FACTORS THAT MAY RESTRICT THE USE OF COB

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ABSTRACT

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It is easy to let the mind labour under particular misconceptions, concepts that seem so *obvious* that they can't possibly be challenged.

Cob seems an *obvious* choice as a building material, it is low tech, low skill, natural, warm, long lasting and bio degradable.

Why is it not more widely used? . . . . . .

In this dissertation I aim to explore the obstacles that may restrict the use of cob in the UK, and ask whether it still represents a viable building material in the 21st Century.

ACKNOWLEDGEMENTS

My Wife

I must thank my wife for picking up the “slack” whilst I have been tied up writing this dissertation. She is pivotal to my existence, and it is my drive to provide for hear and our growing family that has given me the impetus to complete my studies at Bristol, during Full Time Employment, Redundancy, Starting a Company and Moving House.

Alan Feest

I think Alan is the embodiment of what learning should be, his input to the Water and Environmental Management course injected energy and enthusiasm. His guidance on the importance of Reflective Learning has greatly increased my overall academic confidence, after a ten year break from academia this was much needed, and I thank him for that. Besides his academic qualities he is always amicable, and will make time to talk to you, despite I am sure his hectic schedule.

Mum & Dad

Without my parent’s commitment to my obtaining a good education I seriously doubt whether my path in life would have included post graduate education. Since the age of 21 (ish) I have been highly self motivated, but prior to this I was rather directionless, and it is their steward ship that saw me emerge from the earlier chapter of my life in a good starting position.

David Rowley

As time passes you start to appreciate the significance of events in the past, and how they may have shaped who you are, I have a had a number of good teachers, but the best was my A Level geology teacher, would was a most enthusiastic teacher . It was his obvious passion for earth sciences which lead me to choose geology for my first degree.

AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Taught Postgraduate Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, this work is my own work. Work done in collaboration with, or with the assistance of others, is indicated as such. I have identified all material in this dissertation which is not my own work through appropriate referencing and acknowledgement.

Any views expressed in the dissertation are those of the author and in no way represent those of the University of Bristol.

The dissertation has not been presented to any other University for examination either in the United Kingdom or overseas.

SIGNED:

DATE: 03/10/2011

(Signature of student/candidate)

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 COB IN THE UK

When we speak of cob we are in effect talking in dialect, rammed earth, adobe, pise (de terre), taipal, these methods might replace cob on a like for like basis, although each differ slightly. Earth Architecture is a widely employed phrase, stacked earth being the bracket that applies to cob.

1.1.1 THE PAST

Clough Williams – Ellis[1] gives a practical account of using cob, as early as 1919, in reality cob will have been used from as soon as mankind learned to construct dwellings. Its simplicity of use and abundance would have ensured its popularity; outside of the UK records for its use extend back to the 11th Century AD[2].

There is no questioning the longevity of cob, provided rooves are well maintained cob can last for hundreds of years. Many houses in Devon are constructed from Cob constructed from 1700 onwards[3], they provide comfortable dwellings to this day.

1.1.2 THE PRESENT

Currently it is estimated that one half of the world's population, approximately three billion people on six continents, lives or works in buildings constructed of earth[4], it is hard therefore to ignore its significance as a building material on a global scale. However, when we consider the UK, or Western Europe, as a percentage of current housing stock cob represents a very small fraction.

[1] Cottage Building in Pise, Chalk and Clay – Clough Williams – Ellis (1919)
[2] pp. 751–795, in *Encyclopedia of the history of Arabic science*, vol. 3, Roshdi Rashed and Régis Morelon, eds., Routledge, 1996
[3] Authors current residence built in 1750.
[4] Earth Architecture by Ronald Rael, 2008

Cob is being used in the UK, there are various specialist companies around the UK that are building with cob[5], and this suggests a demand. The extent of this demand is unknown, and at first glance cob would appear to be very much a niche market rather than a mass housing solution. Cob is also ideally suited as a self build material[6] (see inset).

1.1.3 THE FUTURE

The 2016 "Zero Carbon" target[7] refers to *operational* carbon of new homes, we can expect the embodied carbon of homes to become a more pressing factor as it significance rises proportionally to lower operational carbon of new homes.

> *"The energy embodied in new construction and renovation each year accounts for about 10% of UK emissions"*[8]

This may ultimately lead the focus to shift from operational energy to embodied energy. It is a logical progression that once houses become zero carbon; in an operational sense the next thing to improve is the embodied carbon, as proportionately this becomes more important.

1.2 WHY THIS TOPIC?

I have chosen this topic for a number of reasons:

1. Gap in the current research: Government policy aims for low embodied carbon, whilst making little mention of cob. Affordable housing is desperately needed[9] and yet the current trend in the use of high tech materials will actually increase the initial cost of homes. It would be beneficial therefore to marry these concepts of *need* for affordable homes and low tech low cost *solutions* if applicable.

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[5] http://cobincornwall.com/index2.htm 18/08/11
[6] Agricultural Tie Dwelling – Dartmoor – Site visit January 2011
[7] http://www.communities.gov.uk/documents/planningandbuilding/pdf/153125.pdf - 03/10/11
[8] http://www.sustainablehomes.co.uk/upload/publication/Embodied%20Energy.pdf – 12/09/11
[9] Understanding demographic, spatial and economic impacts on future affordable housing demand – Source Document from the Cambridge Centre for Housing and Planning Research, University of Cambridge - December 2007

2. Expertise: Although I am a little hesitant in calling myself an expert in any field, I believe that this area of research very much matches my back ground, I have several years experience in Environmental Consulting, and I have further deepened my knowledge owing to the MSc in Water & Environmental Management I have been studying at Bristol University.

   Whilst growing up I have spent many a summer working for my father's construction company, and worked as a brick layer whilst studying my first degree at Portsmouth. 2009 saw me made redundant from consulting and back on the building site, viewing with fresh eyes the materials and methods I saw before me.

1.3 WHAT IS THE PURPOSE OF THIS RESEARCH?

The purpose of this research is to reveal the obstacles that are stalling the wider uptake of cob, and establish whether cob is still an applicable building material in 2011.

1.4 OBJECTIVES

1. By reading a wide variety of literature, try to deduce what obstacles may be slowing the wide utilisation of Cob in the UK housing Industry.

2. After identifying gaps in current literature further explore possible obstacles by conducting research in the form interviews and surveys.

1.5 LIMITATIONS

I am not an architect. I do not work in building control. I do not work in the risk assessment department of a large mortgage lender. I am almost certain that during this research I will make incorrect assumptions about certain aspects of what I am trying to understand.

1.6 HOW IS THE DISSERTATION ARRANGED?

I have followed guidance from the from various official sources, that I have found on Bristol University Intranet and on External Websites, the structure the dissertation can be seen in the contents page, and is arranged in accordance with the University of Bristol guidelines.

I do sincerely hope that this research will be of practical use to someone. Perhaps they may wish to build using cob, give advice on its use, or they are researching themselves. For these reasons I intend to publish this dissertation as free on line content on one of my

websites[10], the structure will be broken down to provide easy navigation of content, definitions and further reading.

1.7 HYPOTHESIS

I predict that there will be number of obstacles that are barring the wider uptake of cob in the UK. These may be for example regulatory or financial, but I predict that they *must* exist, as there is a well published need for easy to build low impact housing.

2.1 REGULATORY OBSTACLES

2.1.1 THE NATIONAL STRATEGY

> *"A quarter of the UK's current carbon emissions (around 150 million tonnes of carbon dioxide each year) arise from the way we heat, light and run our homes. We want to increase protection of the environment by cutting carbon emissions, and we want all new homes to be zero carbon from 2016."*[11]

There is no doubt what so ever when it comes to the governments overarching principles with regards to sustainability. There are well established driver policies for the encouragement of sustainable homes[12], and there is a means of rating these homes in terms of their sustainability[13].

2.1.2 LOCAL PLANNING AUTHORITIES

On a local level designs have to be practical, they have to blend in with other buildings in the area. They are restricted in terms of their maximum height, the external materials and in some cases must match existing historic neighbours[14].

