

## Episode 46

# Manufacturing a House On-Site Using a Mobile Production Facility

The show notes: [www.houseplanninghelp.com/46](http://www.houseplanninghelp.com/46)

Intro: I've been wanting to do something on digital fabrication for some time and was wondering who would make a good guest. Then I watched Grand Designs and saw an episode with Celia Brackenridge and Diana Woodward, and they created this house that I thought, *this is just perfect*. It's a really innovative process and it's time to find out more about it. So I started by asking Diana Woodward about when they came up with the idea of building a house.

Diana: We moved down here as I entered retirement and Celia was nearing retirement to be between our elderly parents. We'd done sort of semi house-hunting before we were ready to proceed for quite a long time and an awful lot of the houses we saw were very dull, very energy inefficient. We couldn't see anything that excited us architecturally.

We weren't frightened to do construction. We've done remodelling. We've done big extensions before. We haven't done a whole house but the idea didn't phase us and eventually when we found this house on this plot we loved the plot and we loved the situation. The more we looked at the house the more we realised that it wasn't going to be something we could efficiently and economically knock about and it became a good idea to knock it down and start again.

Ben: How many different plots did you look at and why did you know that this was the right one?

Diana: We've had quite a few houses in our time. We've moved around a lot for work reasons and I was up in Scotland and Celia was down here. She was doing pre house-hunting, going to look at places she'd found on the internet, not going inside but looking at the outside and she looked at dozens including a few in this area. This was head and shoulders above the others in terms of the site and the location.

Ben: Were there any other factors on your brief? You mentioned energy efficiency right up there but what else were you looking for in this house you were going to create?

Diana: I've come to realise that I need a lot of sunshine. I get very depressed if I'm somewhere gloomy and we wanted either a view or a sense of a vista beyond the garden. We love being in the country. We love the wildlife and the birds and so on but also we didn't want to be too far away from a pint of milk, entertainment and the capacity to get to London when we needed to. This met all of those criteria.

Ben: In terms of getting a good price for the plot, did you bargain hard? What tips would you give other people going into this?

Diana: Oh we always handle money things completely wrongly. The market in Scotland had completely collapsed and we ended up selling for £200,000 less than we'd hoped for. Here the house had been sold a couple of times before to the same man and it had fallen through but the vendor was in a hurry to leave and wasn't in a mood to bargain and there were other people allegedly interested. So we weren't able to bargain down the price and there was quite a hurtful gap between what Scotland went for and what we had to pay to get this.

Ben: You actually ended up going for a very unusual build method so what is the story behind that?

Diana: Well, to start with we looked at the house, which looked quite reasonable and attractive, and thought about knocking it about and spending maybe £100,000 on it. We talked to a local architect. At that time Bruce from Facit Homes had an editorial piece in one of the building magazines that I'm a subscriber too saying they were looking for demonstration projects. We set him against the local builder and we interviewed them and they interviewed us. We gave them both a brief and his response to it was just so much more imaginative and met so many more of the objectives that we had that really it was a no-brainer in terms of going with his design.

As for the construction technique it was novel but I think Kevin McCloud talked it up a lot in the Grand Designs programme. In Scotland most new houses are timber frame and the house that we doubled in size in Scotland was done with timber frame against the original stone building.

My previous job was head of research at Edinburgh Napier University and one of the strongest research teams were the Timber Engineering Research Centre in the Built Environment faculty. I had a lot to do with them, working on research projects with them. I mean I'm not a technical expert but I knew enough from looking at their research bids and their projects to see that timber has been a construction material for hundreds or thousands of years, and it's as least as good as masonry. It's nothing to be frightened of. The house isn't going to burn down. It is going to be strong. It is going to be energy efficient. So I think the idea that anything that is not masonry is dangerously novel is rubbish.

Ben: So you call this a timber frame, do you? I didn't really know how to refer to the house because you've actually manufactured on site but before we get to that maybe we could just look at a couple of other things. Rewinding for a moment to Bruce's design, did he say that this is the house that I would like to create or was it more tailored to your needs?

Diana: We knew what his construction technique was going to be and I wasn't frightened of that. The design was absolutely perfect for what we wanted and it was much more imaginative than anything that we'd come up with.

