TEAM WHAREUKU

SUSTAINABILITY: USING WHAT WE NEED, LIVING WELL AND LEAVING ENOUGH FOR FUTURE GENERATIONS. SUSTAINABLE HOMES SUPPORT A SUSTAINABLE LIFESTYLE.

SUSTAINABLE HABITAT CHALLENGE 09

BUILDING A BETTER WAY

WWW.SHAC.ORG.NZ
0800 SHAC 09

SHAC 09 asks collaborative, tertiary-led teams to **design and build or retrofit a sustainable home**, develop a campaign to **inform the public** about how their design supports sustainable living **and pass on information and techniques** about their design to the building community.

Team outcomes will be judged in several categories. Each category has a number of possible parameters that you may want to consider. Your team will supply a report with reasoned arguments, simulation and modelling results and other research outputs to convince the judges of the benefits you expect in each category. How you make the trade-offs necessary to realise your vision will be based on how people in your region live – and will want to live – in your affordable, sustainable house and community in five years' time.

In November 2009, judges will review the house, your communications campaign, the resources you develop for designers and your final report. Your final report will describe the house and show the improvement your design exhibits when compared with your reference case and regional averages. Note that although reference is frequently made to "your house", solutions are also welcomed for proposals for multi-unit housing proposals. The site shall be included when considering each of the judging categories, for example, site water use and runoff, site contribution to a sustainable community, and others.

MINIMUM STANDARDS

Pick a type of housing currently being used, and design a new house that requires fewer resources and supports delightful, sustainable living. Show in a report how your new design delivers a step-change improvement over regional averages and typical house. Renovations are also welcomed. At the minimum, your house must meet Beacon's High Standard of Sustainability™ (see below), and be rated by the EECA Household Energy Rating Scheme (HERS). The use of other thermal modelling tools such as BRANZ's ALF3 is recommended.

Successful teams will make improvements in each judging category. Houses must meet all required building regulations. Your house must be furnished and fitted with appliances that the team shows to lead to a delightful, more sustainable lifestyle.

JUDGING PROCESS

You will report on your goals, strategies, and achievements in each category. Your report is crucial, as it will present your arguments, simulations and other justifications that demonstrate how your new design is a significant improvement over your reference house and regional averages.

Seven categories consider the house and its link with the community. One category covers the communications campaign that explains the house to the general public and to the design and building community. Judges will examine your house performance in each category, and commend your team were progress has been made and recommend further possibilities and approaches.

Successful teams will consider and make improvements in each category, when compared with their reference house and regional averages.

Beacon's High Standard of Sustainability™ (HSS)

- A 25% reduction in energy use in new homes
- A 15% reduction in energy use in existing homes
- A 25% reduction in water use in both new and existing homes
- Average indoor environment temperatures which meet the World Health Organisation minimum standards
- Adequate ventilation without excessive draughts
- Provision for waste minimisation during construction, renovation and operation of homes
- Consideration of sustainability issues in the choice of materials used for construction or renovation of homes.

Prize Eligibility

Some Teams completed a Vision or Concept, some have also completed their consented Design, and others completed their House, with or without associated Furnishings.

Completed	Prize Eligibility
Vision or Concept	Vision of Practical Sustainable Living Communications
Design	Vision of Practical Sustainable Living Communications Design
House	Vision of Practical Sustainable Living Communications Design SHAC House
Furnishings	Design
Communications Campaign	Communications

Submission Process

9 September 2009 – Tim will contact you to discuss report.
23 September 2009 – Tim will contact you to discuss how to submit report, photos, and files.
1 October 2009 – Final Report Due.
6-8 November 2009 – Auckland Area Judge Site Visits
12-14 November 2009 – Wellington / Christchurch / Dunedin Area Site Visits
19-21 November 2009 – Symposium and Prizes! – book your travel today

The Team Report

The purpose of the report is to explain your vision of housing to support more sustainable living. Explain how you have progressed to this goal, why the general public would want designs of this type, and how the building and development community can successfully re-implement similar designs.

Please submit your report by posting a blog entry in your team's are at www.shac.org.nz. Or email the document to tim@shac.org.nz.

The report outline follows:

whareuku

1 INTRODUCTION – TEAM PRESS RELEASE

Please provide a **three to five paragraph** description of the SHAC Team's **vision** for more sustainable housing **and** their **response** to this vision. Use the style of a press release.

This might consist of a description of what the project has accomplished, what problem it is addressing, how it is part of the longer term vision of sustainable living, the key outcomes, technologies and techniques, and an indication of costs in the ideal case. **Please include quotes** or perspectives **from students, occupants,** or those that participated or **been affected** by the project.

Our scenario for sustainable living is one where the social, cultural and physical needs of all individuals in all communities are met. If these objectives are to be met for present and future generations, the processes and methods implemented must draw on the concept of kaitiakitanga (sustainability and guardianship). The concept of kaitiakitanga is a holistic concept that places the occupants of the land in the context of a greater whole with a responsibility to protect and preserve the environmental and spiritual wellbeing of the land.

The Whareuku team is made up of students that are motivated by the clear need to create a better way to house people so that our generation and the generations after us will be able to inherit a world with a truly sustainable housing industry and have a more vibrant and healthy natural environment to live in. House design and construction is a key aspect that needs to change in order to lessen, and hopefully one day reverse, the negative impact that humans have had on our natural environment. The UKU research arose out of the need for a more accessible housing method for rural Māori communities.

From the early stages of this research a Māori Community Reference Group was formed. The group was made of up representatives from a number of Māori groups in Taitokerau (Northland), Tairāwhiti (East Coast) and Waiariki (Bay of Plenty) who were interested end-users of the research. They provided direct insight into what was hindering housing development on their lands, what they wanted in a new housing method, and kept the community they represented informed and a part of the UKU research. The group highlighted 5 key attributes that were desirable in a housing method.

- Designs that required a minimum of input by professional engineers
- A design-life of six generations or 150 years
- Construction technology that is readily able to be adopted by a non-technical workforce
- Construction technology not overly dependent on large complex machinery
- Low cost easily transferable construction technology

A key measure of the research's value and success was the practical and direct benefit to Māori. Seeing the positive acceptance of Māori towards the UKU housing method and physically building an UKU house on Māori land were important outputs of this research. Soil characterization and material strength tests were conducted at the University of Auckland Engineering Faculty and the results were used to design the Rotoiti UKU house in accordance with the NZ building standard requirements. After an agreement had been reached with a rural Māori community in Rotoiti, the UKU house was designed, consented and built. By October 2008, on the Southern shore of Lake Rotoiti at Haumingi 10a2b Papakainga in the Western Bay of Plenty, a two bedroom, 90 m2 UKU house was completed. The cost of building the Rotoiti UKU house was $84,889 NZD.

"We have learned that living in an earth house is an acceptable option for Māori; this was not a given."

- Principal Investigator, Dr. Kepa Morgan

"I've been working in timber for 50 years; it's hard to get it through your mind that the earth house is superior. Now we are actually standing inside the earth house when it's really hot outside, the temperature inside the earth house is more convenient than a timber house...I think that the earth house is quite superior as far as thermal goes...At the moment, when you go inside from outside, you can feel the temperature drop straight away."

