Multidisciplinary Senior Design
Project Readiness Package

Project Title:	Biochar Concrete Roofing Sheets for Nicaragua 2.0
Project Number: (MSD will assign this)	P17485
Primary Customer: (provide name, phone number, and email)	4 Walls Project: http://www.4wallsproject.org/ Bonnie Yannie, bonnieyannie@gmail.com, phone Ithaka Institute: http://www.ithaka-institut.org/en/home Kathleen Draper, 585 737 7282, kdraper2@rochester.rr.com
Sponsor(s): (provide name, phone number, email, and amount of support)	MSD, $500
Preferred Start Term:	Fall 2016
Faculty Champion: (provide name and email)	Brownell
Other Support:	Manitou Concrete Dr. Todd Dunn, Civil Eng. Tech (for lab use) Dr. Brian Thorn, LCA Sarah Brownell, design for developing world
Project Guide: (MSD will assign this)	

Sarah Brownell — 7/9/15

Prepared By — Date

Received By — Date

Items marked with a * are required, items marked with a † are preferred if available, but we can work with the proposer on these.

Project Information

[*]Overview:

The 4 Walls Project (http://www.4wallsproject.org/) helps indigenous families in El Sauce, Nicaragua obtain their own home. The homes are currently 20' x 20', concrete post and beam construction with brick walls, a dirt floor and a zinc roof. 4 Walls tries to support the local economy as much as possible with their purchases, but the roof material is not currently produced locally. It also brings unwanted heat into the house, is very loud in rainstorms, and costs more than $400/house. Each house requires forty 3` x 10` zinc sheets at $x/sheet.


Current "housing"


House built by 4 Walls




Current roof design

The Ithaka Institute in a non-profit foundation leading research collaboration on carbon sequestration through biological methods. They focus specifically on research enhancing the production, treatment and use of biochar materials. Biochar is created by the thermochemical decomposition of organic materials at elevated temperatures in the absence of oxygen, a process known as pyrolysis. Biochar can be made from many types of biomass including agricultural wastes and has interesting characteristics due to its composition and physical structure including low density, high porosity, and elevated pH. It can be used as a soil amendment, an animal dietary supplement, a sustainable charcoal replacement, a filter material, and as a component in composite building materials. Because of its stability, it also has potential for sequestering carbon taken from the atmosphere by biomass as a remediation for climate change.

One of the more novel uses of biochar is as a component in building materials. Researchers are just beginning to experiment with biochar amended concrete and plastic composites that could result in lighter weight and lower cost building materials with enhanced insulating, filtering, cooling, and humidity control characteristics. Some recent attempts include biochar-concrete panels, biochar-lime bricks, indoor and outside insulating plasters (see http://www.ithaka-institut.org/en/ct/97-Biochar-as-a-Building-Material). Research in Japan has shown biochar spread on the underfloor and ceiling of houses to improve humidity control as well as reduce allergic reactions and asthma in homeowners.

Recently, the Ithaka Institute and the 4 Walls Project teamed up to brainstorm possible uses of biochar made from local agricultural wastes in El Sauce, Nicaragua and the idea to replace the galvanized roofing sheets with a biochar composite concrete was born.

See Ithaka institute website for descriptions/details on these photos: http://www.ithaka-journal.net/pflanzenkohle-zum-hauser-bauen-stadte-als-kohlenstoffsenken?lang=en

Biochar clay plaster in wine cellar helps control humidity.

Biochar lime blocks are so light they float!

Last year MSD team P16485 took the first steps for developing lightweight concrete roofing tiles that can be manufactured locally in El Sauce from innovated waste materials including biochar and string from plastic bottles. They molded shingles using molds made by vacuum forming and provided a wood and bamboo truss design for the support structure. The prototype they developed for 4-Walls met many of the engineering requirements but could still use improvement and optimization. The shingle design needs to be adapted to prevent water running down the roof from entering the house. Also, because experimenting with concrete mixes takes time, the mix chosen by the team is acceptable, but has not been fully optimized and could be improved for strength and reduced weight. Finally, these roofs need to be produced in quantity in Nicaragua, so manufacturing processes, jigs, and fixtures need to be developed to facilitate easy, low cost production. The Ithaka institute has also requested that a streamlined life cycle assessment be conducted to determine if these shingles might be environmentally superior to galvanized roofing sheet or other options.

