

Hempcrete 101

Continued - Q&A with the Presenters

Thank you to all the attendees who asked such engaging and thoughtful questions, over 150 in total! We weren't able to address all of your great questions live on the webinar, so here are our responses to the remaining 100+ inquiries. We look forward to continuing the discussion with you at BuildingEnergy Boston in August. Happy reading! - Alex Sparrow, Tom Rossmassler and Jennifer Martin

Questions are organized by topic:

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Hempcrete Characteristics

1. Building enclosures need to do all of these!

- a. We agree! A building enclosure should offer the following: durability/resilience, low toxicity, fire resistance, ease of installation, naturally deter insects and vermin, have low embodied carbon, offer excellent thermal performance and humidity control, be mold resistant, provide sound attenuation, and come at a low/reasonable cost. Hempcrete ticks all these boxes, with cost being the one downward-trending criteria. As the US develops local supply chains, this cost will lessen over time.

2. What are basic material properties? R value, perms, air permeability, fire resistance etc.?

- a. HEMPCRETE: R-Value - 2+ (Static), Perms - Vapor Permeable (well in excess of 10 but slightly variable depending on the lime-binder mix) , Air permeability - airtight with a lime plaster/render or air tightness membrane which should be at least as vapor open as the hempcrete, Fire resistance - 0 Flame spread, 0 smoke development.

3. What kind of R-value/ inch can be expected from this thermal mass assembly?

- a. A conservative, and widely tested static R value is R-2 per inch. However, that's not the end of the story. Because hempcrete has both insulative and thermal mass properties, the overall thermal performance is better than a static R₂/in insulation value would suggest.

4. Is R2.5-3 considered "high performance" thermal resistance??

- a. It depends on how thick the assembly is. Polyisocyanurate may be a static R7 +/- per inch, but what else is it doing for you, and more importantly, what is it not doing for you? Don't forget that the R value is NOT the full story. Hempcrete far exceeds the performance you'd expect from the R value alone because of the thermal mass present in the material.

5. **With mass in the envelope, I would expect a more noticeable phase shift in the internal temperature?**
 - a. Hempcrete affords pretty much a balance of insulation and thermal mass, so it's the two things working together in the same material that gives a very long phase shift time.
6. **Why not take advantage of hempcrete's physics to allow it to regulate humidity as well as temperature by NOT having watertight finishes, but letting the hempcrete breath?**
 - a. In hempcrete, we do take advantage of the thermal regulation capacity of the material by using air-tight finishes, not vapor-tight ones. The air tight layer is typically addressed by the lime plaster which allows for moisture movement and regulation. In addition to providing an air tightness layer, the external plaster or finish is meant to be a first line of defense to shed the majority of bulk water movement, despite its vapor permeability.
7. **The discussion about being able to quantify thermal insulation properties of hemp is very important. Anecdotal references are not enough for persuading clients to use hemp in high performance buildings. Can we access quantitative information about comprehensive thermal performance?**
 - a. We could not agree more. This was a very simplistic overview of hempcrete, thus the "101". In our next installment we will offer more detail on thermal performance.
8. **Is hempcrete hydrophobic?**
 - a. Hempcrete with a lime plaster should be fairly weather resistant, but certainly not hydrophobic. The whole structure is vapor open, but resistant to liquid water. An UN-rendered block of hempcrete was subjected to standard weather test in the UK - equivalent of 5 years' worth of driven rain in exposed location, sprayed against the block over 72 hrs. The water penetrated 2 and 3/4 inches only. - Note: Exterior plaster is called 'render' in the UK.
9. **Is hempcrete hygroscopic? If so do you have any freeze thaw testing data or mold development testing?**
 - a. Yes, although I think you mean HYGROscopic (absorption of water into the wall). Yes, it passes standard freeze-thaw testing. I don't know about standardized mold development testing, but the lime in the binder naturally inhibits mold growth. As well as absorbing moisture when internal (or external) RH is high, hempcrete easily releases it again when RH drops. This means that there's not a buildup of water / vapor in the assembly.
10. **For reference, in terms of moisture reservoir capacity & openness, is it similar to CMU?**
 - a. This is a much nuanced topic. First, there is porosity which are the spaces between the matrixes of coated hemp hurd which is greater than concrete porosity. Second, there is the capacity of bulk and moisture storage within a material. Third, there is the void or large cavity in the CMU that hempcrete does not have. Fourth, there is the vapor permeability which is greater in hempcrete. To do you question justice, a white paper's worth of data, research and analysis would be most needed.
11. **Are there any published reports/lab results regarding the mechanical, thermal, and hygrothermal properties of Hempcrete? I'm looking for something reliable that can be used for computer modeling purposes.**
 - a. Yes, lots! Inquire with Steve Allin www.hempbuilding.com and consider joining IHBA to access their database of research. Much of the research has been done at University of Bath (UK), and Universite de Rennes (FR) and also at Universite Catholique de Louvain in Belgium if you want to seek publications directly.

12. Has there been testing on indoor air quality?

- a. Yes quite a bit. It's good as you can imagine due to the lack of chemical treatment in hempcrete walls and finishes. Also, the wall is hygroscopic and naturally regulates internal moisture so no mold and viruses / bacteria are inhibited.