Their environmental benefits will have little bearing on whether permission in granted or not;

> *"With regard to Planning Permission, earth-walled buildings would be treated in exactly the same way as those with walls of masonry or timber-framed construction."*[15]

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[10] previous version of this dissertation already published – http://the-environment.org.uk/info_pages/sustainable_housing.html
[11] Homes for the future: More affordable, more sustainable - CM7191
[12] Planning Policy Statements 1 -25 - www.communities.gov.uk
[13] Code for Sustainable Homes
[14] Bell Farm Sedgemoor - Planning Conditions
[15] http://www.devonearthbuilding.com/faq.htm

2.1.3 BUILDING REGULATIONS

The Devon Earth Building Society has successfully undertaken research in to

> *"practical guidance on how traditional cob can satisfy current Building Regulation requirements with respect to low-rise residential properties"*[16]

Barbara Jones notes that building regulations are written to:

> *"cover the most common types of twentieth century building materials, that is concrete, brick and timber"*[17]

So although it is possible to build using cob it is the very least going to be more difficult. Throughout history cob has had increasingly more restriction placed upon its use from around 1850, with various local government acts, effectively excluding it as a viable building material, it was not until 1965 that phrases such as *"fitness of materials*" [18]

were included, prior to this examples such as brick and stone were listed guaranteeing the exclusion of a great many building materials, such as cob. 1985 was the year when Cob became "legal" once more;

> *"any material which can be shown by experience such as a buildings in use, to be capable of performing the function of which it is intended"*[19]

This opened a window of opportunity for the use of cob, but does not guarantee a project will be passed off, with regards to the structural integrity, fire safety, environmental credentials or other areas of assessment within the Building Regulations.

2.2 MORTAGES

How is Cob assessed in terms of risk? Is it easy to acquire a mortgage for a cob house?

2.2.1 EXISTING GUIDANCE FOR LENDERS

2.2.1.1 LPS 2020

LPS 2020[20] is a Standard released by the BRE it aims to:

[16] http://www.devonearthbuilding.com/leaflets/building_regs_pamphlet_08.pdf - Alan Stokes (19/08/11)
[17] Building with Straw Bales - A Practical guide for UK and Ireland by Barbara Jones
[18] National Building Regulations - 1965
[19] National Building Regulations - 1985
[20] BRE - LPS 2020 - Standard for Innovative Systems, Elements and Components of Residential Buildings

"encourage methods of construction whilst maintaining acceptable levels of safety and durability" and *"create confidence in the use of such methods in residential construction"*

It is specifically aimed at;

"Council of Mortgage Lenders and Lenders (and) Surveyors"

as well as a number of other key sectors such as insurers and building control. The standard consists of a 30 page document which gives real technical guidance, and recommendations, with an aim to providing a certification.

Mechanical Resistance and Stability is covered in section 4.1, it refers heavily to building regulations. However, it would appear that there are various methods such as "verification by calculation", perhaps not suited to a non manufactured material.

Section 4.1.2.3 states that

"design of systems elements and components shall be carried out by a qualified structural engineer in accordance with relevant material and structural standards"

I would question as to whether a "structural standard" exists for cob, and as such is LPS 2020 we might consider LPS2020 of limited use with regards to facilitating the wider uptake of cob.

2.2.1.2 The NHBC

Certifying bodies, such as the National House Building Council, which can have a significant influence on domestic projects, will refuse funding on projects using 'novel' materials.[21]

With The NHBC being a foremost authority on the longevity / structural quality of building this may not bode well for lending risk levels, ergo ease of securing loans against cob dwellings.

2.2.2 HOPE?

When lenders adhere to quantitative risk systems where can we look for a more impassioned source of finance, for the purchase of existing or funding of cob building projects.

2.2.2.1 LENDERS WITH A GREEN AGENDA

[21] The NHBC would require demonstration of compliance with a relevant standard to issue their 60 year guarantee. Pers. comm..Neil Smith, NHBC Technical Dept

There are various lenders which have “green” initiatives. The Co-operative Bank and The Norwich & Peterborough Building Society[22], but these schemes are based more on the bank’s behaviour / CSR initiatives rather than its lending model.

One potential source of hope for the future is the Ecology Building Society[23], they have a “*unique lending criteria*” and since their inception they have been committed to mortgage, lending on environmentally beneficial projects.

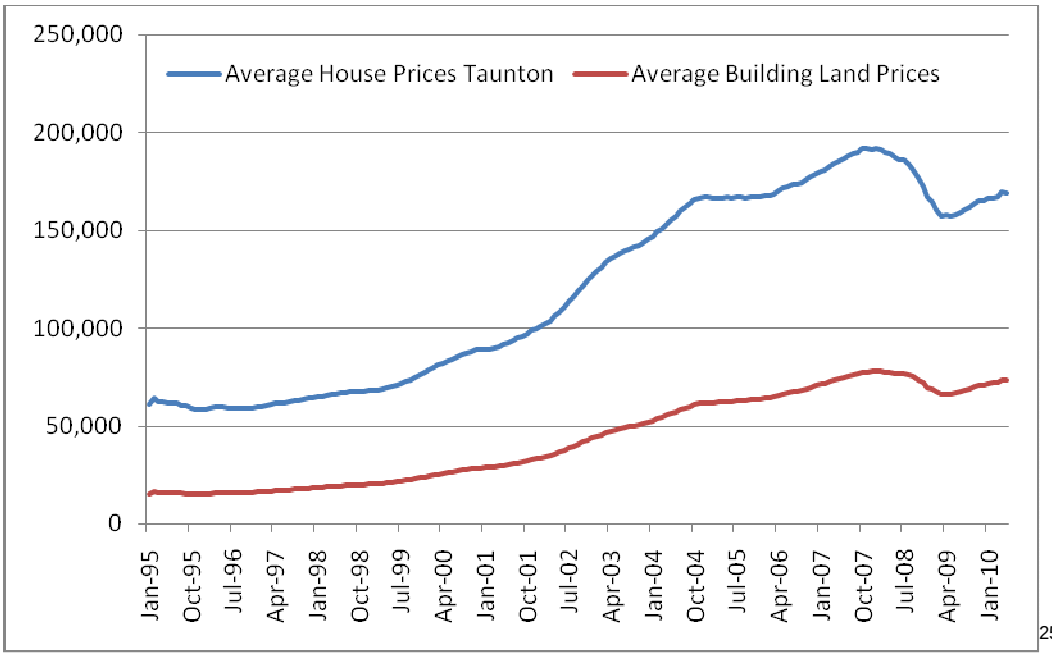
2.2.2.2 HELP FROM THE GOVERNMENT

It might be assumed that cob will incorporate some form of renewable power generation on the basis that developers / builders of such homes will have a strong environmental agenda. The recently introduced feed in tariff[24] for renewable energy may prove a boost for cob built dwellings this may prove particularly relevant if carbon balancing is used to pass building regulations.

2.3 LAND PRICES

Since the most recent housing boom (2000-2007) we have seen land prices increase dramatically, alongside residential housing. As a percentage of the build cost land prices has also risen. Whilst we have seen an inflationary rise in the cost of building materials land prices have increased rather more rapidly.

[22] http://www.sustainablebuild.co.uk/financing-your-sustainable-development-project.html
[23] http://www.ecology.co.uk/
[24] http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Feed-in-Tariff-scheme



[25]

The graph to the above shows *house* prices for Taunton, Somerset UK. In the 1990's[26] the cost of a building plot would represent around 25% of the total build costs, now in 2010 it can represent up to 40% of the build costs. This *must* drive developers to consider how to make best use of what is becoming a rare commodity.

With the purchase of land being the first large outlay for most building projects, the developer / builder is under more pressure than ever to complete the build and sell the finished build (and the land) so as to recoup their investment. With a typical single building plot costing around £140,000[27] and subsequent overdraft interest charges of around £1800[28] a month the emphasis for any developer will be on repaying the debt rather than experimenting with new building methods.

2.4 FINANCING

Just as individuals may be jittery about building with cob on proportionately expensive land, banks may also be hesitant about pouring their own money in to projects with a perceived higher risk.

Traditional lending models from high street banks[29] rely solely on return. Lending is based on track record, and gearing is likely to be low. When such large amounts of the builder's /

[25] Derived from data obtained from http://www.landregistry.gov.uk/
[26] Conversation Manager of Construction Company – W. Thorpe & Son
[27] www.fulfords.co.uk
[28] Current (August2001) Business Lending Rates Lloyds TSB
[29] Telephone Conversation: Lloyds TSB Business Manager - Ian Lowe - 27/08/2010

developer's money are at stake, it can be no wonder that the "tried and tested" designs are the more favourable route to take.

As with mortgage lenders business banking is guided by a written "lending policy" these documents are "internal documents" and as such not available for viewing, to the public or researchers.

There are however, other sources of finance available.

2.4.1 SOURCES OF FINANCE

2.4.1.1 THE GREEN INVESTMENT BANK

The GIB[30] was set up with £1 billion with an aim to;

> *"to support the delivery of the UK's emission reduction targets as set by the Climate Change Act 2008"*[31]

It identifies that there is a;

> *"challenge of making large numbers of small, low carbon investments attractive to institutional investors."*

But how much of this money will go towards helping the proliferation of cob? From reading the above report[32] it would seem that the GIB is primarily interested in infrastructure, and we can expect to see most of the money disappearing in to expensive large scale generation schemes, or "enhancement" of existing schemes (Carbon Capture etc).