- Main Contractor, Brian Morgan

"The parallel concept of sustainability in Māori thinking is the ethic of Kaitiakitanga; enhancing the Mauri in all things. Mauri is the binding force between the physical and the spiritual aspects of an entity. If we enhance that force by impacting upon it positively, then it will be more vibrant; in terms of air, water, soil; it would have a greater capacity to support life.

- Principal Investigator, Dr. Kepa Morgan

"We call this our tūrangawaewae, which is our stamping ground. And I am glad to be home, I am glad to be among my family and I am glad to have a house at last."

- House owner, Margaret Hitchcock

"Jack and Damian worked well because they were young. They didn't know what they were doing, but once they were taught they did 99% of the work, which was hard labour. Without them we couldn't have really done it. It was fabulous. The University students know what it's like because they were ramming walls down here as well as at the university. They have appreciation of what hard labour is."

- Main Contractor, Brian Morgan

(please extend box as needed), or provide separate document.

2 TECHNICAL JUDGING CRITERIA

Describe the main features of the house that support more sustainable living.

Report the Heating Energy Load (MJ/annum) for the entire house as given in your HERS report. Report the HERS star rating. Compare house with Beacon High Standard of Sustainability. Report how your assumptions of living style compares with assumptions for HERS.

For each of the SHAC judging criteria, describe in one or more paragraphs how your design will give an improvement over how we live today with less reliance on resources. Refer to the SHAC Judging Criteria. Arguments will vary from the technical (eg increasing efficiencies, insulation) to the transformational (eg offering a better life in a new location, xeriscaping, different housing and urban forms, high quality and pleasingly compact housing, etc)

We suggest this section to be in the style of a Build Magazine article, describing the features for the design and building community. [2-4 pages]. The article must cover each of the SHAC Judging Criteria.

An Example of a BRANZ technical article is at the Build Magazine web site:
http://www.branz.co.nz/cms_display.php?st=1&pg=2172&sn=62&forced_id=yesUH

Sustainability case study [Roman Jaques with Heidi Mardon]
Follows the design and build of a more sustainable urban house in Hamilton.

* Difficult task of choosing materials wisely
* Passive design strategies
* Planning the new building
* Waste diversion during deconstruction

SHAC Judging criteria to address:

Energy and Indoor Environmental Quality, Water, Materials, Waste, Affordable and Suitable for Purpose, Supporting a Sustainable Community

HERS Assessment

On the 23rd of April, 2009, an HERS assessor, Paul Stock, evaluated the Rotoiti UKU house using the consented drawings. Due to the distance, he did not visit the building. The building was awarded a 3 star rating. The room and water heating rates were not assessed. The Heating Energy Load for the house was calculated at 33282 MJ/annum or 9245 kWh/annum.

Energy

One aim of the UKU Project was to create a housing method that is able to minimize energy consumption. Basic passive solar design techniques (e.g. North facing openings) combined with the high thermal mass of an UKU house has created a house design capable of capturing and storing large amounts of solar heat energy inside the UKU house. The occupants have enjoyed cooler summers and warmer winters inside the house as the walls and floor absorbs solar heat energy during the day and releases it during the night.

All the windows, sliding doors and the sky light in the Rotoiti UKU house are double glazed to minimize the loss of heat through openings whilst allowing light and heat energy into the house from the North, East and West directions. In addition to this, the roof is fully insulated with an R-value of 2.2. Early in the design stage it was decided not to purchase argon filled double glazing due to the increased cost, marginal benefit in the overall thermal performance of the house and the embodied energy required to manufacture such glazing. Passive solar design, the thermal mass of the house and the use of double glazing, has resulted in a house that is better able to capture and retain heat energy and to significantly reduce energy demand due to space heating and cooling. The house features a solar water heating system which has reduced the energy needed to heat water. Electrical lighting inside the Rotoiti UKU house is provided from low-energy compact fluorescent light bulbs. These light bulbs have been proven to use 75% less electricity than equivalent incandescent light bulbs (according to EECA).

To further reduce electricity consumption the occupants of the Rotoiti UKU house, a Centameter was installed that displayed the financial cost per hour arising from the instantaneous electricity usage. This device allows the occupants to quantify and appreciate the monetary cost of using each appliance and encourages a frugal approach to energy use over time as the owners can tangibly and instantly see the benefits of doing so.

Based on the consumption of electricity over a 289 day period (23 Nov 2008 – 7 Sep 2009) the research team has linearly extrapolated the annual electricity consumption of the Rotoiti UKU house at 4200 kWh/year.

From the BRANZ Household Energy End-Use Project (HEEP), the most energy efficient houses in New Zealand, the bottom 20%, use less than 4860 kWh/yr of electrical energy and 6940 kWh/yr in total. For a new home in Climate Zone 3, Beacon's High Standard of Sustainability (HSS) benchmark for reticulated energy is 7300 kWh/yr. The energy consumption of the Rotoiti UKU house is below both benchmarks and can therefore be said to be performing well from an energy conservation point of view.

It should be noted that the owners use a 7 bar electrical oil column heater to heat the house. In the middle of June 2009 the house occupants used an LPG heater to get through the worst of winter which included ambient external air temperatures below zero, while the temperature inside the dwelling never fell below 9^{o}C. The amount of energy used by the LPG heat source has yet to be quantified.

A qualitative comfort survey completed each day by the occupants showed the house provided a comfortable living environment. During the summer, the temperature inside the house remained at a desirable level without needing fans or air conditioning, however it was not able to remain warm enough without additional space heating during the winter.

Water

Water usage is one area where the UKU house is not performing well. The house has been designed with low-flow shower heads, a dual flush toilet and aerated taps, however based off quarterly water meter readings taken from 12 November 2008 to 13 August 2009 (274 days), the average daily water consumption calculated was 409 litres/day. Assuming 2.5 house occupants, Beacons HSS for reticulated water use is 312.5 litres/day (125 litres/person/d) meaning the occupants are using 30% more water than our target consumption. It is interesting to note that it is considered normal by the Rotorua District Council for a household to consume 400 litres/day.

There could be a variety of reasons for this large value. From the house water design perspective and the observable water use behavior of the occupants, the volume of water consumption is inconsistent. The larger consumption of water may possibly have arisen from significant leaks present in the pipe network or the owners may like to have particularly long showers! A check is being organized to establish if there is a leak on the property and whether the water meter readings are accurate. Three of the families occupying Haumingi 10a2b Papakainga experienced much higher than normal water consumption during the 2009 winter which has been linked to damaged water meters that were leaking water onto the State Highway in May and June.

The 13 hectare multiply owned Māori land block on which the UKU house has been built, has been developed with a porous narrow carriageway made up of Beton-Gras turf slabs, grassed channels, and natural sub-canopy ground cover. Sidewalks have been replaced with narrower paths separated from the carriageway. Roof catchments are directed to soak away. Two thirds of the property, from SH30 to the base of the hill sustain native bush and the steeper area at the back of the property has been designated as a reserve, with runoff and erosion reducing measures put in place. The presence of native bush has had immeasurable benefits in terms of increasing landform resilience and also to revitalize the native fauna bird populations in the area. The development has less than 10% of the impervious surfaces inherent in the original design recommended by the Rotorua District Council consisting of kerb and channel, concrete footpaths and a 6.2m wide sealed carriageway.

