Delivering Passivhaus Performance With Natural Materials

Ian Pritchett Greencore Construction 24th October 2017





Introduction

In the quest to reduce CO₂ emissions and produce "nearly zero-carbon buildings" most designers and builders are focussed on low operational emissions, even if it means emitting more carbon in the construction process

This presentation examines the impact of using natural, cellulose based materials to reduce the embodied carbon *as well as* reducing the operational emissions





Greencore Construction Ltd.

Our Purpose

To give everyone the opportunity to live in low carbon homes.

Our Mission

To scale up the delivery of low carbon homes until they can no longer be ignored by the mainstream housebuilders.

Our Vision

To lead by example to reduce the carbon footprint of housing.





Greencore Construction Ltd.

- Bio-based materials lock up CO₂
- Plants absorb CO₂ and turn it into cellulose
- It takes 1.8kg of CO₂ to make 1kg of cellulose
- The more bio-based materials we incorporate in buildings, the more carbon we lock up
- The construction of an average house produces 50T of CO₂ emissions
- We can build houses with zero emissions





Industrial Hemp

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Natural fibres in cars







Natural fibres in cars







Industrial Hemp







Hemp-Lime







Original Use









Cast-on-site Hemp-Lime







DEFRA – LINK Project (2007-10)

- Hemp-Lime has exceptional thermal performance when it is fully dry (5% to 7% moisture content)
- Getting Hemp-Lime fully dry is much harder than previously thought - it can take several years!
- The solution is pre-dried, factory-made panels





Biond™ Panel Construction



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Thermal Modelling

Ce20





Thermal Modelling

- Hemp-Lime is difficult to model (due to the natural phase change) – it always performs better than expected
- This is a **Positive Performance Gap**
- We have developed innovative modelling tools to help predict the real performance
 - IES with Fourrier Filter (slow and expensive)
 - PHPP with adjusted output (easier, but less accurate)



















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- 0.6 ac/hr
- 27kWhrs/m²/yr
- 13W/m²

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- Audit of the house as built -13,654kgCO₂e or -52kgCO₂e/m² of floor area
- Adding in a typical concrete foundation and slab -1,909kgCO₂e or -7.6kgCO₂e/m² of floor area
- Adding in a brick facing rather than timber/render +7,167kgCO₂e or +28.7kgCO₂e/m² of floor area
- UK average is +500 to 600kgCO₂e/m² of floor area

















- The house was modelled in PHPP
- Predicted heating demand 26kWhrs/m²/a
- Predicted heating load 15W/m²





Real Energy Use (normalized to 12 months)

- Total energy use 9,011kWhrs in 12 months (43.3kWhrs/m²/a) split as:-
- Heating 2590kWhrs (12.5kWhrs/m²/a)
- Hot water, lighting, cooking, dish washer, washing machine, tumble drier and all appliances 6,421kWhrs (30.8kWhrs/m²/a)





Real Energy Use (normalized to 12 months)

- 111kWhrs (10m³) of gas ~£50
- 8,900kWhrs of electricity ~£1,140 (inc. £330 heating)
- 3080kWhrs of electricity generated by the PV's ~-£470
- Net energy cost ~£720/a
- Potential to get this down to ~£600 if you can use all the energy generated by the PV's





Marsh Baldon







Cumnor Hill



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Moulsford







Heritage Skills Centre







Long Stanton Park & Ride













Summary

- We have now been involved with building over 250 hemp houses and around 50 non-domestic buildings
- We have been involved in monitoring around 80 of these buildings
- The natural phase change of the Hemp-Lime gives a positive performance gap.
- Real energy use is about 50% of that predicted by PHPP or 25% to 50% of that predicted by IES





Short-cut to Passivhaus!

- PHPP has to be robust and conservative because it has to cover multiple permutations
- We always use the same building system
 - Good insulation
 - Natural phase change (positive performance gap)
 - Very low thermal bridging
 - Good air-tightness
- We always use the same windows and doors
- We keep the geometry simple
- We use sensible glazing ratios





The 80:20 Rule

- We can get 80% of the performance from 20% of the work (getting the basics right)
- We get the other 20% from the natural phase change of the Hemp-Lime
- Passivhaus performance with only 20% of the effort!
- We are now building at around £1200/m²
 - Includes overheads & profit
 - Excludes design costs
 - Excludes abnormals & infra-structure







Street Elevations 1



Street Elevations 2



Street Elevations 3









Conclusion

- We can build houses with low, or zero-carbon footprints that perform to the Passivhaus standard
- We are scaling up our development activities in Oxfordshire
- We are offering opportunities to landowners and investors who want to leave a legacy of sustainable houses