2.4.1.2 FUNDING ON A LOCAL LEVEL

For community development initiatives[33];

- Community Development Finance Institutions
- District Council's Executive Committee
- Defra's Rural Social and Community Fund
- Housing Associations

[30] Considerations for Creating a Green Investment Bank - British Private Equity and Venture Capital Association's Energy, Environment and Technology Board

[31] Unlocking investment to deliver Britain's low carbon future - Report by the Green Investment Bank Commission

[32] Unlocking investment to deliver Britain's low carbon future - Report by the Green Investment Bank Commission

[33] Making It Happen: Working, Learning &Building Together -Timber Frame, Straw Bale housing project, Buckland Newton, Dorset - www.dorset.gov.uk

2.4.1.3 PRIVATE FINACING

On a smaller scale cob projects are often funded by passionate individuals. Although not specifically related to cob these might include;

- Jon Broome - Project Managed and funded the construction a green home in South London.
- Earthship Brighton - The visitor centre for the Low Carbon Trust was the second Earth ship to be built in the UK. This project was again privately funded.[34]

2.5 POPULAR PERCEPTION

When marketing any product market research is a vital part of any would be successful companies operating procedure. We know the UK is short of houses, and this *need* must create a demand in the market. But what shape does the demand take? What do the public want?

2.5.1 HOW IS THE PERCEPTION FORMED?

Painting the Town Green[35] gives an interesting look in to the mind set of three UK family of differing "greenness". Most people over the age of 30 are probably self educated when it comes to environmental matters and those who rely on the media for this education see a ill defined argument that is provided by the tabloids, and the television.

To understand why a particular person may like a particular style of house is to examine the workings of relationships, childhood memories, status, price and a myriad of other factors.

[34] http://www.lowcarbon.co.uk/node/add/contact-details - Telephone Call
[35] http://www.green-engage.co.uk/PaintingtheTownGreen.pdf

2.5.2 WHAT THE PEOPLE WANT?

[36]

The picture to the left shows a future development planned by George Wimpy in Hornchurch. What makes a developer build homes in this way?

1. Meeting their customers' needs, i.e. they are building the type of house that the consumer wants, the type of house that sells.
2. They are operating under the *illusion* that the above type of house is what the public wants, and that faced with a choice the public would choose something more like the homes below.

There are housing developments made from cob (or rammed earth) but not in the UK, a social housing project in France. The one pictured below is *Domaine de la Terre, Isle d'abeau* in France.

[36] http://www.georgewimpey.co.uk/newhomes/North+Thames/HarrowLodge/

The project includes over 70 housing units, of which 45% are constructed from rammed earth, 45% of stabilised compressed earth block and 10% using earth/straw mix within a timber frame.

Language is a barrier here when gauging inhabitants' perception. Recent visits to the site have commented on the degradation of the out layers of walls, leading to a scruffy appearance.[37]

[38]

There are large scale developments occurring which utilise novel designs in the UK, such as the bedZED development (above).

[37] http://www.quandlaterremonte.com/architecture-en-terre/le-domaine-de-la-terre-fr/

[38] http://www.bioregional.com/files/publications/BedZED_seven_years_on.pdf

"The community comprises 50% housing for sale, 25% key worker shared ownership and 25% social housing for rent." [39]

50% of the homes at bedZED were purchased by people, did they have problems overcoming their perception of what a house should be like?

Below are some likes and dislikes mentioned in a survey of residents at bedZED. I have struck off the comments I believe are irrelevant in the context of this discussion.

Likes	Dislikes
• ~~BedZED community (32)~~ • Architecture/ design (28) • Sustainability (21) • Wellbeing (feeling of space, light, quiet, health...) (19) • Garden and sunspace (13) • ~~Cost (5)~~ • ~~Location (5)~~ • Other (uniqueness, modernity...) (4) • ~~Facilities (community centre, car club, showers...) (3)~~ • Size (3)	• ~~Location (15)~~ • Lack of wellbeing (temperature, noise...) (14) • Things not working (CHP, hot water, repairs needed...) (13) • ~~Management (11)~~ • Size (9) • Nothing (8) • ~~Crime/ fear of crime (7)~~ • ~~Parking (6)~~ • ~~BedZED community (5)~~ • Design (5) • ~~Intrusion from visitors (3)~~ • Sustainability (2) [40]

We can see that many of the problems are associated with a method of building that is in its infancy, ie technology that is not working, lack of well being might be improved upon by advance in technology such as better double glazing etc.

In terms of the home owners perception of the building we can see that living in this eco development is "*liked*" by a majority of participants in this particular survey, and "dislikes" although of a significant are considerably less.

The public's perception is an important part of wider acceptance of cob, and as such I will expand on this line of questioning within chapter 3.1

Have people been brainwashed over the ages:

" The poor cottager contenteth himself with cob for his walls."[41]

[39] http://www.bioregional.com/files/publications/BedZED_seven_years_on.pdf
[40] http://www.bioregional.com/files/publications/BedZED_seven_years_on.pdf
[41] R. Carew's - Survey of Cornwall – Pre 1920

2.6 DEMAND

There is a strong demand for housing in the UK[42]. Both in terms of people waiting for social housing and wishing buy affordable properties.

2.7 PRICE OF COB

It can be noted that the price of Cob Built Structures can be at either end of the pricing spectrum, just as conventionally built homes may be designed to a lavish specification or be built in a affordable manner.

When comparing homes on large scale housing development we can notice a marked increase in sale prices;

> *"Additional features needed to make a house zero carbon could add between £35,000 and £50,000"*[43]

It can be said however, that cob may provide cost savings for the small scale self-build projects but, because material cost saving are replaced with labour costs that may be absorbed by the self-builder, before cob can be adopted as a mass housing solution it must become;

> "*not only be economical in materials but labour too*"[44]

2.8 THE RECESSION

In its round table on Carbon Reduction[45] the Guardian News Paper recognised that;

> *"Future spending on sustainability will be at risk because in a year or two there will be a squeeze on public finances"*

A reduction in public sector spending will have knock on detrimental effect on private sector businesses, including house builders.

Despite pressing economic times sustainability is still high on the agenda for many;

[42] http://www.communities.gov.uk/housing/housingsupply/
[43] http://www.hvnplus.co.uk/news/zero-carbon-homes-too-expensive-builders-warn/8603016.article
[44] The Green Building Bible Volume 1 – Light Earth Building – Chris Morgan and Cameron Scott
[45] http://www.guardian.co.uk/carbonreduction/roundtable (15/07/11)

"68% saying sustainability was either 'very' or 'highly' important"[46]

Although many are sceptical of the government ambitions with regards to zero carbon housing.

"76% of respondents think that the Government's plans for making all new housing zero carbon by 2016 are unrealistic"[47]

2.9 AVAILABLE EXPERTISE

With cob, for which there is well documented methodology[48] materials can be sourced easily from within a few miles of site, perhaps even on site. With the regards to England Clough remarks;

"there is no county in the kingdom that has not considerable areas where soil would, if tried, prove well adapted for cob-building"

He also remarks on the remarkably low level of skill required:

"What is most interesting is the workmen's lack of experience, which seemed to be of no hindrance"

I would argue that in 2011, unlike 1920 it is now necessary to lay adequate footings, and a plinth, with damp proofing and insulation.

2.9.1 FORMAL TRAINING

Working with cob can be assimilated in to a number of NVQs that are currently available. Funding is available through the traditional Buildings Bursary Scheme[49].

In France there is funding dedicated to "eco" construction training via the IFECO[50], this funding is available for artisans, workers and job seekers. The fund are generated from a tax levied gainst company in France with more than 10 employees, at a rate of 1.4%.[51]

[46] Hitting the Green Wall ... and Beyond – Taylor Wessing
[47] Hitting the Green Wall ... and Beyond – Taylor Wessing
[48] Cottage Building in Cob, Pise and Clay – Clough Williams Ellis - 1920
[49] http://www.buildingbursaries.org.uk/placements_current_trainees.html#5
[50] www.ifeco.fr – September 2011
[51] http://www.ifeco.fr/financement.html&usg=ALkJrhhSNPe1bpUYqKdPLSYOM2IlKEXubA – September 2011

2.9.2 INFORMAL TRAINING

There are a plethora of informal training courses available from numerous companies within the UK, a number of which are listed below.

- Edwards Eco Builders www.edwardscobbuilding.com
- LILI www.lowimpact.org
- Devon Earth Building Society www.devonearthbuilding.com

2.9.3 AS AN ALTERNATIVE TO BRICKS AND MORTAR

Brick laying is a skilled operation, due to slump of mortar, and joint spacing's achieving the required effect can be difficult. Lime staining of face work can also be a problem and once the cement has cured any irregularities in the wall verticality cannot be corrected. This is not the case with cob, as it is very sculpt-able, and can be trimmed after curing to ensure verticality.