Without considering the cultural and environmental advantages, this low impact land development cost $37,058.70 to implement. The proposed council solution was estimated at $83,109.55.

Figure 1 Photo of the porous carriageway at Haumingi 10a2b Papakainga

Materials

Another aim of the project was to use construction materials that were natural and locally available. The use of natural materials was important to create a healthy living environment, with minimal VOC emissions and other harmful chemicals. Natural untreated macrocarpa timber was used to form the bond beam around the perimeter of the house and the roof rafters. 92% of the material used in the rammed earth walls is soil (7.5% cement content). There has been no additional treatment or paint applied to the walls. Locally sourced and harvested flax-fibres are also used in the walls to add tensile strength, reduce shrinkage and to raise the thermal insulation value.

Although the design life of the Rotoiti UKU house is 50 years, the UKU house may last longer than that. Literature sources and examples of earthen construction around the world indicate that high durability and long-term permanence are common characteristics. Flax harvesting is performed according to traditional Māori methods which leave the flax plant in a better state to grow, and the flax leaves (and soil) are readily available, renewable and affordable. Excess flax fibres can be easily stored and the excess soil is returned to the ground.

Modular construction is a feature of the UKU method. The same set of formwork is reused to build all of the UKU wall panels. Where timber needs to be cut, the design has been drawn in such a way that the off-cuts can be used elsewhere in the structure.

Maintenance of the earth walls is simple and consists of mixing the chosen soil with a slightly higher content of water and cement, and plastering it on the existing wall.

The house is built on a reinforced concrete slab with foundation beams poured along the wall lines of the house. The roof is a Pacific gull wing light timber roof with exposed rafters, plywood diaphragms and coloursteel roofing. The earthen wall panels have vertical D12 reinforcing bars embedded within the earth to assist with resisting

earthquake loads.

"The materials are appropriate to use for construction because they represent the generative foundation for all life. All things are born from her and nurtured by her, including humankind.

- Principal Investigator, Dr. Kepa Morgan

Waste

One of the underlying concepts guiding the project was kaitiakitanga, sustainability and guardianship of the land. Adverse impacts of living on the land, like waste creation and disposal, were minimized and eliminated where possible. Pre-loved bench tops and cabinetry were used for the kitchen including the appliances.

A worm farm has been kindly donated to the project by EarthAngel. The worm farm removes a high proportion of organic waste that would otherwise be land filled. Instead the organic matter is broken down naturally and returned to the soil as high quality nutrients.

A comprehensive storm water design has been implemented on Haumingi 10a2b Papakainga to make use of natural infiltration processes and resilience provided by native flora. More details are explained in the water section.

To reduce construction waste the house was designed so that timber off-cuts could be used. The UKU formwork is modular, flexible and reusable (can be used to build UKU wall panels up to 2.2 meters long at variable thickness and height), and the excess flax and soil can be reused in a future project or returned to nature (flax and soil).

Indoor Environmental Quality

Indoor environmental quality depends on a range of variables including temperature, relative humidity, emissions, particulates, air quality, surface moisture, ventilation, natural light, noise and various combinations there of. Uku has thus far proven to meet a majority of indoor environmental quality requirements, as determined by specific standards in relation to temperature and humidity levels, and a number of subjective thermal comfort observations;

Temperature, Relative Humidity and Thermal Comfort

The Rotoiti house has 14 Hygrochron iButtons installed throughout the house that collect temperature and relative humidity measurements at 20-minute intervals. Data collected over the last 10 months is presented below alongside matching data collected from an equivalent standard timber frame test house built on neighboring land. Annual maximum, minimum and mean temperatures and relative humidity values for living room and master bedroom areas are given in the tables below:

	Temperature ^{o}C	
	Uku House	Timber Frame House
Max Living Room	32.66	33.16
Max Bedroom	28.86	28.45
Min Living Room	9.01	6.00
Min Bedroom	8.83	6.16
Mean Living Room	19.89	18.84
Mean Bedroom	17.74	16.68

Table 1 - Key Temperature Attributes of the Rotoiti UKU house and Timber Framed house (Dec 08 – Sep 09)

	Relative Humidity %	
	Uku House	Timber Frame House
Max Living Room	92.00	80.25
Max Bedroom	94.27	93.93
Min Living Room	36.84	49.08
Min Bedroom	45.55	49.08
Mean Living Room	69.78	61.06
Mean Bedroom	76.64	70.73

Table 2 - Relative Humidity Attributes of the Rotoiti UKU house and Timber Framed house (Dec 08 – Sep 09)

While the ultimate vision for indoor environmental quality is that a house that maintains healthy indoor temperatures all year round naturally, this is not yet a possibility for UKU. Daily surveys have been collected that ask the occupants of the UKU house their perceived level of thermal comfort ranging from Cold (-3) to Neutral (0) to Hot (+3), the number of pieces of clothing they wore, and whether or not any heating was used. Results from these surveys show that during summer, the occupants perceived the thermal performance of the house was cool to neutral, and during winter around neutral. For most days during winter some additional heating was required. Personal communications with the owners have revealed that on most days when a heating device was used, a 7 bar oil-fin heater was used at a medium level (Level 3 out of 7).

Note that the period monitored includes an initial period during which the Rotoiti UKU house was still achieving equilibrium. During construction over the winter the Uku walls and roof framing were totally saturated and a longer period is required for the dwelling to reach an equilibrium state. Future performance is expected to improve as equilibrium is reached. In addition the use of LPG heating during winter will have contributed to the humidity levels inside the UKU house.

Emissions, Particulates, Pollutants & Air Quality

UKU wall panels consist of earth, water, flax, steel reinforcing bars and cement. The high proportion of natural material in an UKU house greatly reduces the Volatile Organic Compounds (VOCs) and Ozone Depleting Potential (ODP) emissions released by the house.

The undesirable emissions come from the reinforced concrete slab foundation, the cement in the UKU wall panels and the light timber frame roofing. Treated plywood sheets in the roof will emit some VOCs however where practical, untreated macrocarpa timber is used as an aesthetically pleasing and healthy alternative.

Due to the dry stone-like nature of rammed earth, intensive rubbing of the surface of UKU panels can flake off a sandy dust. Due to the high proportion of sand in the UKU wall the majority of dust will be heavy and not become airborne. There are currently no gauges monitoring the level of airborne particulates in the Rotoiti UKU house. Oral conversations with the occupants have revealed no problems with excessive dust levels around the house.

There are no reasons to suggest that an Uku house has any pollutant concerns. The Rotoiti house is situated on an open plot of land (approximately a ¼ acre) with vast vacant plot of land to one side, giving the property good ventilation and minimal emissions from vehicles or geothermal activity. The UKU design also benefits from a pitched ceiling (a design feature to eliminate pockets of stagnant air that form in ceiling corners) which allows natural convection currents to form easily and allows natural air circulation to occur within the house.

Moisture Control

Moisture control influences indoor environmental quality by affecting thermal comfort and air quality. It is important that both relative humidity (RH) and surface moisture are within acceptable limits so that thermal comfort can be maintained and mould, fungi and bacteria are prevented from growing. A RH% between 30% and 80% is considered comfortable for most people. As can be seen from the relative humidity tables shown in Table 2, the mean values for the UKU house remain at comfortable levels and occasionally spike to maximum values that are outside the comfort range. These maximum values do not differ significantly from the levels observed in the standard timber frame house.

