weren't even sure then and if you're having to do 10 or 15 measurements to put on the graphs so you can calculate the infiltration rate, that wasn't appropriate.

So I invented the blower door. And what we did was we took a piece of plywood that would fit a door and we cut it in 3 equal parts, put piano hinges on it so they'd fold one over the other and we mounted the fan on the centre one. And now we had to measure the air going through the fan. Well our people in agricultural engineering were using a smooth edged orifice to measure this and that was the logical thing. We put a smooth edge orifice onto our fan, connect up an anemometer to it, take 1 reading and you've got your airflow.

And so that made it very very much simpler, and so we started manufacturing, had a company manufacturing nozzles. And Minneapolis Blower Door heard about us or read our paper on it and came up to Saskatoon, bought some nozzles, went back to Minneapolis and started Minneapolis Blower Door. And so okay, now we've got tests. We ran tests, put crews in and measured hundreds of houses for air leakage because you can do it in about 15 minutes. And so now we have numbers of how fast the air is leaking in the house.

Ben: And which year is this?

Harold: Oh, I started my thesis work in 1960 and I started with National Research Council in 1962, and by the early 70s we were the experts on measuring infiltration or leakage in housing.

So in the 70s then there was the Arab embargo on oil because they thought they were getting not enough money for their oil. And so they shut down large oil fields and made a scarcity of oil, so overnight the oil prices doubled. I mean you went to fill up your car and hey instead of being 35c a gallon it was 70c a gallon and everybody was up in arms. So you put half a tank of gas in, complained to your filling station attendant and then went on to complain to the member of parliament about this.

Well the Saskatchewan government was really concerned about this and they have a research arm. They have a very active research arm called the Saskatchewan Research Council and the Saskatchewan government asked the Saskatchewan Research

Council to design and build a solar house appropriate for Saskatchewan. Now the solar house, they didn't have any expertise at all in building and so here they are, what do we do. Let's get a group of people together that know something about this and so they called on me because I was working with building research. They called on Bob Besant, George Green and several other people from the university who were involved in building and they asked people from HUDAC the Housing and Urban Development Association, and from CMHC and so on.

There was about 10 or 12 of us that were involved in this committee to get there. A couple of architects and Hendrik Grolle and Marvin . . . anyway a couple of architects sitting on the thing, and one student Rob Dumont. And so we got together and we discussed the situation in terms of solar.

Now solar first of all there is essentially, in our climate, there is no solar available between November and April so if you're going to heat a house with solar you're going to heat hot water in the summer time and store it for that. Now if you take a conventional house, this requires about 3 Olympic swimming pools. And if you have 3 Olympic swimming pools the evaporation from this will keep them cold. You have to have an awful lot of heat. Your losses are 70%. You have to put in a lot more energy than you're going to ever get out. So this just didn't make sense and since we knew we didn't have energy available in the wintertime what are we going to do?

We looked at it and said the logical thing was to simply reduce the energy consumption of the house to a very low value. So we sat down and started designing the house and one of the first questions came up: how much insulation should we use in the walls? And someone said how about R20. And I said the problem with R20 is I know of several people who have built houses with R20 and I know that isn't enough. So my suggestion would be R40 in the walls, R60 in the roof and I made the strong proposal that we do not put a basement in because this house was to be built in Regina and the number one problem with housing in Regina is basements. And at the time they were recommending if you do have a basement don't ever add insulation more than 2 feet below ground because if you do you will freeze your footings and the whole thing will go to pot. And we're going to have to insulate everything so we couldn't do this. We won't put a basement in, we'll put it on grade pile and grade beam foundation and so we then put, I recommended we put about R20 in the floor. We actually put in R30.

So then the next problem was we knew that air leakage was going to be a major component and at the time there was nobody in the construction industry involved in making anything airtight and I was the only one basically that had any knowledge on how to make things airtight, so I said well I will install the vapour barriers. So one of the technicians from the National Research Council and I went to Regina and installed the air barrier. And we did I think not a perfect job but a very good job for that time and when the house in Saskatchewan conservation house was built, it was the tightest house in the world at that time.