2.10 STANDARDISATION

Many commonly used building materials are well standardised, as are manufactured environmental products such as insulation board etc. Concrete blocks for example have a great selection of standards relating to them[52] and there is standardised guidance for mortars which are suitable for use with them.[53]

It is questionable as to whether a standard can ever be applied to cob, its strengths as a low embodied carbon building material come from the fact that is sourced locally, and therefore we can expect regional variation on the basis of superficial geology in the vicinity of the build. This is all well and good for the determined personal developer with commitment to their cause, but when we consider an un-standardised building material when being viewed by larger national construction concerns, how does it fit in to their procurement and quality management systems?

With regards to the lack of standards in relation to earth built structures in general the Scottish Executive Central Research Unit conclude that:

> *"This is not a satisfactory basis for the development of the earth construction industry in the U.K. The lack of adequate control documents will inhibit market development and permit a climate where poor quality construction is possible. This could tarnish the*

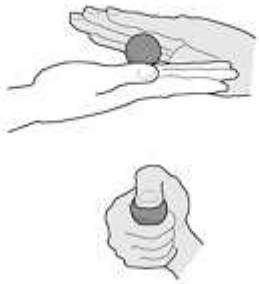
[52] BS EN 771-3 which covers the BS requirements of all types of concrete block (and brick) units.
[53] BS 8103-2, BS 5628-1, BS 5628-2 & BS 5628-3.

image of earth materials and reinforce the common preconception of these materials as being of low quality."[54]

There is no standard in the UK, but there are standard in other countries.

2.10.1 AMERICAN STANDARDS

The ASTM has a standard for Earth Built Walls[55] its authors have sensibly tried to stay away from quantification of limits or thresholds relying more on qualitative, tactile measures that the builder may rely on.



NOTE 1—A wet mass of soil is rolled in the hands so as to make a ball of approximately 2 cm (¾ in.) diameter. Several balls of the same mixture and moisture level are made and set aside to dry out of direct sun. After complete drying, none of the balls should be breakable between the thumb and fingers of one hand.

[56]

It deals with reinforcement to limit damage from earthquakes, which is not particularly relevant for UK properties.

The standard not only covers rammed, tamped earth construction, but also Unbaked Brick construction methods.

The word "cob" is used specifically in the leading paragraph and as such we can be assured the standard is directly relevant in that respect.

[54] BUILDING WITH EARTH IN SCOTLAND: INNOVATIVE DESIGN AND SUSTAINABILITY - Becky Little and Tom Morton

[55] Standard Guide for Design of Earthen Wall Building Systems - ASTM

[56] Standard Guide for Design of Earthen Wall Building Systems - ASTM

2.10.2 NEW ZEALAND STANDARDS

The New Zealand standards are considerable more quantitative than the American standards, which in some instances may be beneficial in achieving consistently high quality. One example of this quantifying sufficient overhang in relation to average wind speeds.

Building wind zone (from table 2.1)	**Ratio of eaves height to eaves width, *h*:*b*** (see figure 2.2)
L	4:1
M	8:3
H	3:2 (see clause 2.10.2)
VH	1:1

2.10.3.1 FRENCH STANDARDS

The CRATerre-EAG has helped develop national standards for earth built dwelling in France.

2.10.4 PROBLEMS WITH USING FOREIGN STANDARDS

Although these standards provide stand alone insight in to certain aspects of building with cob they are virtually unusable on their own, as they rely heavily on cross referencing to other standards. If the BSI (British Standards Institute) were to release a Standard dealing with cob dwellings then we could expect to fit nicely in to established standards library where cross referencing could be accomplished without excessive investment.

I would estimate that to obtain a working set of standards from Standards New Zealand would require around 30 individual standards priced at around 120 NZD (£60) each amounting to some 3600 NZD (£1800), this would add considerably to any architects fees for the smaller developer, although such a trifling amount would obviously be no obstruction to larger developers where standardisation is more applicable. These high prices certainly bar the way where research is concerned, libraries to not hold copies of standards.

Finally even if you where utilise these standards in the design or construction of cob buildings, it would be questionable as to whether local planning authorities would recognise these standards when viewed in a UK context.

2.11 PHYSICAL CHARACTERISTICS AND PERFORMANCE

To explain the merits of cob in a detailed quantitative manner would require a dissertation of its own. I aim to expose the obstacles to its wider use, and thus determine whether it is an applicable building material for the present day.

2.11.1 DESIGN

57

58

One of the best quality of cob as muted by advocates of the material is it sculpt-ability, it can be made in to virtually any shape desired. Left above a modern conceptual design, designed to maximise the visual impact of the chosen material. Above right a clay house from the 19th century which at first glance could be made out of brick or block.

2.11.2 INSULATION

Energy performances of traditionally designed modern houses are ever increasing. Building regulations stipulated 25mm of insulation in 1974, and by 2006 this had increased 250mm[59]. With modern insulation materials such as Polysisocyanurate[60] foam delivering very low thermal conductivity values.

It should be borne in mind however, that a lot of these low U value materials manufacture is very carbon intensive, contain CFCs and are difficult to dispose of, cob may not offer these

[57] Cob Dwelling, Ottery St Mary Constructed 2003 – Kevin McCabe
[58] Clay Dwelling, Buxhall Suffolk Constructed 1843 – Clay and Cob Buildings – John McCann
[59] http://www.communities.gov.uk/planningandbuilding/buildingregulations/ (15/07/2010)
[60] T206 - Energy for Sustainable Future - Open University

extreme values but in terms of its embodied carbon, and disposal options it is very low impact.

Table 1 : Minimum Requirements from Building Regulations

Parameter	2006[61] ($Wm^2.k$)	2010[62] ($Wm^2.k$)	Best Practice[63]
Walls	0.35	0.30	0.25
Floor	0.25	0.25	0.20
Roof	0.25	0.25	0.13
Windows	2.2	2.0	1.80

Cob does not have a sufficiently low U-value to meet building regulations and this obviously has an impact on its acceptance as a building material. Traditionally cob has been used a standalone walling system, but now it requires extra insulation.

> *"U-values for 600mm wide cob of 0.66 W/m^2 K, and 0.55 W/m^2K"*[64]

Although unfortunately they require additional insulation in order to meet building regulations, this could be mitigated by making the walls thicker, some suggest thicknesses should be around 900mm.

> *"thermal resistance is relatively poor a 900mm wall (much thicker than average) achieving a U value of only 0.45W/m2K"*[65]

[61] http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADL1A_2006.pdf (15/07/2010)
[62] http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADL1A_2010.pdf (15/07/2010)
[63] Energy efficient domestic extensions - Publication from Energy Saving Trust
[64] COB DWELLINGS -Compliance with The Building Regulations 2000 – Devon Earth Building Associations
[65] http://www.earthedworld.co.uk/modules.php?op=modload&name=News&file=article&sid=4

However a like for like comparison based on operational U values may not be a fair comparison, use of the carbon indexing system, or some other form of carbon benefit analysis[66] may prove to be more useful.

2.11.3 EMBODIED CARBON

Building materials such as brick and concrete are still predominantly used, which rely on centralized Industry, with many of the bricks being used in the entire UK being sourced from Peterborough[67]. Here below we see a typical development of flats in Taunton, Somerset. No doubt that these flats will perform well in terms of energy efficiency, the 100mm thickness foil clad phenolic foam will ensure that, but what about the *embodied* energy?

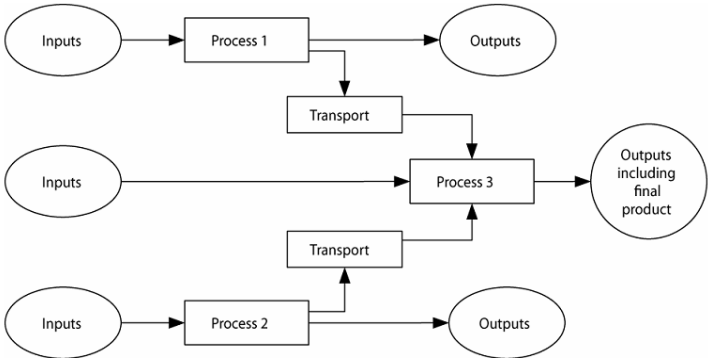
BREEAM[68] has developed a *"Green Guide"*[69] which weighs up the pros and cons of various construction materials presented in a series of Environmental Profiles, and this proves pivotal in the comparison of conventional construction methods and Cob.

The process diagram below shows how these Profiles are derived, and is effectively a simplified from of Life Cycle Analysis (LCA). Cob has a very short life cycle, incorporating minimal transport and manufacturing.