13. Relative to odors, are there any off gassing issues?

- a. Hempcrete is natural and non-toxic, so off-gassing is not an issue. This was a follow-up question to the scent of hempcrete, whose scent is predominantly that of lime initially until the materials dries out. Some installers who are familiar with silage from agricultural processes notice that there is a similar scent with the hempcrete when it's wet.

14. Is Hempcrete fire retardant?

- a. Hempcrete is naturally fire-resistant due to the lime which coats each hurd of hemp in a hempcrete mix. Lime doesn't smolder, smoke, or catch fire.

15. Then the interior lime plaster has nothing to do with fire resistance, unlike other insulation such as foams?

- a. Hempcrete is fire resistant in and of itself. A lime plaster is completely fire-proof, being made of lime and sand. Neither material will burn, smolder, spread flames, or smoke.

16. Good sound insulation between walls and floors is a big concern for me. How does it perform?

- a. Really well (and I mean REALLY well)!

17. Acoustics - Hempcrete use in flooring for thermal performance was mentioned; are there studies related to the value of its density for soundproofing? Condos and affordable housing developments tend to marginalize this aspect.

- a. Not in the US I don't think. There has been some sound absorbency testing of hempcrete in Europe. In a UK study, hempcrete met code for sound insulation in a party wall between neighboring properties.

18. Has there been formal testing for STC, OITC or IIC sound ratings?

- a. Not in the US. There has been some sound testing of hempcrete in Europe. One study had a Mean Acoustic Absorption Coefficient of 0.69 NRC for an 11" thick wall but this should be verified. In a UK study, hempcrete met code for sound insulation in a party wall between neighboring properties.

19. Wondering about structural numbers in terms of racking and replacing sheathing Building in is cheaper I'd say.

- a. This is an important (but complex) question which we're going to deal with in the next session at the NESEA conference in August.

20. Does the hemp have tensile properties - to replace steel- as well as working as an aggregate replacement?

- a. Hemp(crete) does not have the tensile properties to replace steel for structural loading. Hemp fibers are incredibly strong. Perhaps someone is doing research on bio composite hemp members whether extruded like plastic or laid up like carbon fiber as a replacement for steel or other structural components.

21. Re. the block, how is reinforcing installed per seismic loads?

- a. Not sure specifically for Just Bio fiber in their specification, but in Europe it's typical for a bedding mortar of M1 classification (cement-based) to be used in seismic zones, instead of the typical lime mortar

22. How much more CO2 does it store than it uses?

- a. In the presentation we shared the net amounts for differing wall types based on a 1,000 sf unit of wall area. This is also roughly equivalent to 1,000 sf of floor area considering the gross and net of wall areas with an average percentage of window and door area removed. Each component in a wall/roof/floor has material that count towards carbon contribution and some with bio based materials (hemp, straw, and sometimes wood) that can contribute towards storage. The net amount is between 7 and 12 lbs./cf.

23. How can the 2x4 double wall all cellulose be lower (Negative carbon) than hemp (cellulose and lime)?

- a. The cellulose double stud wall, while net carbon beneficial is less carbon beneficial than the hempcrete wall. Our calculations showed that the cellulose wall stores 0.2lbs CO₂/sq. ft., whereas the hempcrete wall stores 1.65 lbs. CO₂/sq.ft. You have to understand where the cellulose comes from for each and how credit can be given to the cellulose insulation and all of its sourcing and carbon storing capacity versus the hempcrete which is greater. In each they both have to overcome the embodied carbon loading of the other parts in the wall. Cellulose Insulation over (Siding, Sheathing, vapor barrier(s), drywall, trim, paint) and Hempcrete over (Lime and trim). The framing for both is a bit of a wild card as wood is often harder to calculate its impacts due to (FSC or not, locally sourced but not credited, transport, processing, etc...)

Hempcrete Construction Details

24. What is the standard hemp particle size for use in soil wall mixture?

- a. Not sure that I understand your question, but if you mean what's the standard size for hemp used in an earth-binder mix, the answer depends on your application method. In-situ placing in a form can accommodate hurd sizes from 3/8" to 1", though less variability in that window has advantages. For spray applied hemp, you'll want materials that are somewhat smaller with even less variability in size.

25. Does the material need to be tamped as it is put in the form?

- a. The amount of tamping you give to hempcrete determines the final density. For a wall mix, you'll want to achieve a nice matrix that maintains air pockets between each hemp hurd. You'll compact at the wall surface and around the framing with higher pressure while material in the middle will be tamped to a lesser density. In the ceilings, you're going for the lightest mix possible to achieve a higher R-value per inch. Whereas for floors, you'll compact the material more to make a denser material that can bear more load.

26. How can the hempcrete extend past the framing? How do you attach the plasterboard?

- a. It's best to think of hempcrete as a solid walling material with insulative and thermal mass properties. Because of this, hempcrete can be cast to any width, and performs optimally when it wraps around the framing members. Once dry, it's a solid material that defines the thickness of the wall. Plasterboard can be screwed directly into the hempcrete. For heavier sheet goods or assemblies, you should screw directly into the embedded studs.