Day lighting

To optimize day lighting, the living room of the Rotoiti UKU house is located on the North side of the house and has large openings on the North, East and West walls to increase sunlight penetration into the living room during the day. To reduce heat loss through window surfaces and UV light entering the house, the skylight, all windows and all sliding doors are double-glazed. The openings are positioned to expose the concrete floor and UKU wall panels to the sun light so that the materials can absorb the radiant heat energy of the sun. The skylight allows natural sunlight to shine on internal UKU walls.

Noise

Due to the high density of the UKU wall panels, the acoustic performance of the house is good. The walls are effective in preventing sound propagation and are perceived to have noise absorbing qualities. Minimal outside noise is able to enter the house and cause disturbance. Being a single level dense dwelling on a concrete foundation, there is very little noise generated within the structure from vibration. Reverberation could potentially pose a noise problem in rooms with few windows or soft material surfaces but no issues on this issue have been raised by the occupants.

Affordable and Suitable for Purpose

Creating an affordable housing method that was suitable for use in rural Māori communities was the main objective of the UKU Project. Early in the project, Māori representatives from a number of rural Māori organizations were brought together to discuss the obstacles encountered with using conventional methods to provide housing solutions on rural Māori land. Desirable aspects of an ideal housing method were also discussed. The Māori Community Reference Group (MCRG) came up with five main desirable aspects.

1. Designs that required a minimum of input by professional engineers
2. A design-life of six generations or 150 years
3. Construction technology that is readily able to be adopted by a non-technical workforce
4. Construction technology not overly dependent on large complex machinery
5. Low cost easily transferable construction technology

Because of these requested attributes, pilot studies began on determining the viability of using flax-fibre reinforced rammed earth as a housing material. The material was called UKU, a Māori word describing a clayey soil, and the initial studies were positive and opened the way to further experimentation and development. The building method has been kept as simple as possible to allow non-technically trained people to understand, learn and build using the UKU method.

Two 6 meter square social acceptance test dwellings have been built and verified that Māori communities would accept and use earthen based housing solutions. In both communities where the UKU dwellings were built there is interest to build more UKU structures in the future.

The 90m^2, two bedroom UKU house located on the Southern shore of Lake Rotoiti was the third UKU structure that has been built. All the UKU structures were built by local Māori with appropriate training, supervision and guidance. As the research progresses and especially as more UKU structures are built, improvements in design and construction are conceived and the building method becomes more practical, effective and better able to satisfy the goal of providing a desirable, high quality house on rural Māori land at an affordable price. Many

people involved in past UKU projects have mentioned how the project has strengthened relationships and the local community. In a discussion with the owner of the first UKU dwelling, he told us not to make the building method too easy, getting everyone to come together and work hard on the project is an important part of the project as well.

Though the UKU structures were designed for a 50 year period, there is the possibility that they may last longer. There are many examples of earthen structures that have lasted the 6 generations or 150 year period requested by the MCRG. UKU has good natural resistance against insects, decay and fire, and building maintenance is expected to be low and carried out by the house owner as needed (e.g. mud plaster). No chemical treatments, paints or other materials have been applied to the UKU walls.

Cost of Construction

The construction of the Rotoiti UKU house and a timber framed house with an equivalent floor plan has allowed a cost comparison to be done. The Rotoiti UKU house build cost was $84889 and the timber frame equivalent house was $72,437 (15% cheaper).

The exercise showed that the light timber housing method is a cost effective, well established building method in New Zealand and should be fairly considered as a potential housing option. The material costs for the UKU house were low but the labour costs were high. Construction costs were more expensive because several procedures and methodologies had to be modified or created by the research team like the formwork system and the mobile flax stripper. In saying that, the cost of the Rotoiti UKU house is not unreasonable and the next UKU house to be built in Ahipara is likely to save at least 10% from improvements in building methodology and design.

Another aspect that makes the UKU housing method potentially more affordable is the sweat equity component; the monetary value of the house that can be sourced from the land and the owner's whanau (extended family). 19% of the cost to build the Rotoiti UKU house (labour, soil and flax) could be sourced in kind from the human and natural resources available in the local community. Financial institutions in New Zealand are reluctant to lend to sweat equity based schemes however it has become an accepted model in some countries; Hawaii, USA, being one example. The use of a sweat equity contribution as a proportion of the upfront deposit required for a mortgage would allow many more rural Māori to be able to afford to build good quality houses on their lands.

"There are over 2000 owners for Haumingi 10a2b Papakainga...The land is not alienable and securing finance for construction (mortgage) over the land and house is not possible.

- Principal Investigator, Dr. Kepa Morgan

Supporting a Sustainable Community

A report by Housing New Zealand in 2005 showed that a disproportionately high and unacceptable number of individuals living in rural Māori communities resided in overcrowded, substandard dwellings. Existing conventional housing solutions are not meeting the needs of many rural Māori because the financial, legal and practical obstacles are insurmountable for many. Rural Māori also have different lifestyle needs.

The UKU method allows the owners to input into the design of the house. A large lounge was built in the Rotoiti house even though there were only two full-time occupants because large house gatherings are common; especially in the summer. The Ahipara owners have developed an open two room house floor plan with a communal sleeping area in one half and a kitchen and eating area in the other – similar to a marae concept. By letting the owners design the floor plan, the needs of the family can be met better than housing methods with preconfigured floor plans or floor plans designed by people who are unaware of the cultural and lifestyle needs and expectations of rural Māori.

As stated above, the process of building an UKU house is a collaborative one where individuals from the community are drawn together to help build the house. Over the course of the construction, relationships are

renewed and strengthened, communication channels are opened and the community is strengthened. There is a collective pride and identity that arises out of the project. One unemployed teenager from the local community that helped to build the Rotoiti house told the Whareuku team proudly, "I built that house." There are good memories and benefits that arose out of the construction of the Rotoiti UKU house and the house is a physical reminder to the community as they drive past it on SH30.

"We noticed the sense of satisfaction and self determination of the owners; and in terms of materials used, it reinforces the connection people have to their land. To take control of the process and to produce something is quite empowering."

- Principal Investigator, Dr. Kepa Morgan

In recent times it is recognized that many Māori are choosing to return home to live with their family on their ancestral lands. Each year this trend can be clearly seen in national population statistics. The lack of existing accommodation and difficulties with developing more houses on rural Māori land results in many overcrowded living arrangements, the construction of sub-standard dwellings or conversion of sheds and garages into living areas, and renting. If the UKU method gains acceptance it will provide numerous benefits to rural Māori communities, reduce the negative impacts related to commuting to be with family, and perhaps most importantly, to allow Māori the option to live on their land, to reconnect with their culture and identity, and be close to family.

(please extend box as needed), or provide separate document.

3 OVERVIEW OF PROGRESS AND CHALLENGES TO DATE:

A very interesting outcome of the SHAC project is the sharing of stories about what teams wanted to do, but could not for various reasons. For example, teams have had troubles getting materials approved, finding the funds to adapt overseas design guides to the New Zealand Environment, or sourcing system components at a price comparable to what is available overseas.

What design elements or strategies did your team wish to consider but could not include in the design? Why?