> *"… whilst a typical new dwelling having walls constructed of masonry and high performance insulants, will achieve acceptable limiting U values, the dwelling emission*

[66] http://m.building.co.uk/data/sustainability-%E2%80%94-embodied-carbon/3097160.article
[67] Peterborough Brick Works – Hanson Aggregates Limited
[68] http://www.bre.co.uk/ (20/07/2010)
[69] http://www.bre.co.uk/filelibrary/greenguide/PDF/Environmental_Profiles_Methodology_2007_-_Draft.pdf (20/07/2010)

rate does not take into account the CO2 used in the material production and transportation."[70]



71

Inputs might include:

- Materials,
- Transport Fuel,
- Process Fuel,
- Heat,
- Water.

Outputs might include: Emissions to air

- Discharge to water
- Emissions to land
- Products, co-products, by-products and wastes
- End of Life Disposal

Rammed earth for example has been shown to have around 50% less embodied carbon than conventional methods[72]. Embodied carbon is explored further in chapter 3.

2.11.4 OPERATIONAL CARBON

There is a distinct lack of information on the operational carbon values attached to cob construction, and this will have to be explored further is chapter 3.

[70] COB DWELLINGS -Compliance with The Building Regulations 2000 – Devon Earth Building Associations

[71] http://www.bre.co.uk/filelibrary/greenguide/PDF/Environmental_Profiles_Methodology_2007_-_Draft.pdf (20/07/2010)

[72] http://www.bre.co.uk/greenguide/ggelement2.jsp?buildingType=Housing&category=1019&parent=6&elementType=10166&eid=17920 (20/07/2011)

2.11.5 THERMAL MASS

The high Thermal Mass of a cob house is a benefit often overlooked, passive solar heating is an important component of many new high performance homes, and cob can make use of around 25% more passive solar energy than a light weight home.

Orientation	Solar gain ($kWh/m^2/day$)		
	Light	Medium	Heavy
South	0.75	0.90	1.04
North	0.23	0.27	0.31
East/west	0.45	0.54	0.62

[73]

Thermal mass is closely related to specific heat capacity, if we compare the specific heat capacities of cob and concrete we will find they are similar.

Material	SHC *(kcal/kg^oC)*
Concrete	0.18 -0.22[74]
Cob	0.190[75] - 0.2[76]

The high thermal mass of cob, is only beneficial in UK winters if good use is made of solar gains, although it is extremely effective in the summer in keeping cool. Thermal mass may prove useful in when used in conjunction with solar gain, to help tip carbon balancing in favour of cob walls.

3.0 METHODOLOGY

[73] Green Building Bible Volume 2 – Passive Solar Heating
[74] http://www.engineeringtoolbox.com/specific-heat-solids-d_154.html
[75] http://www.engineeringtoolbox.com/specific-heat-solids-d_154.html
[76] http://www.quentinwilson.com/adobe-as-mass/

From extensive reading of available literature I have deduced that there are a number gaps in available data. I aim to fill these gaps by sourcing my own data.

3.1 PUBLIC PERCEPTION SURVEY

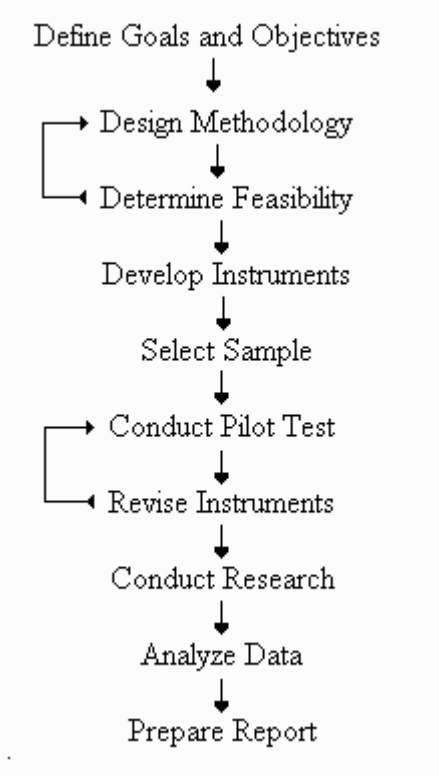
Surveys were used to fill gaps in understanding with regard to public perception. It is important to gauge public perception of cob as this may act as a barrier to its wider uptake.

3.1.1 PREDICTIONS

I predicted that the public's perception of what constitutes an acceptable construction material would be so clear that a survey would prove my "point" in this regard.

3.1.2 SURVEY METHODOLOGY

In order to provide *useful data* a test methodology was used when designing the survey.



[77]

A high response is extremely important. And owing to limited times and resources on my part I had to use a survey method that produce high response, yet return answers to the questions, I posed;

"Low response is the curse of statistical analysis"[78]

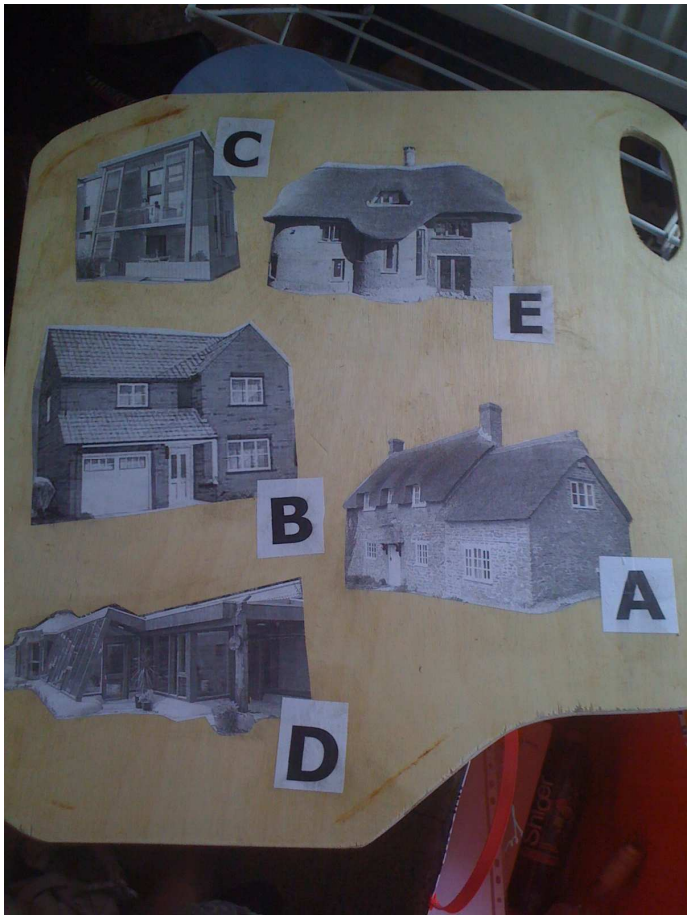
When I am striding through town, on my way to the bank, and some one flaps a piece of paper at me I rarely, if ever stop to answer their questions. Time is of essence for many people. So I felt I should approach data collection in a very time conscience manner. Gauging people's reactions without the need for them to even stop walking. I proposed to use a set of flash boards, pictures of which are presented in section 7.1.2. In this way I could cut down a pedestrian's participation time to perhaps five seconds, thus improving response rate, ergo certainty.

[77] Designing and Using Questionnaires - David S. Walonick
[78] Designing and Using Questionnaires - David S. Walonick

3.1.3 QUESTIONS TO BE ANSWERED

3.1.3.1 WHICH HOUSE WOULD YOU LIKE TO LIVE IN?

Members of the public were presented with the board shown below and asked to choose there preferred design. As mentioned above the idea was to encourage as much participation as possible.



The pictures on the board included various designs of houses. They were designed to show that people are not keen on change, especially when it comes to choosing a place to live.

The pictures were all off three bedroom houses, and they were all detached properties, this was done to ensure that the size / or presumed value of the house did influence peoples decision.

The pictures were changed to

black and white, and they were cropped so as to remove their “setting” from the decision process.

The images were chosen in the hope that they might divide opinion.

The images shown were only intended to assess the perception of the form of the building, and not the material it is made from, although one is a cob house.

Picture A – Shows a typical thatched house, built out of natural stone. This design will be classified as conventional.

Picture B – Shows a detached house on a proposed George Wimpy[79] Development. This design will be classified as conventional.

Picture C – Shows a new zero carbon home from the Barret Hanham Hall[80] development. This design will be classified as alternative.

Picture D – Shows the Earth ship Brighton[81]. This design will be classified as alternative.

Picture E- Shows a low tech cob built house[82], with a thatched roof. This design will be classified as alternative.

Pictures aimed to present a choice ranging from standard to contemporary designs, with roughly divided between conventional and alternative designs. The selection was chosen to try and create a split in results, hopefully proving my point that the general public want conventional housing.

