Objective:
The purpose of this report is to reflect on hempcrete and its possibilities as a design material after a led workshop by the SOA Materials lab. Participants were tasked to first build a formwork suitable for hempcrete and finally cast hempcrete in it. The following is a description of hempcrete as a material, its casting method used during the workshop and potential future studies.

Material:
Hempcrete is a lower-carbon alternative to cast-in-place concrete and other materials. It is typically used as in-fill and insulation within a structural frame. The main ingredients of hempcrete are hemp hurd (taken from the woody core of a non-psychoactive form of Cannabis sativa), binder (typically natural cement, lime, or Portland cement), and water. Ratios are adjusted in response to project requirements. Hemp has been harvested for thousands of years, with diverse uses including fiber for textiles and rope, cellulose for paper and non-petroleum plastics, and seeds and oil for food. As a rapidly renewable crop, it is carbon negative or neutral (depending on end use) and is a hardy plant that grows well without insecticides or pesticides. In the US, the cultivation of industrial hemp was banned between 1938 and late 2018, when the 2018 Farm Bill declassified it as a controlled substance. As such, it is a newly re-emerging resource.

Binders are cementitious products stemming from quicklime, a by-product of burnt limestone that is grounded to a fine powder. The production of different binders is described below:
- Lime binders are the least carbon-intensive, especially when sourced locally. Hydrated lime is formed through the misting of quicklime. Hydraulic lime contains silica compounds embedded in the lime after burning and “set” through the addition of water. Non-hydraulic, or pure lime, sets through the absorption of CO2 from the air, extending its curing process but reducing its overall carbon footprint.
- Natural cement is created from clayey marl, a type of limestone that is mined and heated at 2200°F with no additives. Due to the fusing of alumina compounds with the quicklime formed from heating, natural cement can be used as an additive to lime for its early compressive strength, low permeability, shrinkage, and quick setting time.
- Portland Cement attempts to replicate the composition of natural marls. Its manufacturing involves heating limestone and clay materials in a kiln at 2640°F, and contributes to approximately 10% of global CO2 emissions.

Sourcing:
(N oz) Hemp hurd
Hempitecture
American Hemp

(1.5*N oz) Natural cement binder
- Lime-Based
  - Limeworks
  - Ecowise
- Natural Cement
  - Hempitecture
  - Home Depot
- Hydraulic Lime
- Portland Cement

Hempcrete Casting Methodology Report Fall 2020
Material List and Preparation:

(N oz) Hemp hurd
(1.5*N oz) Natural cement binder
(1.5*N oz) Water
(1) Disposable Gloves
(1) Disposable Dust Mask
(1) Safety Goggles
(1) Casting Mold
(1) Mixing Vessel
(1) Kitchen scale

Formwork:
Formwork can be made of many materials, including wood, cardboard, foam, and plastic. These should be assembled in a way to facilitate demolding that doesn't affect the casted object.

Insertions guidelines:
Rather than creating a solid rectangular volume, we'll be using found objects as insertions to create a subtractive form. Each found object should be securely placed. The final outcome may take the form of a functional vessel, or an abstract sculpture. Tips to keep in mind when selecting inserts: select rigid objects that will keep their shape upon compaction of the hempcrete, which will be tightly tamped into place; use conic and tapered geometry, which will be easier to remove; fill less rigid objects with water to maintain their shape. Examples include used bottles and food containers, scraps of wood and foam, etc. Depending on their placement, inserts may be attached to the perimeters of the box before casting, or inserted after casting has begun. Inserts should be placed with a minimum of 1" allowance from the perimeters and other objects.

Instructions:

Hempcrete Casting:
With the formwork prepared, it is time to cast some hempcrete! Determine the amount needed of each component following mix ratio 1 : 1.5 : 1.5 of hemp: binder: water, by weight. Instructions for manual mixing are as follows:

1. Add hemp to mixing vessel. Spread evenly.
2. Add binder slowly, folding and dry mixing it into the hemp by hand. This should take 1-2 minutes.
3. Once mixed uniformly, slowly add about 75-80% of water volume. Continue mixing for 2 to 4 minutes.
4. Add remaining water slowly and deliberately. Continue mixing for 1 minute. The mix should be consistent and feel like damp wood chips flowing freely. If mix is in big chunks, you may need to break these up manually.
5. Once the mix is ready, begin casting hempcrete in layers. Scoop hempcrete into the casting chamber with your hands, and tamp with your fingers or a blunt tool. Compaction is key. Use your fingers to work the hempcrete, especially around edges, corners, and insertions. Work one layer at a time, in 1" - 2" layers.

Formwork removal:
Although the formwork can be removed immediately, we recommend waiting ~20 minutes after casting to avoid damage and crumbling. To remove formwork, start with the exterior mold, then remove all insertions slowly.

Drying / Curing Tips:
1. Hempcrete cures at the rate of ~1" per week from the exterior surface moving inwards.
2. Keep out of direct sunlight.
3. Optional: Moisten surface with a fine mist a couple times daily to avoid cracking.

Challenges and further investigations:
1. A method for quantifying drying progress and compaction while casting is needed to ensure consistency.
2. Consideration for drying process is required.
3. Which binder is ultimately stronger once cured, lime or natural cement?
4. Post milling/cutting of hempcrete and internal reinforcing has not been tested.
5. CO2 absorption and its impact on hempcrete's drying process.