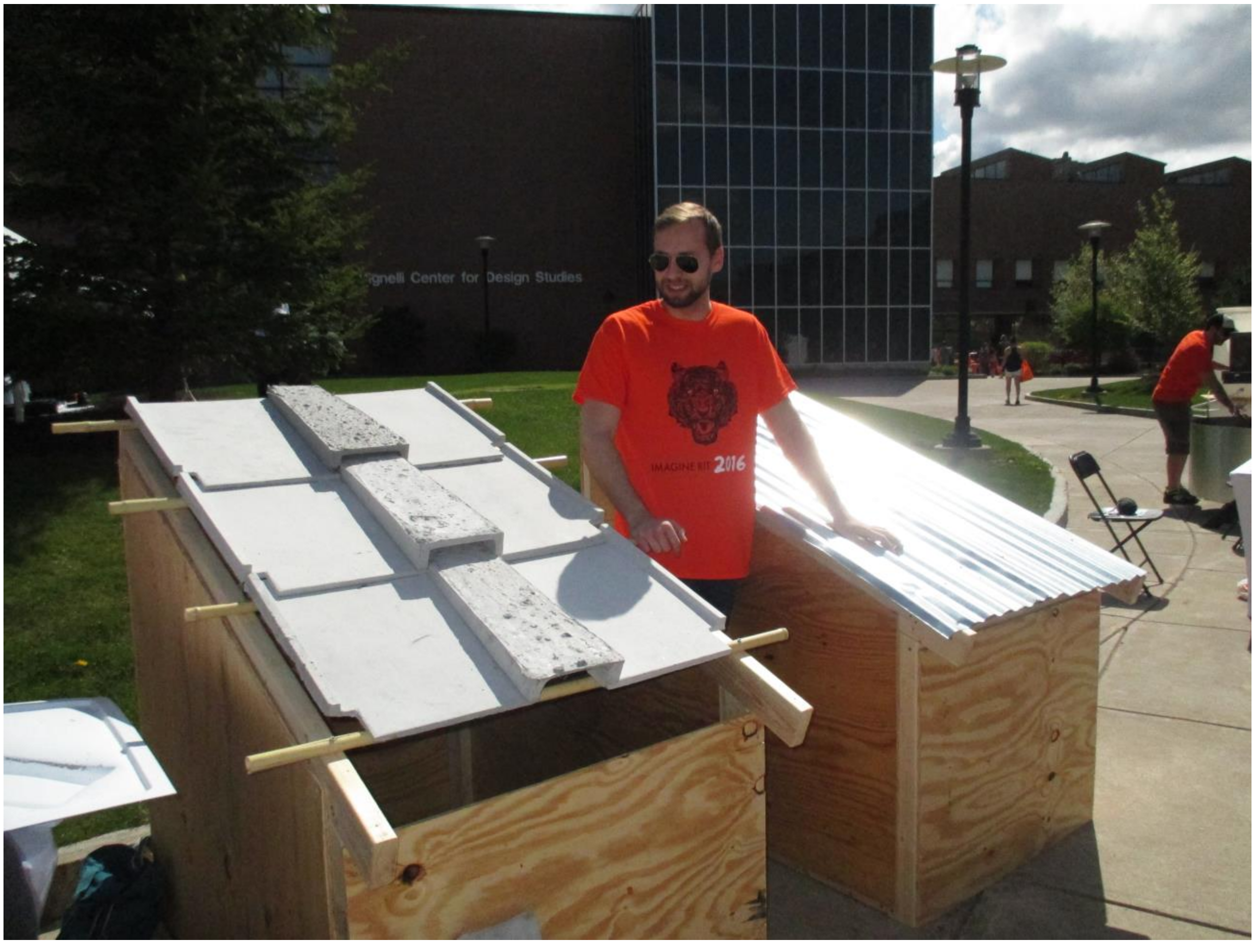

Figure 4: Last year's roof prototype

Working with the Ithaka Institute, this MSD team is charged with improving on last year's prototype and helping 4 Walls replace their roof with a new, better design that could be produced using biochar produced from waste products.