Ben: What was the air barrier?

Harold: The air barrier was 6mm poly and we used acoustical sealant to join one piece to the next piece and to seal it as it went through the floor joists and the various things. And we achieved half an air change, 0.5 air changes per hour at 50 pascals.

Ben: Knowing what it's like today, that many buildings you'll go with the blower door, you'll test it, you'll address some of the issues, what was it like on this first house? Did you have to get that airtightness by going down the same route?

Harold: Well, I knew what we had to do and so we went at it wall by wall. And the vapour barrier was on the inside and we went wall to wall, and when we came to a partition we had to deal with that. When we came to an electrical plug we had to deal with that, and so on.

And as a result of that of course we then switched dreams pretty quickly after we built the Saskatchewan Conservation House. There's better ways of putting a vapour barrier in than putting it on the inside. You put it in the middle of the wall. And you put it on the outside of the inside wall. This means that it's 3 and a half inches from the idiots putting drywall on and [Harold laughs] and all the other things! And you can go right past all the interior partitions. You can go past the floor joists, you can go past most things. It makes so much sense, you know it's really simple to make a house airtight. You make, you cut off everything on the outside that sticks out, you go to Mister Glad and ask him to make you a garbage bag big enough for your house. You pick the house up, put it in and you twist the top and it's airtight.

Now, the only problem with that is now you've got your air and vapour barrier on the outside of the house, and you must keep this warm. So you have to put insulation on the outside of this. So what our technique is in the Prairie double wall is to make a light frame outside of the air barrier / vapour barrier, to make space for adequate insulation to keep the air and vapour barrier always above the dew point. If we do that we've no problems, it's very simple and if you do that you can routinely make houses that are less than 0.1 air changes at 50 pascals.

Ben: At this time you're creating a pioneering house, so what was the reaction?

Harold: Well the house was built and the government wanted to get the best exposure they could to it so they used it as a demonstration house for 2 years, and essentially all the students in high school in the whole province were bussed into Regina and taken through the house and shown the various features. We had about 10 features basically on the house that they were looking at.

We had first, well, the real simple one. To get the greatest volume with least amount of area, is a sphere. The next one is a cube. And so the houses should be most volume for least area because we want to reduce the area as much as possible. The next thing was we want as much wall for exposure to the south so that the sun can come in through the windows on the south exposure. So the house should be a rectangle with the wide side facing south. Those are sort of the logical bases that you always do.

Now the next thing they wanted to do was . . . We'd designed the house as a conserving house but when we presented this to the government they said 'oh that's very nicely done but we want it solar heated’. [Ben laughs.] Okay, so this is a slight change in plan, so in the far north west corner of the house we modified the plan just a little bit and there is an 8ft by 8ft space that's 2 storeys high and in that 8ft by 8ft space 2 storeys high is mounted a water tank, 6ft in diameter and 18ft high. It's insulated to R100. [Harold laughs.]

So anyway, so we built the house, and materials and labour for building the house was approximately $60,000. And the materials for building the solar system was $65,000. And we estimated that the house could be heated using 45 gallons of oil - 170 litres. And at the time oil was less than a dollar a gallon so we could heat it for basically $45 for the winter. But we had the solar system. So anyway, they put the solar system on. The solar system had used vacuum tube collectors, the very best we could buy. It had circulation pumps, it had temperature sensors, it had everything. Heat exchangers to heat water from the solar system to heat water for the domestic hot water to provide heating for the various things in the house. And this needs maintenance and first year maintenance cost was over $10,000 to provide the equivalent of $45 worth of heat with oil and about $25 if we'd been using natural gas.

Ben: And this was something they'd pushed you into?

Harold: Yes. They pushed us into doing this. And the second year the maintenance cost was not quite as high but still was up in the many thousands of dollars. So as soon as the house was sold the new owner for the house removed the solar system.

