UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into a Cob and Straw building for the proposed UBC Farm centre

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Abstract

The following report investigates the viability of using cob and straw as the primary building materials for the new proposed UBC Farm Centre building. The new building is to be used for learning activities, community programs, and other similar activities. The location of the new centre is constrained to the current proposed location at the UBC Farm.

In order to assess the viability, a triple bottom line analysis approach is used. This report is a meta-analysis of scientific data and case studies of previous cob and straw buildings. The environmental analysis reveals that embodied carbon from cob and straw is an order of magnitude less than traditional cement blocks. The economic analysis uses a case study to demonstrate the potential cost savings of using cob and straw as a primary building material over cement. The social aspect analysis finds the using of sustainable building material will have a net positive social benefit for the UBC community.

The final recommendation is to use cob and straw as the primary building material for the proposed UBC Farm centre.

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Glossary

Cob	Building material made from clay, sand, straw, dirt and water.
Embodied Carbon	Amount of carbon equivalent released into the atmosphere by the time you receive the product/material.
Straw	By-product of cereal plants.
UBC	University of British Columbia. A world class university located in Vancouver, Canada.

1.0 Introduction

The University of British Columbia's Farm is 24 hectare farm that is managed by UBC's Center for Sustainable Food Systems. As a center for learning and research, the UBC farm is at the forefront of the university as a living laboratory. Through the Campus as a Living Lab program, the UBC farm is home to many research projects as well as community involvement programs.

To help with increased usage of the farm, the UBC Farm is considering options for building a new farm building, of which one of them is using cob and straw. As a natural resource, cob and straw bale to construct buildings is both an economical and environmental friendly way to build. However, because not much is known about cob and straw bale, there are many mysteries behind whether or not this building option is viable.

In this report, we will evaluate the environmental, social, and economic impacts of using cob and straw bale to build the new farm building. Using the triple-bottom line analysis, a recommendation will be made at the end of the report as to whether or not cob and straw bale is a viable building option.

2.0 Environmental Impact

The environmental impact of the potential cob and straw building is compared to traditional building materials by using the amount of CO_2 equivalent greenhouse gasses released. The comparison will be made for the total expected amount to be released over the entire lifetime of the farm building. Other environmental impacts, such as potential damage to ecosystems are also being taken into consideration.

The factors that will be included in the lifetime CO_2 equivalent release are the embodied carbon, the construction, as well the lifetime insulation variances. In addition, we will consider end of lifetime building removal, and the CO_2 equivalent impact of the removal of the farm building.

2.1 Embodied Carbon

Embodied carbon is the carbon that is released due to the extraction and preparation of a material. The future farm building will require significant amount of building material which will contribute to the environmental impact. The embodied carbon of Cob, Straw Bale and Concrete blocks has been complied in the following table.

	Embodied Carbon kgCO_2/Tonne
Concrete blocks	143
Cob (Earth Bricks)	22
Straw Bale	10

Table 1. Embodied Carbon of Building Materials. Data citations are located in the bibliography.

Concrete blocks have the highest embodied carbon of the building materials being considered in this report. It is an embodied carbon that is an order of magnitude greater than either cob or straw bale. It is still the most commonly used material for modern buildings.

Cob as a building material is environmentally positive in terms of embodied carbon. Cob has significantly lower embodied carbon than concrete blocks, as shown in table X. Since the constituent materials of cob can be locally sourced and do not need to be processed, it is able to have a low embodied carbon value.

Straw bale has an even lower embodied carbon value than either cob or concrete. Along with a significantly lower density than either of the other two materials, it is a clear frontrunner for the lowest embodied carbon.

2.2 Insulation and Thermal

Straw bale has thermal conductivity value that is much less than traditional portland cement or even cob as shown in table 2. This intrinsic feature of straw bale keeps the thermal energy from the interior from escaping to the environment. Additionally, this feature also keeps thermal energy from entering the building when the environmental temperature exceeds the desired internal temperature of the building.