27. Yes - the 2x4 in the middle - how do you attach internal and external materials?

- a. Plasters will adhere readily to the hempcrete faces (both exterior and interior) without any additional connections. Other materials will need to be attached to the hempcrete with screws for lightweight materials, or screwed back to the embedded framing for heavier materials and assemblies - for example, a timber clad veneer with a rain screen.

28. Are there any other options for interior except lime plaster, especially for double stud walls? Drywall?

- a. Interiors can include loads of finishes - wood, stone, brick, lime or clay plaster, vapor open sheet goods, etc. Once the hempcrete is dry, you can put any type of finish, including drywall, though we don't recommend it for the following reasons: 1. Drywall is hygroscopic, but doesn't RELEASE the moisture again, so it keeps absorbing moisture until eventually the gypsum will degrade. 2. You're missing out on one of the big benefits of hempcrete, which is its moisture buffering capacity. One place where drywall can be useful is when used in conjunction with a service chase/void. 3. Drywall contains loads of chemicals which you don't want in your house. 4. Gypsum is a very limited resource and gypsum extraction should be phased out. If you were to use drywall think of substitutions or grade changes as in MgO or paperless drywall that retains permeability.

29. Does the lime finish accept color tints or can it be painted?

- a. Yes! Hempcrete can be tinted with a concrete-grade tint. Lime plaster can also be tinted or lime-wash painted with a tinting. Other natural paints are able to be used as well - clay and milk paints for example.

30. Was the multi-color (in the hempcrete wall you showed) added after or done while placing?

- a. The multi-color hempcrete wall we showed had tinting added to the wet hempcrete mix. This created an even color throughout the thickness of the assembly. Alternatively, you can tint the hempcrete with a lime wash or color it with tinted lime or clay plaster.

31. You mentioned vapor permeable air barrier specifically. What about vapor impermeable air barriers?

- a. You need to avoid vapor-impermeable materials in any hempcrete assembly. This is because hempcrete relies on the property of vapor diffusion through an assembly for its thermal performance.

32. Do you apply a vapor barrier?

- a. No. With hempcrete, we look to keep bulk moisture out of the assembly build-up and provide an airtight barrier along the exterior face of the hempcrete (using lime plaster or other airtight membrane), while still allowing vapor transmission through the assembly. Thus, all materials used throughout the assembly, including any membranes, tapes, or sheet goods need to be at least as vapor permeable as the hempcrete.

33. Could you use a liquid applied WRB material?

- a. In a way, yes, but likely not in the way that you are imagining..... The only need for a liquid-applied membrane would be an airtight, vapor-permeable, bulk-wetting protective coating - such as lime or clay plaster!

34. How do you deal with moisture buildup in the timber cladding when applied on top of hempcrete? And how do you ensure air tightness of the envelope?

- a. The exterior face of the hempcrete will need either an airtight membrane OR a base coat of lime plaster. Then, you'll add an airspace/rain screen for the timber cladding.

35. Is vinyl siding sufficiently vapor permeable because of its joints that it could be used over the air barrier without issues of trapping vapor?

- a. Although vinyl siding has periodic penetrations and is not considered airtight, a hempcrete assembly relies on a higher level of vapor permeability than can be achieved by this product if it was installed directly on the hempcrete. It can be installed if a gap is left

between the hempcrete and siding using a combination of air barrier, furring strips, and then the siding.

36. If air barrier is exterior, is there any reason not to leave it raw and exposed inside as a finish?

- a. The primary reasons to plaster the inside face of the hempcrete are for protection - to keep it from getting knocked at the chair rail height, and to keep any dust from coming off the hempcrete face.

37. Can hempcrete be used as an external, over the ground insulator, similar to foam board or roxul?

- a. As Hempcrete is hygroscopic it is best not to be used in direct contact with the ground. The use of a vapor barrier which is a typical sub slab detail anyway would be required as a separation.

38. Do you need to ventilate below roof sheathing?

- a. Great question. As a vapor open assembly it should be vented below the roof sheathing. The hempcrete should have an integrated air barrier (vapor open) in line with the hempcrete thermal boundary.

39. Please comment on use to add R value to foundation and basement walls on exterior in contact with ground and below grade. - do you have to waterproof it?

- a. Hempcrete should not be used below grade as it has a plant aggregate which will soften and degrade if exposed to groundwater in conditions where it doesn't have the ability to dry out.

40. Would you use it to help insulate a basement that has leak issues?

- a. No. Despite the incredible ability of hempcrete to absorb and deabsorb moisture, this would not be appropriate. As with any basement or crawl space you should pursue the standard ways of mitigating the underlying moisture issues. 1) Proper gutters and down spouts removing bulk water away from building, 2) Proper site drainage with the grade sloping away from the building. 3) Sub grade drainage, 4) Basement perimeter drains with sump pumps, 5) Dehumidification, 6) Closed cell spray foam (except at band if timbersill) 7) masonry wall sealant for minor efflorescence. Once the underlying issue has been dealt with then and only then should you finish the basement regardless of the type of insulation or walling.

41. What is the floor finish used over this?

- a. Floors can be earthen, tiled or strapped and covered with wood. Efforts should be made to maintain the ability of the hempcrete to "breathe" -allow vapor transmission through diffusion - at least to the one upper side.