3.1.3.2 WHAT WOULD YOU DEEM AS SUITABLE BUILDING MATERIALS?

Just as people's perception of what form a house should take will influence uptake of cob so will the materials that are used. In common culture we often hear;

"An English man's home is his castle",

the thought of a home as a place of permanence, safety and strength. So we may expect the average English person to want to live in an over engineered structure that will last for thousands of years??

The second survey question was whether the public's perception of building materials would affect uptake of Cob. The public effetely being the end user of residential developments.

As with the housing form survey, a flash board was used to display a number of materials, a selection of fairly standard day to day materials that people will recognise, and some others they may recognise, but not necessarily trust as building materials.

I predicted that familiar, standardised construction materials will prove more popular with participants, thus proving that use of unfamiliar construction materials such as cob further inhibits there wider uptake by the end user, the general public

[79] http://www.georgewimpey.co.uk/newhomes/Manchester/ManorCourt/
[80] http://www.hanhamhall.co.uk/site/web/home
[81] http://www.lowcarbon.co.uk/earthship-brighton
[82] http://www.builditgreen.co.za/GoingGreen/EarthHouses.aspx

The materials included and a brief justification for their inclusion are described such forth;

A – OSB Board – OSB board features heavily in many new “sustainable developments, it is often incorporated within structural insulant, and is used as supporting backing for external cladding etc. For purposes of the survey this will be classified as a conventional building material.

B – Concrete Block – Perhaps the most ubiquitous building materials of the last 30 years. A reliable contender with dubious environmental credentials. Classified as conventional.

C – Brick – Another widely used, and externally visible construction material. Again with a high environmental impact. Classified as conventional.

D – Natural Stone (Cornish Blue) – Widely used in the past, and certainly a premium product in more recent years. A firm favourite? For purposes of the survey this will be classified as a conventional building material.

E – Straw – Straw is well known as a roofing material which may well aid is cause in the survey. This material will be classified as a alternative.

F – Unfinished Wood – Personally I love the look of unfinished wood. But will people find it a little rudimentary? Unfinished wood can be more easily sourced locally and as such is a very environmentally beneficial material. This material will be classified as alternative.

G – Cob – A house that may well survive 250 years, is durable. But as with unfinished wood, will it be seen as a bit backwards? Cob is one of the lowest embodied energy building materials available. This material will be classified as alternative.

H – Tyres- A great way to use up unwanted and costly waste, they are the back bone of earth ships, and have been used as foundations in affordable housing projects. This material will be classified as a alternative.

I predicted that people would opt for familiar (conventional) building materials.

3.1.4 METHOD OF DATA COLLECTION

3.1.4.1 LOCATION

For reasons of convenience the town of Taunton, Somerset was chosen for the survey. Taunton has a population of approximately 61,400 in 2001[83]. It has low unemployment at 4.1%.

As an indication of the environmental performance of the area Taunton Deane Council currently recycles 48%[84] of refuse. Obviously this is due to a number of factors but some of this success must be attributed to education of the populous on green issues.

3.1.4.2 WORKINGS OF SURVEY

The pedestrian survey was undertaken in the centre of Taunton and a number of locations were used for the collection of data, in order to avoid bias.

Pedestrians were approached and asked the question relevant to each flash board being used. The answer was written on the back of the board using felt tip pen. The sample was stratified by recording adult and child results separately. A dot was placed over a recorded answer if it came from a person judged too young to be “in the market” for buying a house.

3.1.4.3 SAMPLE SIZE

As is common with surveys of this type a margin of error of 5% was deemed appropriate[85], with a confidence level of 95%. With a population size of 61,000 the calculated sample size was 382. These values were calculated using the figures below.

[83] http://www.somerset.gov.uk/irj/public (10/07/11)
[84] www.guardian.co.uk
[85] http://www.raosoft.com/samplesize.html

Field values were considerable less than the calculated values when taken in terms of the separate "materials" and "design" survey. This resulted in a higher margin of error for these data sets of 5.97% and 5.52% respectively.

$$x = Z(c/100)^2 r(100-r)$$
$$n = Nx/((N-1)E^2 + x)$$
$$E = \mathrm{Sqrt}[(N-n)x/n(N-1)]$$ [86]

However, when combined the sample size increases giving a total sample size of 582 giving a margin of error of 4.04%.

3.1.4.4 LIMITATIONS

The following limitations were considered;

- *"Fail to correctly indentify the population.*
- *Choosing a sample which is not representive.*
- *Failure to respond to a survey.*
- *Careless answers to questions.*
- *Dishonest Answers."* [87]

3.1.4.5 OBSERVATION OF PARTICIPANTS

Below are a number of observations I noticed whilst carrying out the survey work.

I found that people were "second guessing" they would say things like "well that one looks the most eco- friendly" and choose that mentioned house. Which was not what the original question was, they were guessing what house *I* wanted them to choose, rather than the house *they* wanted to choose.

[86] http://www.raosoft.com/samplesize.html
[87] Edexcel – GCSE Statistics

3.1.5 SURVEY FINDINGS

3.1.5.1 DESIGN SURVEY FINDINGS

DESIGN SURVEY

Design	Adult	Child	Totals	% Adult	% Child	% Totals
Traditional Stone (A)	82	10	92	32	17	29
Traditional Mass (B)	59	14	73	23	24	23
Zero Mass (C)	18	15	33	7	25	11
Earth Ship (D)	45	15	60	18	25	19
Cob & Thatch (E)	51	5	56	20	8	18
Pop	255	59	314	100	100	100

Unlike the “materials” survey there is no strong tendencies in the “design” survey, traditionally built building did receive more votes but on balance, the results were spread more evenly. If we group the materials in to groups of;

a) Conventional and;
b) Those used in Cob

We can see;

DESIGN SURVEY

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Conventional	141	24	165	55	41	53
Alternative	114	35	149	45	59	47
Pop	255	59	314	100	100	100

There is a 53%/47% in favour of Conventional designs, which I find to be inconclusive in terms of gauging the public's perception.

The groups were established as follows;

Group	Materials
Conventional	Stone and Thatch Historic, Brick Built Mass Housing,
Alternative	Zero Carbon Mass Housing, Modern Cob & Thatch, Earth Ship.

3.1.5.2 MATERIALS SURVEY FINDINGS

MATERIALS SURVEY

Materials	Adult	Child	Totals	% Adult	% Child	% Totals
OSB	11	3	14	5	5	5
Concrete	5	0	5	2	0	2
Brick	62	23	85	30	38	32
Stone	57	23	80	27	38	30
Straw	22	2	24	11	3	9
Wood	31	5	36	15	8	13
Cob	14	4	18	7	7	7
Tires	6	0	6	3	0	2
Pop	208	60	268	100	100	100

Question: "When buying new home which of the materials on the board would be you preferred construction material?"

Traditional Building materials namely brick and stone took 62% of the vote, with Unfinished Wood being the third largest at 13%. If we group the materials in to groups of;

a) Conventional and;
b) Alternative.

We can see that;

MATERIALS SURVEY

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Conventional	135	51	186	65	85	69
Alternative	73	9	82	35	15	31
Pop	208	60	268	100	100	100

In total 69% of participants opted for conventional materials. The groupings are explained in the table below.

Group	Materials
Conventional	OSB, Concrete, Brisk & Stone
Alternative	Straw, Unfinished Wood, Cob, Tyres

In terms of materials we can see that there is a strong tendency in preference of conventional building materials.

3.1.5.3 COMBINED SURVEY FINDINGS

When grouping the results as above it is possible to combine data from the “materials” survey and the “design” survey to give an overall view with regards to the public’s perception of conventional versus alternative.

COMBINED						
Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Conventional	276	75	351	60	63	60
Cob	187	44	231	40	37	40
Pop	463	119	582	100	100	100

Overall we can see that conventional materials and designs attracted 60% of the vote.

3.2 SOURCING INFORMATION WITH REGARDS TO FINANCING OF COB

It was clear from the literature review conducted within chapter 2.2 and 2.4, that further information was needed on the process by which lending is approved on unusual building projects, which may include Cob.

This was an area that I considered I would have guaranteed success, I have contacts that work in risk assessment for a major high street building society, so I expected that a request for information would find its way in to the right hands trough him. This was not the case.

Never the less I will state my intentions, and reveal what little information I did receive.

3.2.1 QUESTIONS

It is easy to find superficial information with regards to lending practices. Any of the larger conventional financial institutions have websites that provide information on Ethics, Who they lend to, How much they will lend. It was my intention to source information on the mechanisms of this lending, and as such indentify which aspects of their structure might have an impact on the wider uptake of cob.

3.2.1.1 QUESTIONS SENT TO THE ECOLOGICAL BUILDING SOCIETY

The questions were are followed;

1. What is different about the Ecological Building Society in the way it *works?* - I have read your website. I need to know which part of your “rule book” states that is OK to lend on unusual properties. Who wrote this rule book? I realize you may not have a

document called a rule book. But what is the closest thing to a rule book that you *do* have.