I think timber frame is a description that works if you want house insurance or it's a sort of broad brush category. It's actually not timber frame because it's timber, but I tell people who don't know about construction that it's timber frame because that's a phrase they are familiar with. It's actually made out of timber.

Ben: What type of timber is it?

Diana: It's WISA board, very strong plywood that comes from Finland and we had a delivery of it that came straight from the docks at Tilbury every Monday. Then once Bruce had designed the house he had a couple of Spanish guys who were experts in computer-aided design (CAD) and they translated his design into technical specifications to tell the computer how to cut the wood to make the boxes that make the house.

Ben: Was it a special design programme that they used to do this . . . This may not be your specialist area. [Ben laughs.] I don't know but I don't quite see . . . He's got his design that he wants to do. How does he translate it?

Diana: It was several months work for these two guys and I think that they had to deconstruct Bruce's design and say: "Right, that wall is this long." The idea is that none of the boxes are too big for one or two guys to man-handle on their own, which is why the largest ones are the size of a big man's coffin.

I'm not sure I know enough to answer your question in detail but as far as we could see there were very complicated plans that the Spanish guys had come up with that were then translated into computer instructions for the cutting of the boards, to make the boxes to make the house.

Ben: Maybe you can take us through that process for anyone who hasn't seen the programme or how a similar project might work. What arrives on site and how does it turn into one of these boxes?

Diana: A shipping container came on site and it had a very large cutting machine in it. I don't know what they did to tell it what to do but there was some sort of very high tech procedure to instruct the machine to cut particular shapes of wood out of each sheet of ply. You won't know about cutting fabric for making dresses.

Ben: Oh yes, it's my speciality . . . No! [Diana laughs.]

Diana: What you do is you lay out your pattern so that there's as little waste as possible and that's what happened with these big sheets of plywood. The computer would configure the shapes it wanted to make the best possible use out of each sheet of wood. Then when it had done the cutting it included the number of that shaped piece of wood and then the guys would bash the flat pieces of wood together to make a box. Each box of the same shape has the same number so the machine might be asked to do six boxes of this number for a run of wall pieces or base units that go underneath the house.

The guys would bang them together with a massive mallet and each box had a large hole the size of a saucer in it. After the basis of the house was constructed – the walls and the ceiling and everything – we had the inside of the boxes filled with Warmcel which is shredded insulation. Then we had disks to bash into place to keep that in and then that made a contained box with the insulation in it in situ.

Ben: How many different varieties of boxes were there? Are we talking about quite a small number because these are building blocks really, aren't they?

Diana: They're like huge Lego blocks. I couldn't really tell you. Maybe 40 or 50?

Ben: Okay. So they're all pieced into place and they have their code written on of where they are.

Diana: Yes, yes.

Ben: One aspect that we haven't mentioned is what goes underneath. What's the foundation?

Diana: Here, it's very heavy clay with flints and chalk. There was a house here before. Years ago there were massive Leylandii trees that had been cut down so the house had been hugely extended and at that time the building regulations inspector had insisted that there were foundations strong enough to be Hitler's bunker underneath the house!

So when the house was demolished there was a real mess of virgin soil, lumps of concrete, God knows what. The obvious thing to do was to have screw piles, also because the ground doesn't drain very well. Certainly next door has been flooded. I'm not sure if this place has been flooded but it made sense to lift up the house a couple of feet above the ground level. We've got decking front and back, and it also means the house links with the garden really well. You've got fantastic views front and back.

So we've got the screw piles going in at critical points under the house to provide support. Then there are joists in the shape of I-beams that sit in cradles that are welded on top of each of the screw piles and then when you've got those joists in place, the big boxes sit in between those to make the ground floor. Once you've got your ground floor then you can screw walls on. Then the first floor goes in, another set of walls and then the roof.

Ben: Let me see if I understand this correctly. The foundations are actually a collection of boxes along . . .

Diana: No, you could actually physically go underneath the house and you can see all the screw piles. Each screw pile has got a metal cradle welded onto it. That holds the I-beams in place and then the big boxes fit in between the I-beams.