Ben: Well you would.

Harold: Yeah. The other thing was, the big problem was nobody built triple glazed windows. And we needed at least triple glazed windows and we actually need, they're commonly available now, triple glazed double low-E argon filled on and on and on. But it wasn't available then, so we decided to put on shutters on the outside of the windows. Now the south face had an overhang sufficiently long and properly designed so in the summer time no sun shines into the windows. In the winter time full sun shines in through the windows and the shutters were hinged at the top and would fold up against this overhang. But in the winter time when it's 40 below, the weather stripping on this is at 40 below, and it's like a piece of iron and it does not seal. And so the cold air circulates around the shutter and so it warms up the windows a little bit but we'd put something like R20 shutters on the thing and they're more like R3. [Harold laughs.] Not very effective.

So, guess what, the other problem is with shutters even though they're electrically operated someone had to go around and push the button for each shutter and make sure each shutter was open in the morning and closed at night. And okay, that's fun the first day! [Ben laughs.] It's less fun the second day and after the first week it's a pain! So they were never used.

So, okay, the next item was well we're going to recover all of the heat, or some of the heat, from the grey water. And having not had any experience on this they came up with a counter flow heat exchange that consists basically of a barrel where the grey water ran into and then we took the grey water off the bottom over a weir and down the drain so that the barrel was always full. And then in the barrel we had a coil, a water coil and the water coil then came in the bottom and out at the top. Counter flow because you're putting the grey water in at the top, goes out at the bottom, the fresh water comes in at the bottom goes out at the top. Nobody had seriously thought about this but after you have a shower or after you have washed your clothes and there's water from both the shower and the laundry that was going into this, it has soap in it. And if you cool down the water that's washed from the bath and there's soap in it it congeals. And so now you have a barrel full of jelly! And it doesn't work! [Harold laughs.] So okay, scratch that one.

Another thing they did was they put an airlock entry at the front door and at the back door. Well that's very important if your house is a sieve and so when you open the front door the air blows through the house and out the other side, but this is a very tight house and it doesn't do that. So the airlock entry is really very ineffective.

Ben: So some of these things that you were trying, was this house evolving or was this all in one go? I'm slightly confused there.

Harold: Well it was all in one go, but as a result of this it gave us a lot of information as to how we shouldn't do things and how we should do things. And so the things that worked were the massive amounts of insulation, the airtightness, and thank goodness it really caused a revolution in the window manufacturing to make windows that are really effective. And windows that are, well, triple glazed, double low-E, argon-filled windows even on the north side now, gain enough energy through them to counteract their losses. They're heat gainers always.

Ben: How did you deal with the ventilation?

Harold: Oh, the ventilation of course was a concern. We recognised that we needed ventilation. So, Dick VanEe, a technician from the University of Saskatchewan, was given the project of designing and building an air to air heat exchanger for the house. And he built the first one for the house. It was about 14 inches thick, about 2 feet wide and it was 8 feet tall. And it used buoyancy effects because the airflow through it was quite slow and the spaces were used half inch plywood to make spaces for it, and the heat exchange media was a sheet of 6mm poly. And so he designed it so the cold air would come in at the bottom and go up through the exchanger. As it went up it gained temperature and it stratosphies in the thing and goes up and comes out hot at the top whereas the hot air comes in at the top, exhaust air comes in at the top, and goes down and as it goes down it cools and at the bottom it goes out in the cold. So it was really quite effective. He built it in a couple of days in the shop at the university. It was installed and used fans from, computer fans to provide the motor force for it. Very low energy use and recovered high percentages of the heat.

Ben: I think what's amazing me is how many elements of this you've managed to do on one project. I suppose it had to come together at one point, but there will be lots of challenges out there in the future and people will need to come up with ideas. So what advice do you give to people who are trying to solve what seem really difficult issues?