42. Have you done earthen floors over a hempcrete subfloor?

- a. Yes, it works well.

43. I second the question of pouring a floor, in particular a basement floor and maybe with radiant heat?

- a. Best not to use hempcrete below grade as it's a plant aggregate which will soften on prolonged exposure to ground water. Can be used in a vapor open floor build up, but the hempcrete layer is best above external grade. Hempcrete could fit under the lime-sand screed which would contain the radiant heat. You don't want heating IN your insulation layer...

44. I'm interested to know more about using hempcrete / hemplime at grade situations. I understand it cannot be used below grade, but if hempcrete is as durable, moisture resistant, rot proof,

insect proof, etc. can it be used below grade if a waterproofing membrane or material is applied as well?

- a. If a vapor barrier is installed beneath the hempcrete than it can be used at grade. Below grade with robust bulk moisture and vapor controls it is possible but, that said, people don't typically try to build boats out of hemp or concrete for that matter. You will be relying on some other material to prevent moisture movement.

45. I'm curious about weatherproofing details around openings. Is one of the recommended texts a good source for that info?

- a. Yes the construction details in The Hempcrete Book (Stanwix and Sparrow) will tell you everything you need to know.

46. Is that last project sitting on conventional cast in place concrete foundation?

- a. The Hempcrete house in Goshen, MA is set atop a Superior Wall foundation system.

47. Do you suggest to keep these walls 8" above surrounding grades?

- a. Yes. Just as you would with other wall systems you should keep the walls 8" (code) to 12" minimum above grade.

48. What is the impact of moisture content levels during processing?

- a. Just as with any recipe or formula, the moisture content of the ingredients matters. Ideally, your materials sourcing will control for stable moisture of materials within a specified range. If the hemp hurd, for example, already has a high moisture content this will impact the mix - it's as if you've already added water. If you're unaware of this, you could end up with a mix that is too wet.

49. Are the drying challenges and concerns for hempcrete similar or different than that of concrete?

- a. Hempcrete has its own drying considerations. One of the primary considerations when planning a hempcrete build is taking into account for the drying time of the hempcrete assemblies. In an on-site application, hempcrete gets installed wet and dries over time - a good rule of thumb during drying conditions is about 1 week of thickness per inch - meaning that if you have an 8" wall and are able to dry it from both sides, it will take about a month to dry. Hempcrete drying doesn't necessarily mean a delay to the project - it simply means that other work should be scheduled during the drying phase.

50. Probable curing time for hempcrete prior to lime/plaster coatings?

- a. The curing time of hempcrete is variable, depending on the chosen binder mix as well as weather and site conditions. If hempcrete were placed in a wet season, the drying time would be extended. Some steps can be taken to speed drying time - delaying install of windows and doors until the hempcrete has dried, use of fans to enhance airflow, and the use of wood stoves in buildings that have them. The rule of thumb for drying in good conditions is one week per inch of hempcrete. Thus, a 12" wall allowed to dry on both sides would take about 6 weeks to dry. During this time, other construction work can be completed, including interior walls, MEP, flooring and ceiling finishes, roofing, site work, etc. It's also possible to install permanent formwork on one side of a hempcrete. Though this extends the overall drying time (since it's only drying to one side), it means that finishes can be completed on the retained formwork before the hempcrete has finished drying.

51. Approximately how much more water does hempcrete require vs. traditional concrete?

- a. It's best not to compare hempcrete to concrete. Though they are both can be walling materials, they are used in different applications and their properties are very different. Hempcrete needs sufficient water to activate the lime binder in the hempcrete. Typically

water weight of a mix is similar to the lime-binder weight, though it varies based on the binder and the climatic conditions at the time.

52. How would you recommend covering existing joist hangers (galvanized)?

- a. Spray paint, because though galvanized we would call them thinly or lightly galvanized

53. Ah, paint the galvanized hangers then?

- a. Yup!

54. Does hempcrete act as a fire barrier, i.e. around the steel?

- a. Yes.

55. Does the alkalinity of the product have any long term impacts on framing materials or MEP systems that come into contact with hempcrete?

- a. No, the alkaline environment is worse when first cast, as the lime is wet. Steps are always taken to protect ferrous structural elements and fixings from contact with the wet lime (use of HDG nails, stainless straps and galvanized powder coated beams, and primed surfaces is typical).

56. Also, what about expansion / contraction? Can it fill gaps and stay or will it move like wood?

- a. Hempcrete has flexural strength but doesn't expand and contract like wood. It's great for mouse-proof insulated gap filling in old walls!

57. Surprised there are not more curves given how easy it is to cut shape and stucco or plaster.

- a. Yes, hempcrete is capable of conforming to any form, so the limits are truly your imagination!

58. Could you talk a bit more about what the differences are between Hempcrete and any other rigid insulation with low embodied carbon & low GWP?

- a. There really are few other rigid insulation materials that have low embodied carbon. The only things close are straw panels which is more like an entire assembly like hempcrete. Mycelium (mushroom) based foam board is not yet commercially available and is not quite as rigid but R-value research has been done by Evocative in New York State.