The whole thing is absolutely critical on measurements. We made a big mistake because when the I-beams arrived, made out of wood,

we didn't store them in a waterproof place so they got a little bit bent by the time they were installed. That meant some adjustment to the cradles to make sure that they sat properly but it worked out okay but it's obviously critical to get the dimensions absolutely spot on so that the boxes will fit in place and will leave enough space for openings around. Everything fits together in a very precise way.

With mortar and masonry it's usually quite forgiving and if you make some mistakes you can correct it later on. With this, it's not like that. It's absolutely precise and pre-planned. Everything has to be dimensionally spot on.

Ben: In terms of the strength of what you've got, how does it get that? Is there anything else there? Because you've got a second floor over part of the building.

Diana: Yes, there's one steel somewhere that supports the upper floor and that's it. There are massive screws that hold the boxes together and big u-shaped pieces made out of plywood that hold the boxes together so that it's very rigid and strong once it's all put together.

Ben: It does amaze me [Ben laughs] to think of such a natural material having that strength but I'm in it now and this has been fantastic to have a little tour around here. So as we get towards the end of the construction process how was it all sealed and rendered?

Diana: We had a bit of a panic during the construction because we had a spell of very wet weather and the wood expanded a bit. By the time Bruce Bell, the designer, had got to designing the first floor boxes he allowed a little bit more tolerance for things like that, otherwise if the design doesn't allow you any scope for shrinkage or expansion you could be in trouble. So the box was up and a sort of waterproof building paper wraps the whole building. In some places we've got strips of cedar that won't ever need any treatment, screwed to that, and then in other places there are boards made out of compressed hamster bedding, sort of shredded something or other. [Diana laughs.] Maybe wood shavings or something like that and these big panels were screwed to the structure and that provided a base for the lime render to go on.

We decided on a fibreglass roof. We were going to have EPDM but we went to one of the building shows and we were seduced by fibreglass which is quite strong so we've got that which is very weatherproof. The windows are pretty airtight so the whole point of the building is that it's very airtight, it's very well insulated so that it keeps the warmth in the house and you've got no draughts.

Ben: Did you ever have a blower door test to check the airtightness?

Diana: Yes, yes. We did. I think this was an experimental house. It was the first time that the builders and designers had worked on something like this and I think in retrospect they could have improved the way the windows were installed. We've got expanding foam around and I think that isn't as done to such a high standard as it could have been. The steel loses a little bit of heat. We did a thermal efficiency test as well as the airtightness test.

I mean it's not too bad. I think it's 4 when the test was done. Does that mean anything to you?

Ben: 4 or 0.4? I don't know. 4. We're going with 4.

Diana: It's pretty good and then we had a little bit of remedial work done at the points where the draughts had been detected. We haven't had it retested but it should've come down from there but compared with our Scottish house where at one point when the wind blew the curtains one room away from the outside would blow, it's fantastic, there are no detectable draughts.

Ben: And your heating system for this, what is a typical heating bill for the year? Have you gone through a good set of readings yet?

Diana: Yes, we've been in two and a quarter years now and we both qualify for the old people's heating allowance which is £200 altogether. We've got photovoltaic panels on the upper roof, we've got solar thermal panels on the lower roof. And for gas, for heating and cooking, electricity and water, by the time you look at the feed-in tariffs and the old people's allowance I think there's about £50 credit coming into the kitty at the end of the year. [Diana laughs.]

Ben: Can't argue with that! So this was very experimental but I must admit it seems as if it's all gone well. I just wondered whether there's anything that perhaps you could offer people who might be trying something else that's experimental?

Diana: Well Celia had done a bit of renovation with a friend on wood houses in North America so both of us knew that wood was a perfectly sensible material to build with and we weren't frightened of it. I think that novices need to do a lot of research before they go into something like this.

I've seen programmes on the television, I've seen articles about using foam blocks with concrete poured into them and I think I'd be a bit worried about that because it appears that sometimes the concrete splits the plastic holding it in place and it spills out. I'd be a bit worried about that but I don't think I could go back to a masonry house after this. I think it's just so out of date and so inefficient, so slow. It's just a no-brainer that in the future I think more and more houses will either be manufactured off site and brought on site, you know, two thirds complete or they'll be like this, they'll be fabricated on site using very high tech materials and techniques.