An advantage of the UKU building system is the potential to source building materials locally, especially the soil. For the Rotoiti UKU house soil samples from six local quarries were analyzed; four quarries had soils with suitable characteristics for rammed earth construction. The quarries were ranked based on distance from site, quantity available, cost, colour and composition. All the quarries were initially happy to supply the soil however when asked for the soil, all four quarries changed their mind because the extraction of soil was not included in their resource consent. Due to time constraints soil from Lyons quarry in Auckland was used to build the house. To put the sourcing of soils in context, the Lyons quarry soil had been used to build the second UKU structure (Auckland), the first UKU structure was built using on-site soil deposits and the next UKU house in Ahipara will be built using on-site soil deposits.

"We knew what we could use." "The transport cost (of the soil) was about five times more than the materials"

- Main Contractor, Brian Morgan

In the Rotoiti area, water is provided from a nearby natural spring for a fixed cost per quarter. This raised an issue over implementing dual flush toilets, flow restricting shower heads and aerated taps because there was no financial or practical incentive to install more expensive water saving devices. In the end these features were implemented.

Composting toilets were an attractive addition to the house but was not included in the final design because of the difficulty of passing the alternative toilet design through the Rotorua District Council. The council required the installation of a septic tank unit costing over $15,000 due to the close proximity of the site to Lake Rotoiti. The septic tank was installed to comply with council requirements.

The original site for the UKU house was not where it was built. The original site was on the Western shore of Lake Rotoiti. Early dialogue with five rural Māori papakainga revealed the original site as the best site to build the UKU house in terms of available land, agreement with the land owners and the available community labour for the research project. The project progressed to the point where the house design, the labour force and the site had been confirmed. Nearer to the time of construction however, a few people with an interest in the land objected to the project and the dispute reached a point where a Māori Land Court injunction was being prepared to stop the project. Māori land is owned collectively by thousands of people spanning several generations, and collectively they have many different ideas on how to best develop their land. This situation is not uncommon. Significant delays were encountered as the research team sought a new site to build upon. The replacement site identified is where the Rotoiti UKU house stands today. From this experience the research team learnt to always have a backup location in mind because providing housing on Māori land is, more often than not, a difficult process.

The original UKU method did not have vertical steel reinforcing bars embedded within the UKU wall panels. Initial tests showed that the flax-fibre reinforced panels were flexible and strong enough to withstand the highest seismic design loads in New Zealand. As more tests were conducted, the results obtained showed very great variability in the material performance of UKU. The research revealed that significant variations could arise from using different soils and builders, but also between panels built by the same builder using the same soils. One of the conclusions of the tests was that the flax-fibres could not be relied on to guarantee adequate performance in

an earthquake until the variability of the soil could be better controlled and consistently strong samples could be produced. Due to the strict time frame of the project and the need to satisfy council requirements to gain building consent, vertical steel reinforcement bars were introduced into the panels to raise the seismic performance of the UKU panels to acceptable levels.

(please extend box as needed), or provide separate document.

4 TEAM FINDINGS

Please list the main findings from your experience. What recommendations do you have for someone who wants to attempt a similar project at your institution? This includes but is not limited to technical, process, support, and management areas.

Diversity and unity is key

Whether within the team or working with people from the rural Māori community, there are a great range of personalities, ideas and strengths that are available – if individuals are able to work well together as one team. This involves investing time into building relationships, encouraging an inclusive mindset, compromise and collaboration, and by having clear goals which all members agree with and commit to achieving.

Because of the Whareuku team's diversity the outputs of the team are broad, varied and rich and the research has benefitted greatly; Technical presentations have been presented both in Aotearoa and overseas in China, Australia and the UK, several movie clips have been produced featuring the Rotoiti house and the Whareuku team, outreach programs have been put together for the local Rotoiti community and an interactive art gallery exhibition has let a diverse crowd of family, friends, classmates and the general public learn, physically build and appreciate the UKU method.

On a broader level the research is made relevant to the communities we are working with because they were given the opportunity to input into it. If a solution is sought for a particular need, the people experiencing the need should have a say. Interaction and consideration of people cannot be avoided if an appropriate solution is to be developed. Construction approaches that strengthen community cohesion and resilience are preferable. Good conventional housing methods have been demonstrated not to work so well in a rural Māori context. Research that aims to benefit a community works best if the researchers have experienced and are a part of the community. A technical solution won't suffice. This is especially true in the complex housing situation on rural Māori land.

"My only recommendation for future teams is the necessity of getting the owners behind you; I found the wholehearted backing of Ross and Margaret behind the construction of their new house something that was both encouraging and essential to the success of the project."

- Whareuku team member, Anna Robertson

" We have had the advantage of meeting each other and sharing experiences with people from other departments of the university, which is something I have always had lingering in my mind but couldn't think of a way to achieve it; and then it came to me, so to speak."

- Whareuku Team member, Julia Chiesa

"The interdisciplinary co-operation has brought so many personalities of people together, and with that so many styles of doing things. I've really learnt to value the diverse passions that people bring to the group. Without someone really going into thermal imaging, or someone passionate about the finer aspects of video work, we would have been much less as a team."

- Whareuku Team member, Deborah Teh

Positive thinking is important

When concrete was first discovered, it took over a century of struggle and scorn to gain the world wide acceptance it enjoys today. A similar story can be told for many building materials in the market today. Development of a new housing method will be the same. In addition to the many (and sometimes powerful) detractors that want to keep doing things 'the old way', there are significant practical obstacles that will need to be overcome. Some will seem insurmountable. Times of doubt and hardship are bound to occur. Positive

thinking greatly increases the creative capacity of the mind to solve problems. Instead of saying "We can't do it", "This is impossible", it asks "How can we get around this?", "What options do we have?"

Enjoy and make the most of the journey

Be prepared for a long journey and recognise that the majority of value in the project is received along the way. Being a people orientated project with many different sub projects, one is sure to meet new people and have several mini-successes along the way. Make time to meet and teach the people you meet, celebrate the intermediate successes and enjoy the journey. When the Whareuku Team passes the best pie shop in NZ on the 3.5 hour trip down to Rotoiti, we stop to enjoy a delicious lunch. There is a (free) natural hot spring nearby the Rotoiti UKU house so whenever we stay overnight we bring our togs. We have met many people in the Rotoiti local community and from the general public who are interested to learn about what we are doing. The project has provided many opportunities to mix with and learn from people that we would not otherwise have been able to meet.

Expect delays

If it's a choice between having lunch at lunchtime and getting the job done - get the job done. Housing projects like this are huge and are prone to a similarly large range of delays. Rain, illness, changing requests from the client, council processes, unexpected events (e.g. bereavement), financial issues, schedules not coinciding, heavy workload, other commitments, etc... We've had them all during this project. To have a chance at staying on schedule it is important to 'do things now' even if it can be done tomorrow.

"9 to 5 doesn't work so well if you're trying to create this level of change."

- Whareuku Team Leader, John Cheah

"If it was raining, we couldn't ram and it would hold up the bobcat driver where he was working; so he couldn't come out to the land to do the job...You have to go for the best weather you can get...from November through to February..."

- Main Contractor, Brian Morgan

Be flexible

Working with a new technology like UKU, sometimes you have to create a solution "on the back of an envelope". Sometimes something will happen that was not pre-empted – you must be flexible and ready.

"When you have a "new construction system with new materials it is going to raise more questions than it answers in the beginning. That is a benefit."