Hempcrete Design Considerations

59. Has Hempcrete been used for parking structures or for structural elements in general?

- a. Hempcrete is not a structural material - at least not yet. I do not know whether it has been cast around a frame for a parking structure use. I have seen it spray applied over a steel frame for an apartment buildings 3-4 stories high so it is entirely feasible for the external walls. The load bearing floor systems would still require more robust structural properties than hempcrete can provide.

60. In which climate zones has Hempcrete construction been used? Are some better suited for the material composition / performance than others?

- a. Hempcrete has been used everywhere from peri-equatorial dry/humid zones through maritime climates to colder northern latitudes (Canada / Scotland / Scandinavia. The formulation of the hempcrete material will ideally change to suit the region's climate (i.e. the type of binder used can vary to suit available minerals in the local geology and e.g. favor high mass binders in tropics / peri-equatorial zones where insulation is less important than thermal mass.

61. Does an extremely humid and rainy environment have a particularly negative affect on a hempcrete structure?

- a. No, but a limited amount of buildings have been built in tropical rainforest level of humidity. In theory, the "resting moisture content" of the wall would be higher than normal and over time this could theoretically shorten the lifespan of the hempcrete. More research is needed.

62. Hi! I come from the middle east where is very hot with temperatures up to 50 degrees centigrade. Do you think it is wise to use Hempcrete in such extreme temperatures? We also use HVAC, so will hempcrete be compatible with the effects of HVAC?

- a. Yes to both, although consider developing a higher mass binder e.g. earth-lime binder. That way you maximize the thermal mass over the insulation. Yes, it works fine with HVAC systems.

63. Would it be advisable to not think of Hempcrete as a variant of fiber-reinforced concrete since it's not intended for structural applications?

- a. Correct. It's best to think of hempcrete as a novel material. Though it has some similarities to concrete in how it can be placed into a formwork, and it shares the suffix 'crete' in common with concrete, this material is altogether different. Hempcrete is an insulation and walling material. Made of a plant aggregate and lime-based binder, hempcrete has vapor-permeable characteristics and stores carbon absorbed from the atmosphere.

64. Can you speak to any commercial applications of hempcrete? How can designers make a case for hemp over traditional concrete?

- a. It's been used extensively for commercial projects (industrial, retail, office buildings, scale housing developments etc.). It isn't a comparable material to concrete though - they are very different materials in composition / performance characteristics / cost & sustainability!

65. Are there many non-residential installations?

- a. Yes - a lot in Europe but not in the US at this stage.

66. Is hempcrete more expensive than concrete? What are the barriers for using it in the US?

- a. Hempcrete is not used in place of concrete so it is not appropriate for cost comparison. Typical use for hempcrete is in walls, above grade floors, and ceilings as an insulative walling material. At this point, barriers to use of hempcrete are due to it being a novel material in the US, though that is changing rapidly.

67. Why has Hempcrete not been used on commercial projects in the US?

- a. Hempcrete is still new to the US - while there are hundreds of buildings ranging in size from small cabins to large homes, no one has *yet* built a large commercial building in the US, though this is sure to change soon. There have been plenty of commercial hempcrete projects in Europe.

68. Has there been any testing / modeling of using Hempcrete as a trombe wall?

- a. Hempcrete isn't a high thermal mass assembly, so it's unlikely to be used in this application. However, hempcrete can be tinted black for use in regions/structures where absorbing additional heat onto the wall face would be beneficial, and binders could be adapted to increase the thermal mass.

69. Is Hempcrete compatible with the Passive House standards, in terms of the envelope air and vapor tightness requirements? Any built example you can share?

- a. Hempcrete houses can meet Passivhaus specs for airtightness, but that's more dependent on good detailing and careful construction than the material itself. I don't know anything about passivehaus vapor requirements, but to make a hempcrete building meet PH

requirements for INSULATION is quite hard and involves massively OVER-specifying the hempcrete or adding extra insulation. A hempcrete wall at 12-16 inches (R24-32) is already PERFORMING like passivehaus due to the extra performance brought by the thermal mass but this needs to be proven out by truing up energy models to reflect the real world (utility bills) performance.

Hempcrete General Questions

70. What does the end of life disposal look like for hempcrete? How does that impact life cycle carbon?

- a. At a buildings end of life, hempcrete can be composted. Some early tests have reused hempcrete in new hempcrete formulations, to test hempcrete a cradle to cradle material without additional processing. Without referencing specific research, there is carbon released in the firing of lime, which is partly or largely reabsorbed as the hempcrete sets (depending on the type of lime-binder used). The hemp captures and stores carbon until the material decomposes. So, at the end of life, in a situation where the hempcrete is composted, carbon from hemp is released, while the carbon from the lime burning and subsequent curing was long ago captured when the lime-binder set.