Harold: Well, I think in terms of if you take a look and I don't care which programme you use, PHPP or HOT2000 or whatever, you go ahead and you should go ahead and analyse either the existing house you want to renovate or your new house that you're planning on designing. And put in whatever insulation you have or whatever you're planning on putting in and look at the results as they come out and they will tell you where the heat is going. You'll find in every case, I think without exception, the major component of heat loss is air leakage. And it really bothers me because I see so many people going out, their siding is 30 years old now and it's looking decrepit, so they rip off the siding and they put an inch and a half of Styrofoam on and nail new siding on and they think they're going to get a major reduction on their energy consumption, but they haven't done anything to do with airtightness.

Ben: Okay, let's look at that. You sussed all this out in the 70s, how we're in 2015 now, why have we not progressed? I know obviously the Passivhaus movement is taking hold, but why has it taken this long?

Harold: Well, in Canada of course the problem is that energy is still so inexpensive that it's still a small item on the budget.

Ben: But this isn't going to look good in the future? When it runs out, the people who are living on the planet then will be thinking what the heck were you doing!

Harold: That's right. Exactly. But it bothers me to see people going in and ripping off their siding and putting in an inch and a half of Styrofoam and thinking you're going to get anything, because basically that reduces the heat loss through the wall and the heat loss through the wall is normally around 10% so if they double the insulation that was in the wall they're going to save 5% and I will defy you to find that on your energy bill. [Harold laughs.] But people just don't recognise what happens.

But to give you an example of this, a friend of mine in Saskatoon was trying to do all the right things. First of all his furnace was failing so he had to replace the furnace. So he went in and had the old furnace taken out, put a new high efficiency condensing furnace in and said okay I've done my part. And then he looked up in the spring time he happened to look up in his attic and he found that they had blown about 6 inches of cellulose fibre over on top of the old insulation and there'd been enough condensation because now with the new furnace his chimney is not active. Because the chimney's not active this means that air comes into the house, as it warms up it rises, tries to find its way out and it goes through the ceiling into the attic space which has moisture. It condenses on the roof and what had happened was he had 2 to 3 inches of frost up there. When it melted and came down he now had 6 inches of wet paper mache in his attic. And he said 'what on earth do I do?' And I said well I'll tell you what the problem is. The problem is you've got holes in the ceiling where the partitions are, where the electrical boxes are, where the plumbing stack is. All of these are holes in the ceiling where the air is going from the house up into the attic carrying the moisture there where it condenses. And I said the only way I know of stopping that is to stop those holes. But unfortunately there's no possible way of getting up there and doing it. You just can't do that. So he said 'what do you suggest?' So I said I would suggest a chainsaw retrofit.

Ben: Is this another one of yours? Is this another, oh my goodness, okay!

Harold: Yes. So what we did was we had a bee with our church people and they came over one Friday evening and we stripped off the shingles off the roof. We got a chainsaw and we cut the eaves and the overhangs off. We then made sure the roof surface was nice, no nails sticking up or anything. Put polyethylene on it. Put strapping on to provide 2 by 8s parallel to the roof edge and then 2 by 4s on top so we now had 12 inches of space. We put 12 inches of insulation on the top, a new roof deck and new shingles, and we got the roof done. We carried this down and we took the siding off the house, we dug a backhole and dug down to the footings, we carried the vapour barrier right to the footings. We started out with a foot of insulation at the footings and carried it right up to the roof. We put new exterior finish on. The house looks beautiful and he's reduced his bill to practically nothing. He's essentially if you put solar collectors on the roof he's a net zero house. And he has no more problems with condensation in his attic.

Ben: So that's your retrofit as well. You've had your new build and your retrofit.

Harold: That's right.

Ben: Well, it's been fantastic to get a chance to meet you, and to have a chat. Maybe, is there one thing that you'd like to conclude this chat with?

Harold: Yes. If you're building new houses, build tight, ventilate right. If you're retrofitting, consider first, there's a first component of retrofitting, how am I going to make the house tight because that is the most important component. Make it tight and then ventilate right.

Ben: Harold, thank you very much.

Harold: Okay, thank you.