- Principal Investigator, Dr. Kepa Morgan

"The challenges for me have been greatly educational towards my art practice and art work. I had a great challenge of working with two other students with the simple struggle of distributing tasks. I also had trouble knowing how much work I was capable of holding as this project is something on the side for me, but has demanded many hours of travel, planning, shooting and mostly editing and structuring the edit. I would say I have spent at least 35 hours on the movie itself. It was a new way of working as I usually create more abstract videos for my degree that includes installations and contemporary artistic styles, so the conventional structure was a great challenge that I had foreseen and I appreciated what I learned through that process. Working with engineers was another great challenge and learning experience. I am not really used to other people setting goals with me and dates for things to be done, as our practice at Elam is self directed and we set the dates for ourselves. It is another aspect that I really enjoyed because it helped me towards my own structuring of when and what to get finished and ready

for the next task in all aspects of my degree."

- Whareuku Team Member, Julia Chiesa

A passion for the work

The team really has to buy into the project because there is a significant cost of time and energy for students, lecturers and professionals that form a SHaC09 team. You won't get a grade, pay-rise or formal acknowledgement to encourage you on, and the great future outcomes and opportunities this project will create won't help much during the hard times – passion will. (Having encouraging team members helps!)

To be a member of the Whareuku Team you have got to be prepared to get outside your comfort zone. You can expect to have hands on experience with building walls, namely out of dirt! So you need to be happy to get your hands dirty. You need to be committed to researching a holistic building system. When you are part of the Whareuku Team you need to be ready to chip in with any part of the team even if it is not in a field of your strength. The biggest thing you need however is to be interested in helping to provide a practical solution to rural housing issues.

- Whareuku Team member, Jason Kururangi

"Participating in this competition has time and again reminded me that there are motivated people in the community who are dedicated to helping both to improve the standards of living of others as well as to do their part in protecting the environment."

– Whareuku Team member, Gabrielle Chin

Building with earth is easy to learn but requires time and practice to master

As with anything, new methods take time to learn and master. Find someone who knows how to do it and ask them to show you how to do it the first time. The UKU building method is simple and intuitive but nothing is as important as experience.

"The first wall is always the worst wall. Perhaps make a test one first."

- Whareuku Team Leader, John Cheah

5 TEAM MEMBER COMMENTS

Please solicit comments from your team members about their experience. Emotional as well as reasoned responses are good for communicating the successes and challenges of this project.

The easiest way to collect these responses may be to have your team members sign up to the SHAC site at http://www.shac.org.nz/main/authorization/signUp and ask them to answer this question when they sign up.

When the idea to build UKU walls as an art exhibition was suggested, I thought it was quite a novel idea. It was with a little surprise a few days later that I heard Anna (a Whareuku Team member) had gone ahead, put in a last minute submission to the George Fraser Gallery, and got accepted. I thought it was a unique opportunity to show the public about UKU and for those who were keen, to teach them how to build using the UKU method and let them get some hands on experience. I knew it would take a lot of work but didn't think much about it then. As the opening date came closer, the planning and preparation took an enormous amount of time and my engineering colleagues increasingly reminded me that an art gallery exhibition was stretching it, in terms of my doctoral research. The 9 days of open exhibition demanded a large commitment of time and energy from everyone. Every day the team stayed late, finishing unfinished work and preparing for the next day. Was it worth it?

Definitely!

During the exhibition, the team met lecturers and students from different departments around the university, people passing by, friends of friends, environmental enthusiasts - all sorts of people. There was a great diversity in the people coming into the gallery and it was humbling and rewarding to have visitors taking the time to see, learn about and help build the UKU wall. There was great public interest, lots of sharing of knowledge, time to chat (whilst working hard) and something I didn't expect - a powerful sense of community. From this experience I was able to appreciate another part of the UKU building method I hadn't picked up when working on the project from a technical perspective. UKU wasn't just an affordable, appropriate, engineered housing method - it was a way to bind people and communities together.

- Whareuku Team Leader, John Cheah

"SHaC has given me the opportunity to work with people who are actively engaged with issues that should concern all of us, and who are consistently an encouragement and a reminder to keep working towards bringing us all to a better place."

- Whareuku team member, Deborah Teh

I joined the SHaC09 competition because it raises public awareness of a diverse range of visionary housing solutions. The domestic house construction industry will have to undergo great change in the future as resource availability decreases and environmental policies are enacted. In as short a time as 10 or 20 years, houses in New Zealand won't be designed and built like what is common today, they're likely to resemble houses SHaC teams are designing and building now.

- Whareuku Team Leader, John Cheah

I found this a really great experience. As a fine arts student my path very rarely crosses with anything remotely connected with civil engineering and I knew next to nothing about it. Now I can talk on and on about sustainable building techniques, particularly the rammed earth method and found myself explaining it to a friend of mine who actually studies civil engineering. I really enjoyed meeting new people both on the team and also at Lake Rotoiti, and hearing about their passion for both quality housing and sustainability. This has inspired me. Two things really stick out to me; One is the awkward realisation of how different people are when I first sat in a meeting with the team and how now we sit around and joke that unlikely friendships have emerged out of a shared experience. The second thing about the project that really stands out to me was interviewing Ross and Margaret Hitchcock, the owners of the Lake Rotoiti house, and hearing Margaret talk passionately about owning an earth

home, and also the significance of the land to her, her ancestors and her daughters. She has dreamed of having an earth house for a long time and even had plans drawn up. To hear her talk about achieving this seemingly unachievable dream was really beautiful. To see a building invention designed, not as a money making scheme, but rather in conversation with rural Māori to meet their housing needs, and also aligned with their values, gives me hope for the future, both in terms of the development of affordable, quality housing for everyone and the overall pursuit of sustainable living in New Zealand.

- Whareuku team member, Anna Robertson

It has been a great experience being a member of the Whareuku Team 2009. I have been working on the future application of the technology in various environments. One of my major roles has been to look into the ability of UKU to be used in various geographic environments around New Zealand. I have been doing this by running computer simulations on a simplified version of the Rotoiti UKU house. This has been extremely challenging as computer programmes and me don't tend to go hand in hand! On the positive side to this however is that I managed to get some results that were useful in predicting how Uku will perform in different locations with different wall thicknesses throughout New Zealand. Hopefully this model will provide some of the guides to predicting applicable wall thicknesses throughout New Zealand

- Whareuku team member, Jason Kururangi

"I learned much more about rammed earth housing that I hadn't previously known. My father is a builder in New York and he had built our house in a very innovative way in regards to orientation and fanning systems for regulating temperatures in seasons via a belvedere and other deliberate designs. I was and am excited about this technology and would definitely build my own house out of Whareuku because of its awareness to those aspects and because of the way it feels. When I was filming Ross and Margaret at the Rotoiti house in June, it felt so warm and unlike any other house I had visited. The walls didn't feel like barriers to separate the outside from the inside, as I feel in my house in Herne Bay, Auckland. It feels more continuous to the environment outside, yet protects from the wind and wet. The sun radiated from the inside of the walls and was sensational and felt very healing. The walls made me think about how they would also avoid bug infestations and then I realized how different a technology it is. I realised through our journey of this project, that it is a very old way of building but has reinforced and readapted to the people and situations here, and this makes it very personable and approachable. I have spoken with other people in New Zealand in different communities and they feel like this is a very necessary direction to progress as everything in the world is working towards creating the least amount of waste and most sustainable approaches to maintain the earth's ecosystems and vitality. And to have something that brings people together to create as we used to create is a gift to this modern era of separation and individuality. In reality, we can never exist in total independence from one another, everything we use in everyday life is made via a massive collaboration between people's efforts; this technology has shown that these relations can cross and the people involved can feel closer to each other through the design process. I think we are all beginning to realize the importance of this."