71. Can you say more about the quality and supply limitations in the US and why that is?

- a. Fundamentally, this is a product of simply being a nascent industry. Supply chain processes on both the hemp and binder sides are extensive, expensive, and take time to develop. In the US, there is a sudden flood of interest in growing hemp, but not all hemp is designed to be turned into hemp hurds for building stock. US farmers have a variety of strains and end products to choose from and must decide between growing for fiber (and hemp hurd for building) and compare that market with the CBD/THC flower markets. Their considerations must consider what will come of their crop. In the case of industrial hemp, it takes a decortication machine - a specialized piece of equipment that separates the fibers from the stalk - to turn a crop into cash. At this time, few such operations exist. From there, the hurd must be further refined to become viable hemp material for use in building. Too much dust, fines, or fiber will be problematic - and potentially catastrophic - in a building. Meanwhile, the bushy flower plants can't be processed for hemp hurd in a decorticator, though developments may be underway to change this. However, the CBD market proved risky for farmers in 2019, so some farmers have been turned off hemp for now. On the binder side, there is a ton of research still needing to be done to create US binders that perform as well or better than those being imported from Europe. In the meantime, folks who want to build with hempcrete are largely importing their materials from Europe while trying to bolster the industry state-side however they can. The USHBA membership is working hard to produce hempcrete at home.

72. Can hemp grown for soil remediation be used for hempcrete as an environmentally safe use?

- a. This is a great question, and one that we don't have an answer for. It's possible that these studies have been done, although I am unfamiliar with them. Inquire with Steve Allin www.hempbuilding.com

73. As R&D on hempcrete continues to progress, could this material possibly be used to make siding? I'm specifically thinking as a substitute for fiber cement siding?

- a. There is a hemp-plastic siding that has been developed and prototyped in the UK - by Margent Farm. Bio-plastics have had issues with degradation by UV light but this may be solvable.

74. Is there a reason the US can't use the research from Europe? Is this just a way for U.S. regulating agencies to make \$?

- a. At this point, building inspectors are the primary determinant of which research will be accepted - or not. Some officials accept foreign standards, while others do not. Our advice is to make it easy for inspectors to understand the research - including metric conversions and by providing details of the standard specifications that are being met elsewhere. You basically want to paint a clear picture of how this material WOULD meet our US certifications had testing already been done here in the US. Further, testing in Canada is sometimes looked upon more favorably due to geographic proximity on the same continent (rightly or wrongly), so referencing Canadian standards can prove useful.

75. Is hempcrete used in making ICF's? I seem to remember that it didn't take off...

- a. Not as infill inside ICF's as ICF's get their structural strength from concrete and hempcrete is not structural. If you are referring to ICF-like blocks made from hempcrete there are none. I have seen videos of others making what looks like a hempcrete CMU and others have combinations of wood chips and other cellulosic material combined usually with cement or one with 85% recycled expanded polystyrene (Styrofoam) and 15% cement (RASTRA). If you remember what it is or was let us know!

76. Can hempcrete be 3d printed?

- a. Allegedly. Or at least lots of people are looking into it... We have heard an MIT materials lab project along these lines.

77. Is the hemp-plastic inside the hemp block biodegradable as well?

- a. Please contact Just Bio fiber, who can address your question directly.
<https://justbiofiber.com/>

78. I can't find where you are located, are you in the US? If what you say is correct regarding CBD vs fiber hurd, then I have a lot of hemp for you!

- a. HempStone is located in Western Massachusetts. At this time, CBD processing is still in the research phase of development, but please stay connected to us to keep abreast of developments.

79. What kind of historical info on how hempcrete ages?

- a. Europe has hempcrete buildings that have been around for 30+ years, with no reported issues. Hempcrete was developed to replace wattle and daub, which was used successfully for centuries.

80. Will you be able to address where ACI is with respect to Hempcrete?

- a. Assuming you are referring to the American Concrete Institute and not the former Affordable Comfort Inc. (now the Building Performance Association). The ACI has had only a handful of publications and white papers regarding Hempcrete over the past decade. Typically these papers are authored by folks overseas and either explore the use of hemp as a bio based aggregate alternative or the use of lime as a cementitious binder alternative or additive. In at least one case that I know of, there's an exploration of true hempcrete without a Portland cement component. Hempcrete was on the agenda for an ACI conference in Singapore last year.

Hempcrete and Regulatory Bodies

81. Is this regulated in building codes in any way, or is it too new?

- a. Hempcrete is not yet included directly in the International Building Code the way straw bale is. The US Hemp Building Association is working hard to get this material certified and included, though this will take time. Meanwhile, you can use the Alternative Compliance Path of the IECC (R102) to pursue an alternative compliance path with the local building inspector.

82. Can you address the code compliance issues (if any) that you've come up against in the US?

- a. We've used the Alternative Compliance Path of the IBC/IECC to get hempcrete buildings approved. Building officials will dictate the ease of using this method in your area. We've had an easy go of it in Western Massachusetts and Vermont, but have heard of areas in Eastern MA where building inspectors want specific documentation that is simply not available yet in the US. The best advice we can give is to be proactive with your building inspector - engage them early, answer their questions and share international case studies, research and certifications. It might mean going the extra mile in the beginning, but before long there will be enough US buildings that this material will no longer be seen as unfamiliar.

Hempcrete Costs

83. Are there any studies out there comparing performance of hempcrete vs straw bale?

- a. Yes, this has been done for cost and carbon. One North America reference to pursue is Chris Magwood from the Endeavour Centre in Petersborough, Canada.

84. Will you please talk about cost comparisons to traditional materials and how you see that changing as domestic decortication ramps up?