2. Where did your initial funding come from?
3. When you source money for your operation do you find that it costs you more in terms of interest / assurances due to a higher risk portfolio?;
4. Is your business deemed to have a higher risk than the mainstream equivalents?

3.2.1.2 QUESTIONS SENT TO CHELTENHAM AND GLOUCESTER

The questions were as followed;

1. How do you judge the risk lending with regards to a property?
2. When a surveyor assesses a building with regards to its suitability for mortgage lending, what sort of information does the report contain? . .
3. How do you then translate this in to a Yes / No Lending Decision?
4. Do you know of any examples when C&G have leant on new properties that were unusual in terms of their construction?. . . . .
5. If so can you give details?
6.

3.2.1.3 QUESTIONS INTENDED TO BE PUT TO THE NATIONWIDE

As per 3.2.1.2

3.2.3 METHODS OF CONTACT USED

In order to arrange an interview I tried a number of different methods.

3.2.3.1 TELEPHONE

Many people joke of the notoriety of telephone switch boards for wasting people's time. My experience was seldom amusing.

The problem was that there are many specialist teams ie. "Press 1 for Mortages". Or "Press 2 for Insurance". Unfortunately there is no "Press X for Enquires relating to academic studies", and so I ended up being passed around, because no one would answer my questions, whether they couldn't or weren't allowed too, I can't say.

Eventually I tried "Can I speak to your advisor" and this often resulted in the same kind of problem as their subordinates. Most of the useful information I gained from these calls is presented in section 3.2.3.1.1 (below).

3.2.3.1.1 LENDING TERMS

When talking to a customer service representative at Nationwide, I managed to obtain the following information:

When assessing particular properties a mortgage advisor, working for a large high street lender will at first refer to a set of “lending terms”. This consists of a list of building designs that have various lending terms attached to them.

Appendix 3 shows the information sourced from Nationwide with regard to Lending Terms this information is summarised in the table[88] below.

Lending Terms	Construction types which might be classed as sustainable.	Frame Type
Lending Term A (Acceptable)	A-Frame (Nucleus Projects Limited) Anvil Anvil 6B	Timber Timber Timber
Lending Term B (Unacceptable)	Aberdeen Corporation	Timber
Lending Term C (Unacceptable)	No Examples	No Examples
Lending Term D (Acceptable)	No Examples	No Examples
Lending Term E (Acceptable)	No Examples	No Examples
Lending Term F	Applies to certain types of PRC construction.	NA. Precast Concrete

[88] Nationwide Building Society - Lending Terms - Appendix X

The list supplied did not include cob.

It is very apparent that successful lending is secured by the structural survey element of the process ie Lending term E for example is;

> *"Acceptable for houses and bungalows not more than two storeys in height, provided that a survey and appraisal from a structural engineer is available in accordance with the BRE."*

But what method of assessment can be used to give a credible and uniform approach?

3.2.3.2 EMAIL

Proved utterly fruitless.

3.2.3.3 VISITS

On visiting branches of Nationwide and Cheltenham and Gloucester with a view to arranging a meeting, I was advised that there was no one in branch privy to the kind of information I was seeking. I was recommended to ring head office as per 3.2.3.1.

3.3 CARBON ESTIMATES

Some effort must be made to examine the performance of cob, in a quantitative manner with regards to carbon. For this data from the BREEAM Green Guide, along with other sited values have been manipulated to create a comparison between cob and some other commonly used construction methods.

Material Element	Lime render, insulation, rammed chalk wall (0% cement), sodium silicate treatment [89]	Brickwork outer leaf, insulation, aircrete blockwork inner leaf, cement mortar, plaster, paint	Brickwork, cement mortar, cement-bonded particle board, timber frame with insulation, vapour control layer, plasterboard on battens, paint
Kg of CO2 eq. (60 years)	38.0	73.0	82.0

[89] http://www.bre.co.uk/greenguide/

3.3.1 OPERATIONAL CARBON

A simplified method of demonstrating the operational carbon impacts for a structure utilising cob, can be demonstrated in terms of fuel use.

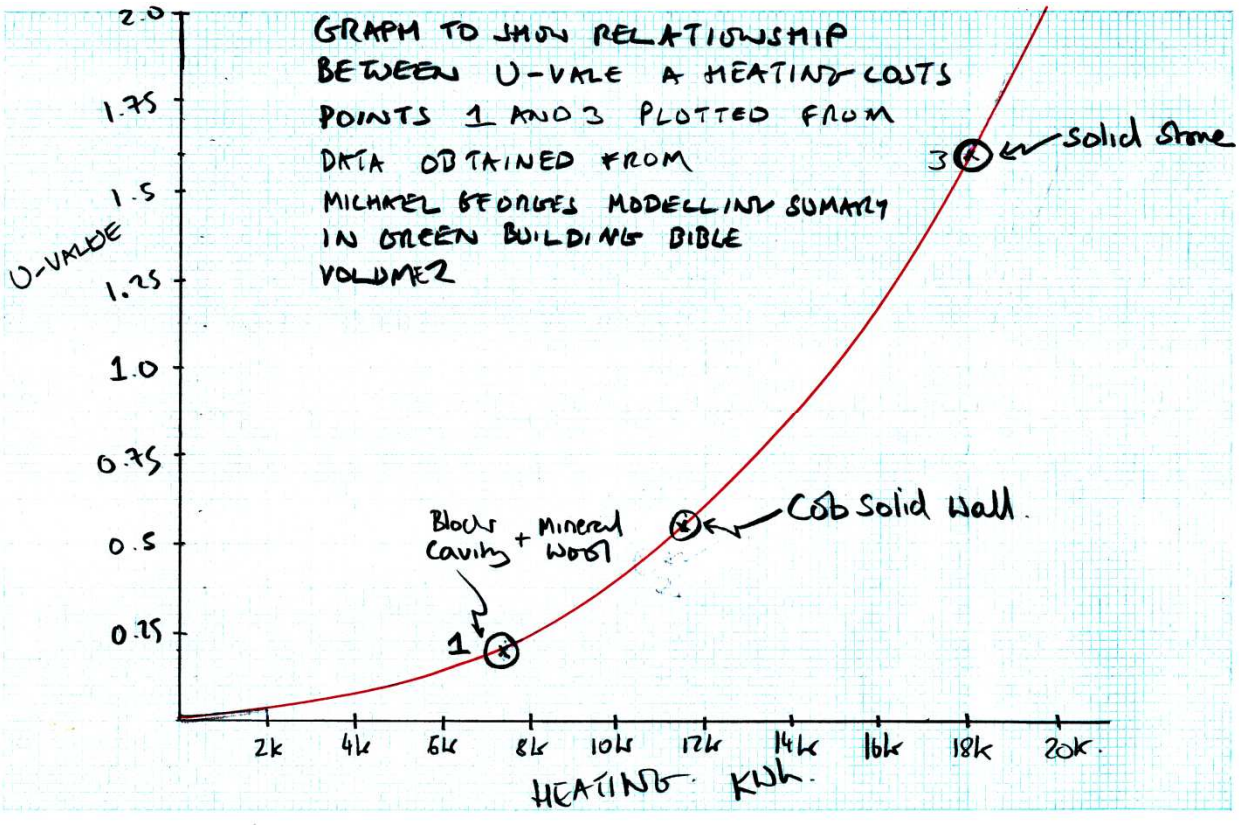
Available Data[90] is shown in the table below;

Structure Type	U – Value (KW/m^2K)	Heating Demand (KWh / year)
Insulated Cavity	0.2	7,616
Stone	1.6	17,939
Cob	0.45[91]	?

Using a graph plotted from available data we can obtain estimated heating demands for a cob wall of 600mm which we know from chapter 2.0.2 to be a sub optimal thickness but is more in keeping with the wall thickness used in the modelling example.

[90] Green Building Bible Volume 1 – Michael George – Modelling to assess the thermal mass in a range of wall types.

[91] COB DWELLINGS -Compliance with The Building Regulations 2000 – Devon Earth Building Associations



We can now fill in the blank with regards to heating demand, and derive annual operational carbon emissions from established factors[92].

Structure Type	U – Value (KW/m^2K)	Heating Demand (KWh / year)	CO^2Foorprint (Kg/year) (Gas)	CO^2 Footprint (Kg/year) (Wood Chip)
Insulated Cavity	0.2	7,616	1408	297
Stone	1.6	17,939	3318	699
Cob	0.45	11,500	2127	448

The table below show values over a 60 year life span carbon foot print calculated from the above table.