	Specific Heat Capacity $J\ kg^{-1}\ K^{-1}$	Density $kg\ m^{-3}$	Thermal Conductivity, $W\ m^{-1}\ K^{-1}$
Portland Cement	750	2320	0.29
Cob	800	1450	0.45
Straw Bale	600	60	0.067

Table 2. Insulation properties of Building Materials. See bibliography for citations.

The density of straw bale is significantly smaller than the density of either portland cement or cob. Straw bale does not work for thermal energy storage. However, since the building is not to be used for overnight purposes, the volumetric heat capacity is not relevant.

2.3 Ecosystem Impacts

The local ecosystem for the farm building is an important aspect for the environmental considerations. This analysis does not consider the effects of CO_2 equivalent gas release, but rather the effects the building materials could have on the local ecosystem.

Cement poses a potential problem for the farms ecosystem in the form of cement dust. Cement dust is a potential threat to the ecosystem of the farm in terms of "vegetation injury, crop yield losses" (Iqbal, 2000, p.1). This effect is not desired for a building that will be contracted near a farm; where crop yields are considered valuable.

2.4 Environmental Conclusion

Cob and Straw has a clear advantage over traditional cement in terms of the environmental impact. It is an order of magnitude better in embodied carbon released, and it does not cause harm to the local farm ecosystem. Environmentally, Cob and Straw should be the material of choice.

3.0 Economic Impact of Cob and Straw

This section will review, analyze, compare and contrast the economic impact of using Cob and Straw Bale versus traditional building methods (cement and concrete) to build the new UBC farm building. This section will begin with a case study to give a cost break down of building with straw bale versus concrete buildings, followed by maintenance, and then procurement of cob and straw bale.

3.1 Production

In a case study conducted by Garas G, Allam M. and El Dessuky R, two buildings with the dimensions of 3 meters wide * 3 meters wide * 3 meters in height were used as test parameters. Where one built using traditional method, using walls made of cement bricks with the roof and foundations made using reinforced concrete; while the straw bale unit were made with straw bale walls, wooden beams and plywood as the roof and concrete for foundations.

From table 3.0, the cost of using straw bale to build is cheaper than using the traditional methods (with cement and bricks). Even though this case study was performed in Egypt, this cost can be used to reflect Canadian costs because the amount of hours spent on building the straw bale unit versus the cement brick unit is proportional. Also, the costs of materials are relatively similar internationally in the global economy.

3.1.1 Procurement of Materials

One of the major reasons why cob and straw bale is an economic way of building a building is because of the fact that the materials to make cob and straw bale is abundant everywhere. This means that transporting the materials over long distances is not necessary, which saves in transportation costs. In addition, buying locally sourced materials to make cob and straw bale is beneficial to the local economy.

Here are some suppliers in Canada that sells clay (which is the main ingredient of cob)and straw bale:

Straw Bales	http://www.vanderveenhay.com/Prices.html
Cob	http://www.greenbarn.com/

Because there is not a solid architectural design for the new farm building, the exact price (which can be hassled down further from these big suppliers), cannot be determined.

3.1.2 Economic disadvantage of Cob and Straw buildings

With respect to cob, a lot of manual labour is needed to mix the cob and also bound the straw bale together. Currently because of the low demand of cob and straw bale, there does not seem to be any company that delivers cob and straw bales in the state where they can be used for building.