- a. Currently, roughly 40% of the cost of hemp hurd from overseas is shipping cost. Current domestic hemp growth and production is limited and has not yet achieved any economies of scale and therefore domestic costs are not any better right now, even for large quantities. Once the industry ramps up, North American costs will decrease below the imported costs which will help. In addition, development of domestic binder formulations will decrease costs for those still using binder material from overseas. As the infrastructure ramps up and innovations are made in installation techniques (block, panel, spray application) costs will continue to decrease relative to traditional materials. If the US can ever get its derriere in gear with carbon credits for carbon storing materials, then this would further tilt the equation for bio-based building materials like hempcrete.

85. What should pricing for a complete hempcrete mix be in current market for an American producer? Vs foreign producers?

- a. Costs for installation depend on material sourcing, job spec, job size, job location, installation methodology (cast in place, panelized, block, spray applied). Not sure if you are asking about material cost or installed cost. Due to the regional variations in material cost and labor, we recommend you reach out to a hempcrete consultant or installer through the US Hemp building Association to get more detailed costing.

86. For the costs and carbon slide, it would be good to have a price/square foot value. Hard to compare when hempcrete is 2x4 and typical assemblies are 2x6-2x4.

- a. The subtotal cost has assumptions not shown regarding the costs for their respective framing, be it 2x6, double 2x4, or single 2x4. These are in cost per SF of wall area, as in \$3.00 per SF or framed wall for example. Since all of the specs were based on 1,000 sf of conditioned floor area as well as a roughly corresponding 1,000 sf of gross wall area the numbers roughly translate.

87. Does the consistency of hempcrete require further construction labor costs than a pour concrete would?

- a. Concrete consistency on the "pour" is easier since it can flow and also be pumped to where you want it. Vibrating and floating and dressing concrete is has specific labor associated and costs. Depending on the project the labor rates may be affected by prevailing wage rates which is less likely for Hempcrete which would not be an approved subgrade. The labor to install hempcrete requires mixing (at scale) that is embedded in the cost of calling up the concrete truck. The labor for casting hempcrete in place is mainly low tech except for a foreman and technician good at mixing and people good with forms work. The forms for concrete are more commercially available and extensive. The forms and forming for hempcrete is usually more involved and adhoc, but cheaper as they are often fabricated on site. There are some commercially available forms which are good for hempcrete, and can be worth the investment when building at scale.

88. Not sure if Tom's response was intended to answer my question about cost of hempcrete compared to other materials, but would be good to get an estimate on the current cost premium of hempcrete now vs alternatives.

- a. There is a premium to install hempcrete from an overall cost standpoint. You mention compared to other alternative materials. Unsure if you are asking about installed cost differentials or material costs. For Walls, Floor and roof material cost will differ due to the use of more and less lime or binder equivalency in each respectively.

Questions about 'Hemp' in hempcrete

89. What is required to process CBD hemp for use?

- a. Good Question! Folks are still in the process of truly figuring that out. One of the challenges with a CBD plant is that decortication equipment, intended for the straight and long industrial hemp plant, is not equipped to transition easily to a bushy stalk. These bushy stalks are robust - with fibers running the length of each branch. HempStone has conducted some small-scale tests which are not practical to replicate at scale. I'd suggest inquiring further with academic institutions - University of Vermont, Oregon State University, and others that may be investigating this further. The states I mentioned have both a strong agricultural foundation in academia, and CBD farming in their state.

90. Is hemp available in Massachusetts in a quantity required for this?

- a. As of June 2020 HempStone does have a supply of hemp hurd in stock in MA/VT but only enough for three small houses or two average US sized houses. Presently, most hemp for construction is being imported from Europe, where there has been a vibrant and robust hempcrete industry for decades. Several US hemp processing facilities have come online, and US farmers are now growing industrial hemp throughout the country. In Massachusetts, farmers have tended to explore CBD and THC flower strains in lieu of

industrial hemp, but we expect this to shift as the markets and processing centers become more established.

91. Which seed strain is best to obtain the thick woody hemp plant?

- a. I do not know enough about seed varieties to provide an answer though in the Northeast a lot of research on growing all types of hemp including industrial hemp has been done by Heather Darby and the folks at the University of Vermont.

92. Is there a simple way to process the woody core besides the big expense of typical expensive processing facility?

- a. Unfortunately, not at scale. The woody core of the hemp plant is surrounded by a fibrous mass of hemp that runs the length of the plant. These fibers are some of the most robust that nature makes, and they can wreak havoc on processing equipment. A decorticator is a piece of mechanical equipment that separates the fiber from the stalk, creating two viable products. At a very small scale, HempStone has had some success with chopping CBD stalks to test this hurd for viability. During this process, we used a Vermeer 6" chipper shredder. We didn't have trouble with the machine getting wrapped in fibers, but we did have to follow up the mechanical chopping with a ton of additional processing. The entire process was ten steps, took over 8 hours, and only yielded enough material for 5 cubic feet of material. While more research can certainly be done, when working at the scale needed to build structures, we need processing facilities that can handle tons of material at once and process it cleanly.