- Whareuku team member, Julia Chiesa

"If I had known the amount of work to be done, and the amount of time to do it; I definitely would have asked in the beginning for another editor/film maker to help carry that weight. It is all part of the learning process and now I feel more aware to evaluate that and suggest it in my next projects."

- Whareuku team member, Julia Chiesa

"I also found a struggle by the way that we structured the filming and pre production aspects of the video. If I had made a shot list and rough script then I could have sculpted the interviews more precisely. The blindness of the shoots was a great challenge but very constructive in my learning because it brought out the aspects of my weaknesses and made them apparent. This means I know how to approach the next project more confidently and with more structure."

- Whareuku team member, Julia Chiesa

(please extend box as needed), or provide separate document.

6 COMMUNICATIONS CAMPAIGN

Please list promotions, communications and research outputs. Please list current and expected. Use either a formal (as below), or informal style as convenient. Attach copies of Media and Publicity Achieved by the team.

1. **Cheah, J.S. (2008) A New Zealand Sustainable Housing Competition. South Pacific Island Engineering Students Association meeting, 03 April 2008.**
2. **Cheah, J.S. (2008) Whareuku Team 2008 Launch. 14th April, The University of Auckland Engineering School Cafetaria, NZ.**
3. **Claire Choe (2008) Radio interview with John Cheah on bFM Radio station GreenDesk. 29 April 2008.**
4. **UKU Interview with John Cheah. Central Leader Newspaper. May 2008.**
5. **Cheah, J.S. (2008) A New Zealand Sustainable Housing Competition. Waitakere City Council Sustainable Building Network Conference. 21 May 2008.**
6. **Khoo, H. (2008) Green Edge to Houses. Eastern Courier Newspaper. 30 July 2008**
7. **Yuyi Shi. Whareuku Team Sponsorship Pack sent to potential sponsors. 26th August, 2008**
8. **Whareuku Team (2008) Exhibition at the University of Auckland Open Day. 30 August 2008.**
9. **Whareuku Team (2008) Exhibition at the University of Auckland E'Day for Indigenous Students. 02 September 2008.**
10. **Cheah, J.S., Morgan, T.K.K.B. and Ingham, J.M. (2008) Overview of a Cement-Stabilized Flax-Fibre Reinforced Rammed Earth (UKU) Building System for New Zealand Indigenous Communities. World Sustainability Conference 2008, September 21-25, Melbourne, Australia.**
11. **Cheah, J.S., Morgan, T.K.K.B. and Ingham, J.M. (2008) Cyclic Testing of a Full-Size Stabilized, Flax-Fibre Reinforced Earth (UKU) Wall System with Openings. 14th World Conference on Earthquake Engineering, October 12-17, Beijing, China.**
12. **Sonia Randhawa. UKU Interview with John Cheah. Radio Australia / ABC Radio, Melbourne, Australia. 7 October 2008.**
13. **Whareuku House Blessing. November 12th, 2008.**
14. **Whareuku Team (2008) Posters of UKU Research Display. 3rd International Conference on Sustainability Engineering and Science, December 9-12, Auckland, New Zealand.**
15. **Lahni Sowter (2008) UKU Interview with John Cheah. Radio TautokoFM, Maungamuka, New Zealand. 31 December 2008.**
16. **Cheah, J.S. (2009) The UKU Project: A Sustainable Housing System for Rural Māori Communities. U3A Meeting, Nixon Hall, Howick, Auckland, NZ, 9th February, 2009.**
17. **Deborah Teh (2009) Whareuku Poster. Created 18th February.**
18. **Whareuku Team. Website Launch 1st March, 2009. www.whareuku.com**
19. **Cheah, J.S. (2009) Whareuku Team e-Newsletter March.**
20. **Whareuku Team (2009) University of Auckland Engineering Library Display 24th March to 7th June.**
21. **Whareuku Team (2009) Whareuku Team 2009 Re-Launch. 27th March 2009.**
22. **Paul Stock (2009) Interim HERA Report. Received 23rd April.**
23. **Cheah, J.S. (2009) Whareuku Team e-Newsletter July.**
24. **Whareuku Team (2009) UKU Workshop. July 1-3, The University of Auckland, Civil Engineering Test Hall**
25. **Danelle Clayton (2009) Earth Housing a New Low-Cost Option. Building Today, 1st July 2009, pg 13.**
26. **Ngawai Herewini. UKU Interview with Rueben Porter. 3rd July 2009, Te Hiku 94.4FM / NgatihineFM 96.8 / Radio Tautoko FM.**
27. **Ngawai Herewini. UKU Interview with Rueben Porter. 7th July 2009, Te Hiku 94.4FM / NgatihineFM 96.8 / Radio Tautoko FM.**
28. **The University of Auckland. (2009) Earth housing could be the Way Forward for Rural Māori. Retrieved 9th July from http://www.auckland.ac.nz/uoa/home/about/news-events-and-notices/news/template/news_item.jsp?cid=169017**
29. **The University of Auckland Faculty of Engineering. (2009) Earth housing could be the Way Forward for Rural Māori. Retrieved 9th July from http://www.engineering.auckland.ac.nz/uoa/engineering/news/2009/july/uku-house.cfm**
30. **The University of Auckland (2009) Earth housing could be the Way Forward for Rural Māori. Retrieved 9th July from http://www.scoop.co.nz/stories/ED0907/S00036.htm**
31. **Kingi Kiriona (2009) UKU Interview with John Cheah. TV1 Te Karere News, 9th July.**
32. **Whareuku Team (2009) UKU Field Trip. 10th July.**
33. **Yandre Hueber (2009) "UKU" House will be built of Clay and Flax. Northern Advocate, 13th July, pg 3.**
34. **Clay, Flax House for Māori. Hawke's Bay Today, 13th July 2009, pg 5.**
35. **Jim Perry (2009) Tuesday Night Talkback with John Cheah. Radio Waatea 603AM, 14th July.**