Type of Building	Material	Quantity	Component	Total Cost
Cement Brick Unit	Bricks			
		1000	Cement Bricks	320 EGP
			Labour and Handling	100 EGP
		5 Sacks	Cement	120 EGP
		$1.0m^3$	Sand	30 EGP
			570 EGP/1000bricks	
			Total Cost:	70 EGP/m^2
Cement Brick Unit	Reinforced Concrete			
		100 kg	Steel reinforcement	767 EGP
		7 sacks	Cement	168 EGP
		$0.4m^3$	Sand	15 EGP
		$0.8\ m^3$	Course Aggregate	55 EGP
			Labour	140 EGP
			Total Cost:	1145 EGP/m^3
Strawbale Unit	Plain Concrete	5 Sacks	Cement	120 EGP
		$0.4\ m^3$	Sand	15 EGP
		$0.8\ m^3$	Course Aggregate	55 EGP
			Labour	100 EGP
			Total Cost:	290 EGP/m^3
Strawbale Unit	Strawbale			
		Compression and transportation		8 EPG/bale
Strawbale Unit	Steel mesh		Steel Mesh	4 EGP/m^2
			Labour	2 EGP
			Total Cost:	8 EGP/m^2
Strawbale Unit	Timber Roofing			
		0.065m*0.1m	Wooden Main Beams	700 EGP/m
		0.065m*0.1m	Wooden Cross Beams	250 EGP/m
		4*1.2m*2.44m	Plywood	360 EGP
			Labour	300 EGP
		Total Cost for the Cement Brick Unit		881 EGP/m^2
		Total Cost for the Straw Bale Unit		535 EGP/m^2

Table 3. On this table, we can see the cost breakdown of building a cement brick unit versus a straw bale unit. Note: as of April 1st, $1 Egyptian Pound (EGP) is approximately $0.15 Canadian. This chart was created from the data from Garas et el, "Straw Bale Construction and an Economic Environmental Building Alternative – A Case Study".

In other words, the materials for building would need to be made before the building can occur. For example, cob is made using a "mixture of clay subsoil, aggregate, straw, and water"

(Weisman), which requires attention as to the quality of the cob to ensure a sturdy structure. Compared to materials such as cement and concrete, where it is readily available, a significant amount of labour would be needed to produce these materials for cob and straw bale.

3.2 Maintenance

From the previous sections; we can see that cob and straw bale are better insulators than many of the other traditional building materials. In the long run, with better insulation, the energy costs of a cob and straw bale building is less than the building with the traditional materials.

With respect to durability, cob and straw bale buildings have been around for centuries. Many buildings in Europe such as the building in figure 3.1 is said to have been around for 500 years. Although care needs to be taken into account as with all types of buildings, it is evident that with continuous care, cob buildings can last long. That said, cob buildings would be more economical in the long run to maintain.

Figure 1. 500 year old cob building in Europe. Retrieved on April 2nd 2013 from:
http://www.daycreek.com/dc/html/dc_cob.htm

3.3 Economical Conclusion

You may ask, if cob and straw bale is so great, why are not there more people using it? A reason why cob and straw bale is not common is because of the lack of public knowledge about cob and straw bale. Furthermore, straw bale is seen as an industrial waste in Egypt as well as something that is purely agricultural. Without knowledge that cob an d straw bale can be used as a building material, it is the main reason why cob and straw bale houses are not common (Garas).

Given the circumstances of how cob and straw bale requires more manual labour, the economic benefits such as the lower prices of obtaining materials of cob and straw bale, would make it an ideal choice for the new UBC Farm building.

4.0 Social Impacts

As a world's top academic institute with social responsibility, UBC has always be focusing on sustainability. UBC Farm cob and straw bale building is unique in sustainability technologies.

This section discusses three social impacts of UBC Farm cob and straw bale building. In collaboration with UBC Sustainable Science Building Program and Campus as a Living Lab, project research outcome can be used as an example for other cob and straw bale buildings in the world. Behaviour changes of occupants in the cob and straw bale building are also examined. In addition, sustainable building increases UBC's sustainable image; thus, UBC is able to attract more students and researchers.

4.1 Academic Impact

UBC is known for sustainability technologies research. Programs such as Sustainable Science Building Program (SBSP), UBC Sustainability Initiatives, Campus as a Living Lab and Clean Energy Research Centre allow UBC to develop new sustainability technologies with industries, and pass on the knowledge to the rest of the world.