***Customer Requirements (CR):**

- Attaches to the existing post and beam with brick construction used by 4 walls
- Prevents rain from entering the house
- Reduces noise from rainstorms as compared to galvanized sheets
- Reduces solar gain to the house as compared to galvanized sheets
- Resists removal by wind
- Modular (accommodates different size and shape homes)
- Portable by truck for transport to site
- Portable by people for installation
- Supports a person on the roof for installation and maintenance
- Utilizes a local waste product (such as coffee husk biochar, plastic bottles)
- Inhibits animals from making homes in the roof

- Reduces overall roof cost for a 4 Walls house
- Can be constructed locally in El Sauce
- Can be installed using local labor
- Cost effective

†**Engineering Requirements (ER)**:

Requirement	**Ideal**	**Marginal**
Time to install a roof on 4 Walls House (h)	Faster than current	current
Resists lifting force (N)	Estimated class II hurricane	Estimated class 1 Hurricane
Meets waterproof standards		
Loudness in rainstorm (db)	>25% less than galvanized sheet	Less than galvanized sheet
Supports a person (lb)	250	150
Reduces solar heat gain transmitted to home (%)	>20	>10
Max dimensions of each piece	< size of local truck bed	Size of local truck bed
Weight of each piece (lb)	<30	<50
Estimated weight of full 4 Walls roof (lb)	Same or less than current	<x% greater than current (need calcs on what house can support)
Largest hole/space in roof connections (mm)	<5	Resists snake nesting
Total roof cost for 4 Walls ($)	<300	<400
Power tools required for installation	0	<2
Hand tools required for installation	<2	<4
Skilled operators required for fabrication	<1	<2
Total operators required for fabrication	<2	<4
Materials imported (% of total roof cost)	<25	<50
Level of modularity (dimensions accommodated in length and width)	Continuous	<1 foot increments

***Constraints:**
- Consider earthquake and hurricane resistance in the design (may not be possible to test)
- Utilize local materials
- Construct and install locally
- Reduce cost of roof to <$400
- Modular and transportable
- Attach to post and beam construction
- Adjust for different size houses

[*]Project Deliverables:
Minimum requirements:

- All design documents (e.g., concepts, analysis, detailed drawings/schematics, BOM, test results)
- working prototype
- technical paper
- poster
- complete edge site
- All teams finishing during the spring term are expected to participate in ImagineRIT

Additional required deliverables:

- Molds or custom fabrication tools
- Construction manual
- Installation manual
- User manual
- LCA

[†]Budget Information:

Item	**Cost**
Concrete materials	$100
Concrete test materials (compression)	$50
Molds (limiting factor…depends on size of each piece)	$200
Test fixtures (solar gain, water proof-ness)	$100
Misc.	$50
Total	**$500**

[*]Intellectual Property:
May have patent potential…depending on what students come up with! Up to them to patent.

Project Resources

†Required Resources (besides student staffing):
Describe the resources necessary for successful project completion. When the resource is secured, the responsible person should initial and date to acknowledge that they have agreed to provide this support. We assume that all teams with ME/ISE students will have access to the ME Machine Shop and all teams with EE students will have access to the EE Senior Design Lab, so it is not necessary to list these! Limit this list to specialized expertise, space, equipment, and materials

Faculty list individuals and their area of expertise (people who can provide specialized knowledge unique to your project, e.g., faculty you will need to consult for more than a basic technical question during office hours)	**Initial/ date**
Ravi Ranade (UB professor)	
Environment (e.g., a specific lab with specialized equipment/facilities, space for very large or oily/greasy projects, space for projects that generate airborne debris or hazardous gases, specific electrical requirements such as 3-phase power)	**Initial/ date**
Civil Tech concrete lab	
Equipment (specific computing, test, measurement, or construction equipment that the team will need to borrow, e.g., CMM, SEM,)	**Initial/ date**
Materials (materials that will be consumed during the course of the project, e.g., test samples from customer, specialized raw material for construction, chemicals that must be purchased and stored)	**Initial/ date**
Biochar (ask Kathleen)	
Other	**Initial/ date**
Manitou Concrete (consultation, possible material support)	

†Anticipated Staffing By Discipline:
Indicate the requested staffing for each discipline, along with a brief explanation of the associated activities. “Other” includes students from any department on campus besides those explicitly listed. For example, we have done projects with students from Industrial Design, Business, Software Engineering, Civil Engineering Technology, and Information Technology. **If you have recruited students to work on this project (including student-initiated projects), include their names here, as well!**