93. Curious about sourcing the hurd for cast in place application. Thank you

- a. There are several hemp hurd sources for building material in the US. If you're building in New England, let HempStone be your source for materials. If you're outside of our region, please refer to the US Hemp Building Association for suppliers in your area. ushba.org

Lime' in Hempcrete

94. Compare using the local lime/hemp products to the European products commercially available.

- a. This is a complex question, as there are variations of lime, and thus lime-based mixes, around the world. For example, in the US there are no naturally occurring hydraulic lime sources. In Europe, natural hydraulic cement is a common binder used in hempcrete. The work for lime manufacturers in North America is to develop US based lime-binder mixes that perform as well, or better, than those imported from across the Atlantic Ocean.

95. What are the pozzolans that can be used with hydrated limes available here in the states? There was a discussion between Alex, Steve Allen and a few others on the Facebook International Hempcrete Building group on this topic and the potential for hydrated lime binders to not "set" completely through the wall.

- a. Available US natural pozzolans include metakaolin along the East, and pumice in the West, and there are likely others being tested regionally that we're not yet aware of. Other widely available pozzolans include brick dust, fly ash, blast furnace slag, and other industrial waste minerals. The Int'l Hemp Builders Forum on Facebook is a great resource to find out more about pozzolans being utilized in your region.

96. Is there a formula available for the lime binder? Shipping the Pre-mixed binder to WA has been cost prohibitive. We do have access to hydrated lime. I've tried a few times and never have been able to get it right.

- a. While there are some rules of thumb for binder mixes, the variability of lime around the world - due to local geologic and climate conditions - creates a nearly endless level of diversity in lime. For example, the dolomitic lime that is so common in North America is virtually unheard of in Europe. The Natural Cements that constitute lime binders from France are limited to that region. Lime binders are steeped in chemistry, with additional elements mixed in the lime giving the lime binder different properties. To do lime variation justice would take a team of experts and a lot more time than I have here! In Europe, hempcrete is well established, with binder companies offering several proprietary blends. In the US, the industry is much younger, and state-side proprietary blends are much less common. If you are committed to using a local lime binder, then we recommend that you partner with a university and set aside time to develop a binder that performs in a variety of test processes.

Alternative Materials

- 97. Wow, someone else asked the Knotweed question! I can tell you it does not have as much fiber as hemp, but we have a pretty unlimited amount of it here in NJ as well. I was thinking the same thing though.**
 - a. HempStone is planning to do research on Japanese knotweed as an invasive, local alternative to hemp. However, the stalks are largely hollow, so it takes loads more material to make a building assembly out of than hemp. Stay connected to us this Fall/Winter to learn more!
- 98. Also, I try to source local waste materials here in New Jersey so are there any forestry, farm or other bio waste streams to tap into for smaller quantities since I guess a single house or heated garage will not use more than 10-20 cubic yards of such fiber material?**
 - a. You'd be surprised at how much hemp goes into a house or a garage, as the hemp makes up the majority of the mix. In a standard 2 car garage, you'd need 384 cu feet (25 cubic yards) of hempcrete for a 6 inch wall. For a wall mix, this totals 20 cubic yards of hemp, which is at the upper end of your calculation. Adding hempcrete to the floors and ceiling add to that calculation significantly, depending on your design. A house will tend be bigger, and the walls will vernally be thicker than 6". Even if you stayed with a small footprint, say 900 square feet, you'd need 960 cubic feet (35.5 cubic yards) of hempcrete just for the walls!
- 99. What are the carbon sequester effects of substitute-materials like sugar cane? Similar, less?**
 - a. There have been some studies I have heard referenced from Europe that have explored and compared differing aggregates. Data not readily available.
- 100. Please compare and contrast with adobe straw bale concrete and lightweight concrete.**
 - a. Assuming you meant adobe vs. straw bale vs. concrete vs. lightweight concrete. There is a lot here so oversimplifying for sake of brevity. Adobe and straw bale are self-supporting as concrete can be whereas while hempcrete can support its own weight, hempcrete buildings require a structural frame to pick up the loads. In general there are varying degrees of performance characteristics between all of these and it also depends on design and location and siting considerations. Adobe and concrete have high mass and thermal storage whereas hempcrete has medium mass and some thermal storage and straw bale less so. As density is usually inverse to insulative value Adobe and concrete tend to be less insulative for the same thickness of material and straw bale is closer in performance to hempcrete in

terms of strict insulation value. In terms of carbon capture and storage concrete is pretty offensive, lightweight concrete less but still carbon intensive, adobe has some straw in it and is typically locally made and not shipped far and so low impact but unsure of the specifics, and straw and hempcrete both store more carbon than it takes to grow, extract, process, and transport and install.

101. Any native UK plants that can be used as bio aggregates for this purpose instead of hemp?

- a. I don't know about native plants - but you could use any waste agricultural stalk, like rapeseed or other invasive like elephant grass. However, hemp has more woody structure and is optimal for use as a walling and insulation material.

102. What are examples of earth binders?

- a. Clay or lime-stabilized clay work best. More research is needed though on these traditional technologies.

103. Please address the lime, water, hemp proportions in the soil type compacted mixtures.

- a. I don't understand the question, but if you mean earth binders.... you replace the lime binder with a clay / clay-lime binder. You may need some sand and/or lime mixed into the clay to stabilize it against shrinkage. You'll need to experiment with your local materials.