36. **UKU Interview with Rueben Porter. Radio Waatea 603AM, 14th July, 2009.**
37. **An UKU House for Ahipara. Northland Age, 14th July 2009, pg 6.**
38. **Yvonne Tahana (2009) Living in the Arms of Mother Earth. New Zealand Herald, 14th July, pg 4.**
39. **Eru Rerekura (2009) Morning Report. Radio NZ – National (Auckland/Christchurch/Wellington), 15th July.**
40. **Rural Māori May Benefit from Earthen Technology. Northern News, 15th July 2009, pg 14.**
41. **Cheah, J.S. (2009) The UKU Project: A Sustainable Housing System for Rural Māori Communities. Minverva Club, Masonic Hall, Highland Park, Auckland, NZ, 16th July.**
42. **Kingi Kiriona (2009) UKU Interview with Rueben Porter and Heeni Hoterini. TV1 Te Karere News, 16th July.**
43. **Earth Housing could be the Way Forward for Rural Māori. NZ Education Review, 17th July 2009, General News, pg 5.**
44. **Ngawai Herewini (2009) UKU Interview with Rueben Porter. 17th July, Te Hiku 94.4FM / NgatihineFM 96.8 / Radio Tautoko FM.**
45. **Whareuku Team (2009). Eco houses / Eco property / Sutainable Houses. Ecobob. Retrieved 12th July, 2009 from http://www.ecobob.co.nz/EcoProperty/1234/Whareuku-Earth-House.aspx**
46. **Whareuku Team Report. IPENZ StudentDirect July/August 2009, Issue 33, pg 13.**
47. **Cheah, J.S. and Morgan, T.K.K.B. (2009) UKU: Concept to Construction Using Flax-Fibre Reinforced Stabilized Rammed Earth. 11th International Conference on Non-conventional Materials and Technologies. September 6-8, Bath, UK.**
48. **Whareuku Team (2009) UKU: Towards Sustainable Housing Solutions for Māori. Engineers for Social Responsibility Meeting, The University of Auckland, NZ, 17th September.**
49. **Julia Chiesa, Deborah Teh and Anna Robertson (2009) Whareuku Team Movie Clip. First screened 17th September 2009, The University of Auckland Engineering School, Auckland, NZ.**
50. **Jenny Chu, Yuyi Shi and Heeni Hogrene (2009) Creation of bi-lingual brochure and pamphlet for UKU promotion to public. Printed 28th September, 2009.**
51. **Whareuku Team (2009) "One Quarter of a Whare" Art Exhibition, 29th September – 8th October. George Fraser Gallery, Auckland, NZ.**
52. **Cheah, J.S. (2009) UKU: Towards Sustainable Housing Solutions for Māori: UKU. Engineers for Social Responsibility Newsletter, October, Vol. 25, No. 5, pg 11-13.**
53. **Anna Robertson, Deborah Teh and Julia Chiesa (2009). Elam/Engineering installation lets visitors get their hands dirty. Retrieved 5th October from http://www.engineering.auckland.ac.nz/uoa/engineering/news/2009/october/one-quarter-of-a-whare.cfm**

Future Events

54. ***Cheah, J.S. (2009) UKU: Concept to Construction Using Flax-Fibre Reinforced Stabilized Rammed Earth. Earth Building Association of New Zealand Conference 2009. October 23-26, Dunedin, NZ.***
55. ***Cheah, J.S. (2009) Whareuku Team e-Newsletter November.***
56. ***Whareuku Team (2009) Rotoiti UKU House Open Day 8 November, 2009, Rotoiti, Western Bay of Plenty, NZ.***
57. ***Whareuku Team (2009) The Rotoiti UKU House. SHaC09 Symposium: Practical Housing to Support Sustainable Living, November 19-21, Dunedin, NZ.***
58. ***Whareuku Team (2009). UKU Workshop. November 27-29, Ahipara, Tai Tokerau, NZ.***

(please extend box as needed), or provide separate document.

7 COLLABORATION AND INVOLVEMENT

Please list your team members, email, and a few word description of their role.

Dr. Kepa Morgan k.morgan@auckland.ac.nz – Associate Dean Māori / Senior Lecturer
- Team Mentor

Jing Siong (John) Cheah jche242@aucklanduni.ac.nz – PhD Engineering(Civil) student
- Team Leader, Webmaster, Newsletter Editor, Treasurer (2009), Presenter, Library Display, George Fraser Art Exhibition

Yuyi Shi shi.yuyi@gmail.com – BPlan student
- Sponsorship Pack Design, Secretary (2009), Community Outreach (2009), Bi-lingual Whareuku Brochure and Pamphlet

Jenny Chu yy.jenny.chu@gmail.com – LLB/BE conjoint student
- Sponsorship Pack Design, Public Relations (2009), Community Outreach (2009), Bi-lingual Whareuku Brochure and Pamphlet

Deborah Teh furor.pietas@gmail.com – BFA(Hons)/BA student
- Website, Newsletter Design, Movie Team, George Fraser Art Exhibition, Photographer, Library Display, Logo Design

Paul Jarvie pjar013@aucklanduni.ac.nz – BE(Civil) student
- Monitoring (2009), Presenter

Jason Kururangi jkur006@aucklanduni.ac.nz – BE(Civil) student
- Monitoring (2009), Presenter

Anna Robertson arob148@aucklanduni.ac.nz – BFA(Hons) student
- Movie Team, George Fraser Gallery Exhibition, George Fraser Gallery Exhibition Publication

Julia Chiesa chiesa.chiesa@gmail.com – BFA(Hons) student
- Movie Team Leader, George Fraser Art Exhibition

Van Tran vtra011@aucklanduni.ac.nz – BE(Civil) student
- Monitoring (2009)

Gabrielle Chin gabrielle.chin@gmail.com – LLB student
- Public Relations (2008)

Navin Nair bikubiku_literature511@hotmail.com – GradDip(Com) student
- Treasurer (2008)

Hsen-Han Khoo hkho008@aucklanduni.ac.nz – BE(Civil) student
- Monitoring (2008)

David Fehsenfeld dfeh002@ec.auckland.ac.nz – BE(Civil) student
- Secretary (2008), Monitoring (2008)

Kerin Brockbank wadeandkerin@gmail.com – BE(EngSci) graduate
- Social Officer (2008)

Alice Lee summer_style@hotmail.com – BProp graduate
- Community Outreach (2008)

8 BUDGET

Please provide an indication of the significant budget items for the house construction working from your published plans. For houses that have yet to be sold, these numbers will not be published until after sale. Please attach a spreadsheet.

9 KEY PHOTOS

Please supply 5-10 hi-res photos of the project. Action shots of team, construction, design, and photos or rendering key concepts.

10 CONSENT DOCUMENTATION

Please provide copies of the consent documentation.

11 SURPRISE THE JUDGES

Please include, if desired, any more information or attachments that tells your team storey to judges, the design community, and the general public.

The Whareuku Team have put together a 7 minute video clip that provides an overview of the UKU Project that will help the general public get an appreciation of what the research and housing method is about. It is viewable on youtube at http://www.youtube.com/watch?v=BqrKjBN0kOc

A digital model of the thermal performance of the Rotoiti UKU house has been made on the Finite Element program ANSYS. Animations of the internal and external temperatures of a 300mm thick UKU house are attached.

Visit our website on www.whareuku.com

(please extend box as needed), or provide separate document.

12 REPORT LICENSE

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Costs incurred during construction of the Rotoiti Uku House

		Unit	No.	$/unit	Cost	Total
Labour		hrs	904	15		**13560**
Machinery	Bobcat & Compressor	hrs	86	115		**9890**
Materials	Bond beam (shutters, concrete)	m	58	42.5	2465	
	Reinforcing steel & Fasteners				1276	
	Shadow clad timber walls	m2	12	201	2412	
	Soil	m3	21	45	945	
	Soil Transportation	km	3	310	930	
	Cement (40 kg bag)	each	77	18	1386	
	Flax	kg	21	25.00	525	**9939**
Subcontracted Work	Foundation				14000	
	Roof				21000	
	Fixtures (windows, doors, skylight)				16500	**51500**
TOTAL						**$84,889**