Disc.	# Req.	Expected Activities
BME		
CE		
EE		
ISE	2-3	Mold making, manufacturing processes with constraints of developing world (possible DFx), ergonomics, experimental design for concrete formula development, engineering economics , LCA

ME	2	CAD, stress analysis, FEA, fabrication, design of test rigs, molds, heat transfer analysis for solar gain, mold design
Other	1	Civil tech would be fabulous…

†Skills Checklist:

Indicate the sills or knowledge that will be needed by students working on this project. Please use the following scale:

1=must have
2=helpful, but not essential
3=either a very small part of the project, or relates to a "bonus" feature
blank = not applicable to this project

Mechanical Engineering

	ME Core Knowledge		**ME Elective Knowledge**
1	3D CAD	1	Finite element analysis
	Matlab programming	1	Heat transfer
1	Basic machining		Modeling of electromechanical & fluid systems
1	2D stress analysis	2	Fatigue and static failure criteria
	2D static/dynamic analysis		Machine elements
	Thermodynamics		Aerodynamics
	Fluid dynamics (CV)		Computational fluid dynamics
	LabView		Biomaterials
	Statistics		Vibrations
			IC Engines
			GD&T
			Linear Controls
		1	Composites
			Robotics
			Other (specify)

Electrical Engineering

	EE Core Knowledge		**EE Elective Knowledge**
	Circuit Design (AC/DC converters, regulators, amplifies, analog filter design, FPGA logic design, sensor bias/support circuitry)		Digital filter design and implementation
	Power systems: selection, analysis, power budget		Digital signal processing
	System analysis: frequency analysis (Fourier, Laplace), stability, PID controllers, modulation schemes, VCO's & mixers, ADC selection		Microcontroller selection/application
	Circuit build, test, debug (scope, DMM, function generator		Wireless: communication protocol, component selection
	Board layout		Antenna selection (simple design)
	Matlab		Communication system front end design
	PSpice		Algorithm design/simulation
	Programming: C, Assembly		Embedded software design/implementation
	Electromagnetics: shielding, interference		Other (specify)

Industrial & Systems Engineering

	ISE Core Knowledge		ISE Elective Knowledge
	Statistical analysis of data: regression	2	Design of Experiment
1	Materials science	1	Systems design – product/process design
1	Materials processing, machining lab		Data analysis, data mining
	Facilities planning: layout, mat'l handling		Manufacturing engineering
2	Production systems design: cycle time, throughput, assembly line design, manufacturing process design	2	DFx: manufacturing, assembly, environment, sustainability
1	Ergonomics: interface of people and equipment (procedures, training, maintenance)		Rapid prototyping
	Math modeling: OR (linear programming, simulation)		Safety engineering
1	Project management		Other (specify)
1	Engineering economy: Return on Investment		
	Quality tools: SPC		
	Production control: scheduling		
2	Shop floor IE: methods, time studies		
	Computer tools: Excel, Access, AutoCAD		
	Programming (C++)		

Biomedical Engineering

	BME Core Knowledge		BME Elective Knowledge
	Matlab		Medical image processing
	Aseptic lab techniques		COMSOL software modeling
	Gel electrophoresis		Medical visualization software
	Linear signal analysis and processing		Biomaterial testing/evaluation
	Fluid mechanics		Tissue culture
	Biomaterials		Advanced microscopy
	Labview		Microfluidic device fabrication and measurement
	Simulation (Simulink)		Other (specify)
	System physiology		
	Biosystems process analysis (mass, energy balance)		
	Cell culture		
	Computer-based data acquisition		
	Probability & statistics		
	Numerical & statistical analysis		
	Biomechanics		
	Design of biomedical devices		

Computer Engineering

	CE Core Knowledge		CE Elective Knowledge
	Digital design (including HDL and FPGA)		Networking & network protocols
	Software for microcontrollers (including Linux and Windows)		Wireless networks
	Device programming (Assembly, C)		Robotics (guidance, navigation, vision, machine learning, control)
	Programming: Python, Java, C++		Concurrent and embedded software
	Basic analog design		Embedded and real-time systems
	Scientific computing (including C and Matlab)		Digital image processing
	Signal processing		Computer vision
	Interfacing transducers and actuators to microcontrollers		Network security

	CE Core Knowledge		CE Elective Knowledge
			Other (specify)