Ben: It does sound to me as if you don't see this almost as a very different process, which I find is quite interesting because I see it as something that's very innovative but what were the pros and cons of going down this route?

Diana: I mean it is innovative but it's common sense. In Scotland the timber frame that we had for the new end of the house were massive pieces of foam wrapped in foil with a timber structure around them and this is much sturdier than that. You couldn't have curved walls very easily if you have a traditional timber framed house and this did.

On the Grand Designs programme they made a huge palaver about it being innovative and how risky it was but really it didn't feel like that at the time. What's the worse that was going to happen?

Ben: I think that's a good way of looking at it. How cost effective was this compared to some of the other options that you looked into?

Diana: We didn't look at any other options because once we decided on this design the construction came as part of the job lot but the basic wooden structure of the house, excluding the screw piles and levelling of the site and all that sort of stuff but the actual Facit structure cost £70,000. Well £73,000 which I think is comparable with a lot of other house structures. You've obviously got a lot more to do after that but I think that it compares well with cost and particularly if you take into account time. We started the construction in May. We were in by the end of November. We were paying £1000 a month in rent.

The house next door is being built at the moment. This is over a year. If you're paying £1000 a month in rent and you've got to keep taking time out of work to supervise what's going on, all of those costs mount up, which makes a quick build much more efficient and more cost effective.

Ben: Have you recommended this to other people who've been looking into self build?

Diana: Bruce sometimes brings potential clients round here to have a look and his next big project, he's finished recently which is about half a mile away, much fancier than this. This cost us about £300,000 to build. That's cost £1 million to build. [Diana laughs.] It's got a drum room and things like that . . . a pottery room which we've not got. He's done another project in Bedford. He's got others that are in the offing and I think people come and they see that okay it's a new technique but the house feels warm, comfortable, liveable. It's not dangerous and modern!

Ben: How do you see this moving forwards? Is this something that you imagine will be more common because part of that process of just bashing all the boxes together is fairly low skilled, I guess, once it's been programmed?

Diana: I'm quite interested in structural insulated panels, SIPs, because I think they're between timber framing and this. I think that this took a lot of expertise to translate the house into the boxes and into the construction before traditional building techniques took over to finish it off and I'm wondering if SIPs aren't a way ahead, that you can make the panels off site and bring them on site, put the house together very quickly so you've got the advantages of a quick build and very high thermal efficiency but without the amount of very expert input that the construction of this house took.

Ben: As we get to the final couple of questions, are there any other challenges that we should have mentioned in this process?

Diana: The television programme looked at the roof on top of the ground floor which wasn't quite designed with enough slope on it and when the fibreglass roof was put in I think the layers were a bit too thick to encourage water to drain off the roof. So we've been thinking about all sorts of ways of dealing with that because we're not really comfortable about living with a roof with an inch or two of water on it.

Ben: Is there actually any danger of the water being there? What's the situation of that?

Diana: The fibreglass shouldn't deteriorate for, I don't know, 30 or 50 years and there isn't any immediate danger but it just doesn't feel comfortable to be living with a roof with water on top. So what we're

thinking of doing is installing a green roof with a medium for plants to grow in and putting sedum and other low growing plants up there. I'm quite excited about that because I'm a keen gardener. That's our next project.

The other things are going pretty well. The house works very well. If the weather's really warm we've got skylights that lift up that encourage passive stack ventilation and keep the house slightly cooled. If there's any sunshine at all even on very cold days the house stays warm. We've got the wood burner when necessary to top up the temperature in the house but we don't need to use it very often. So the house really works very well for us.

What I particularly like is Bruce's design which isn't necessarily to do with the boxes, that with the house being slightly above the level of the garden front and back, and with large areas of decking, lots of French windows, it's really easy to get outside, to see it, to look at the birds and to feel that you're part of the local environment. I absolutely love living in this house because of that.

Ben: Well, I have to say it's a terrific house and I thank you very much for all the information you've provided today. Thank you, Diana.

Diana: Thank you.