UBC Centre for Interactive Research on Sustainability (CIRS) is a product of UBC in cooperative with industries. Professionals with different expertise from various organizations work together on this project. Companies include BC Hydro, Honeywell and Modern Green Development Ltd. are involved in the project. Each of these groups contributes knowledge and expertise in the CIRS building. SBSP has also used this opportunity to enhance its research and learning developments. The academic outcome of CIRS has been included in SBSP curriculum. For example, passive ventilation and lightings are used as study case for SBSP students and researchers. During the designing phase, all groups work together and achieve this new UBC sustainability landmark. The industries that are involved in CIRS project are now capable of working on similar sustainable building projects.

The experience of CIRS has set an example for UBC Farm cob and straw bale building. The design experience and research outcome lead industries and researchers to work on more sustainable cob and straw bale facilities. This successful case also encourages more organization to consider cob and straw bale buildings as a sustainable solution.

4.2 Behavioural Impact

Human behaviours have always been influenced by surrounding environment. Different environment has different impact on people's behaviour. For example, most people do not need to be told 'quiet' in library (Salina Marshall). Similarly, green building users are more environmentally concerned. Professor Alan Kingstone, the Head of UBC's Psychological Department, states that "a green atmosphere promotes more green behaviour. It's almost like it's in the air." Environmental consciousness is created by the individual buildings. Professor Kingstone and his team have conducted a research on food disposal between Student Union Building (SUB) and CIRS. These two buildings carter to a variety range of students. The eating areas in both SUB and CIRS buildings have disposal options for compostable and recyclable materials. The environmental disposal rate is 86 per cent at CIRS versus 58 per cent at SUB. The researchers believe that the value of sustainable is emphasized in CIRS, and patrons change their behaviour subconsciously. According to Kingstone, "(CIRS) is a building that has a lot of light, a lot of wood, and it feels clean and fresh and sustainable."

From the example of CIRS versus SUB, similar behavioural changes are expected in the UBC cob and straw bale building. Patrons become more environmentally concerned in sustainable buildings; thus, the cob and straw bale building create a positive impact on behaviours.

4.3 Image Impact

In the past few decades, UBC has put a tremendous amount of effort in sustainability. In 1990, UBC signs a sustainability action plan: Tailloires Declaration. Since then, UBC has been promoting campus sustainability in different ways. UBC adopts the first sustainable development policy in Canada universities in 1997. In 1998, the first Canadian university Sustainability Officer is opened at UBC. Sustainable actions such as U-Pass program and Energy Retrofitting program have been implemented. UBC reaches its Kyoto targets in 2007. (UBC Sustainability)

Sustainable actions have made UBC one of the most sustainable campuses in the world. Researchers, industries as well as general public admire UBC's achievement. The cob and straw bale building creates another sustainability landmark at UBC. More professionals and students who are interested in sustainability are attracted by UBC and therefore, UBC is able to keep the momentum of sustainable development and achieve its goals.

4.4 Social Conclusion

As an environmental leader, UBC has built up its sustainable reputations. The UBC cob and straw bale building creates opportunities for professionals and industry leaders to work together and pass on the knowledge to other projects. Patrons and occupants' behaviours are expected to be more environmental friendly in the cob and straw bale buildings. UBC's image on suitability is also redefined. Cob and straw bale building has positive social impacts; therefore, it should be considered as the new UBC Farm building.

5.0 Conclusion

The trip bottom line analysis suggests that all three impacts: environmental, economical and social, support the UBC Farm cob and straw bale building. The following key points summarize the triple-bottom line analysis:

- Cob and straw bale have less embodied carbon compare to concrete blocks.
- Straw bale has lower thermal conductivity value to keep the thermal energy within the building; however, the building materials include cob so that the thermal conductivity is kept in a desirable range.
- Costs of traditional concrete are more expensive than cob and straw bale.
- Cob and straw bale building have positive impacts on academic research, patrons' behaviour and the university's image.

It is proven cob and straw bale building is more environmental friendly, cheaper in production and maintenance cost and having positive social impact on both UBC and its communities; hence, cob and straw bale should be considered as an alternative building material for UBC Farm building.

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