[92] Carbon Trust - Energy and carbon conversions 2010 update

Structure Type	60 Year Heating Demand (KWh / year)	60 Year CO^2Foorprint (Kg/ 60year) (Gas)	60 Year CO^2Foorprint (Kg/60year) (Wood Chip)
Insulated Cavity	456960	84480	17820
Stone	1076340	199080	41940
Cob	690000	127620	26880

3.3.2 EMBODIED VERSUS OPERATIONAL CARBON

The model used above used dimensions from houses being used in the Ty Charwel Project in South Wales, they had an external surface wall area of 130 m^2 on that basis I shall make some comparisons on embodied and operational carbon using the values from sections 2.0.3. The figures for the rammed earth carbon foot print have been adjusted to remove the carbon footprint contributions for insulation[93] which is not used in the above model, but the rammed earth construction is relied upon for the remainder value. 11 kg per m^2 was deducted from the above rammed earth method on that basis.

Units: Kg Carbon over 60 years	Embodied Carbon For 130m^2	Gas	Gas Embodied +Operational	Wood Chip	Wood Chip Embodied +Operational
Insulated Block Cavity	9490	84480	93970	17820	27310
Cob / Rammed Earth	3510	127620	131130	26880	30390

[93] Expanded polystyrene (EPS) - density 25 kg/m³ - BREEAM Green Guide

So approximately you are saving 6 tonnes of carbon over the design life of the building, by using earth for walls. Which when weighed up against a fossil fuel heat source makes little impact. But the lower the carbon foot print of your heat source, the more important this 6 tonnes becomes in terms of its proportional benefit.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 REGULATORY

4.1.1 CONCLUSIONS

Cob does not hold any special favour with regulators and as such with regard to the average house builder there is no benefit in pursuing a "cob based" application. But that be said in terms of planning permission there I could not indentify an obstacle to building with cob in the UK.

Building regulations present more of a challenge but, cob has been proved "fit for use" with various recent projects, and so a small amount of extra negotiation with building control will ensure success of the project, with regards to building regulations.

4.1.2 SOLUTIONS

There are no real obstacles with regards to cob from building regulations, it is not as easy with cob, as it would be with say concrete blocks but it is not overly difficult. Further Standardisation may help.

In Spain[94] they have a different planning system, which is rather more flexible, especially at the individual / family level. To build a property with the intention of sale, full regulations apply. However, if an individual is building and merely wants to provide accommodation for themselves and their family then the regulations are significantly slackened. The down side being that the property can not be sold for any reason; perhaps a similar scheme could be used in the UK, for self build social housing projects perhaps.

In France the "CRATerre-EAG"[95] (which stands for Centre de Recherche en Architecture de Terre – Ecole d'Architecture de Grenoble) provides strength / performance data on earthen walling, established in 1979, it has a long track records of providing support to earth built projects.

[94] Personal Experience – Gaining planning permission for building project in Spain. 1999 - 2002
[95] http://www.icomos.org/~fleblanc/projects/2001-2007_GCI/field_trip_reports/2002-06-france-terra.pdf

4.1.3 LIMITATIONS

Government Documentation is well published and highly accessible. I believe there fore that the reading carried out with regards to this line of investigation was well covered. The government's use of the internet to disseminate information makes content highly "searchable" and relevant materials can easily be found.

4.2 MORTGAGE LENDING

4.2.1 CONCLUSIONS

I conclude that is very difficult extracting information from financial institutions with regards to their operating procedures. Nationwide, C&G, Lloyds have all been contacted and on the whole have been non responsive. It would appear the information I am seeking is contained within the confidential documents, and as such I will have to either engage in espionage, or remain ignorant.

On the whole getting a home loan on Cob will be difficult, since the credit crunch lending has become more and more risk averse[96]. Insurance also takes a similar line, with Cob Construction being outside companies risk classification structure.

Help may be at hand from specialist lenders, such as the Ecological Building Society, but unfortunately I am unable to discuss their methods as they were just as unresponsive to communications as the other lending institutions.

4.2.2 SOLUTIONS

I do not think that building with mud and straw is very high up on the agenda of a newly formed government, in recession.

Again the answer may come from the private sector, and companies may take accept the higher risks involved in order to promote their environmental superiority[97].

I think the biggest element that will help with mortgages is time. As 2016 approaches and more and more unusual zero carbon houses pop up on the scene lending models will have to adapt. For example Hanham Hall[98] incorporates unusual buildings, and lenders will have to be found. As to whether any of these new builds will incorporate Cob Construction is yet to be seen.

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[96] http://www.bbc.co.uk/news/business-11862428
[97] Hanson Building - http://ttocb.blogspot.com/2009/03/monday-300309.html
[98] http://www.hanhamhall.co.uk/

Another solution may be found in the tenure of the property. Housing associations could lease people a plot of land for 100 years and they could build there own homes on the site. Historically this has been a popular tenure option.

4.2.3 LIMITATIONS

I am dissatisfied with the content and quality of the information present in this line of investigation. It is also the area that I spent most time in trying to source information.

The shear lack of reading material available due to confidentiality etc, is very evident when search for such documents on the internet. Although lenders such as the ecological building society presented a very helpful façade, detailed information was impossible to come by. Although I understand that they (Ecological Building Society) are different I do not understand why. Similarly with conventional lenders such as the Nationwide, and as such I can not compare lending models.

I also feel that the hours spent being passed around various switch boards could have been better spent elsewhere.

4.3 LAND PRICES

4.3.1 CONCLUSIONS

The proportionate increase in land prices over that last 20 years can only be damaging to the wider uptake of Cob Construction. Most Cob Construction has a high area to occupancy ratio, and as such represent poor value, when utilising high value building land.

4.3.2 SOLUTIONS

Again, Cob Construction may prove most suitable for affordable housing. Land price per residential unit is normally lower, and so perhaps there is a higher land area budget available per residential unit. After all low tech materials such as cob are cheaper[99], and so given regulatory support they may be a popular option with affordable homes where budgets are often tight.

The recession has seen some fluctuation in property prices, with further public sector job cuts forecast in 2011 will we see spiralling property prices. This in turn will lead to proportional land prices being lowered.

[99] Cob =£3.00m^2 (Farmer) Concrete Block = £20m^2 (Travis Perkins)

4.3.3 LIMITATIONS

In many respects this one of the more simple facts to demonstrate. Good quality, data is readily available for property prices through the Land Registry. Therefore I would hope this line of investigation proved accurate.

4.4 FINANCING

4.4.1 CONCLUSIONS

For a number of factors mentioned in the main body financing from conventional lending, is not influenced by the materials or techniques used in particular project. So we can not consider this aspect to be an obstacle to the wider uptake of Cob Construction in the UK.

Where the opportunity lies is with privately funded builds. An individual or a private company may embark freely in to any business venture they wish. However, most people have come to the position of being moneyed by making shrewd discussions, I am unsure as to whether Cob Construction represent such a decision, being relatively untested when compared to conventional construction methods.

4.4.2 SOLUTIONS

A possible source of funding for Cob may well be through Housing Associations via the Homes and Communities Agency. Perhaps the subsidies offered by the Homes and Communities Agency could be made available to a wider number of individuals who would like to become involved in building there own homes. Skills required to build with cob are low, and training can be given to those wanting housing. At present there are 4.5million[100] people are on waiting lists for social housing, how many of these would be willing to lend a hand building their own home? This would reduce costs in labor, as well as empower individuals, and kindle community spirit.

4.4.3 LIMITATIONS

I would write similar comment here as to Section 8.2.3. All in all a frustrating experience with little hard data to show for it.

[100] http://www.lga.gov.uk/lga/core/page.do?pageId=1518784

4.5 POPULAR PERCEPTION

4.5.1 CONCLUSIONS

In section 8.1 I mentioned that in the UK building are over engineered, in Australia and New Zealand[101] people expect their house to last maybe 50 years, any more is a bonus. Houses are typically made of wood, with corrugated iron roves, and provide comfortable accommodation. In Australia and New Zealand this is the norm, it is how the public perceive their homes being built.

The materials survey showed that over 60% of people expect their home to be built out of either Brick or Stone, they did not recognise the other materials on the board as worthy building materials. This is a major obstacle in the wider uptake of Cob Construction.

Perhaps where this will have the largest negative effect is where large companies who *really* have the ability to change the way the UK approaches mass housing, will avoid cob due to its lack of appeal to their prospective clientele.

In terms of *design* however people appeared generally open minded in with a roughly 50 / 50 spilt overall, typical mass housing option which I expected to be a run away leader received similar votes to Earthships, and cob & thatch housing. I would conclude therefore that the appearance of Cob Construction is not a limiting factor in their wider uptake.

4.5.2 SOLUTIONS

My compulsory education finished in 1996, and it did not contain a great deal of environmental content. With regards to people older than myself we can assume will have had minimal education with regards to environmental issues, people younger than myself will have had ever increasing environmental content in their education. Now in 2010 the National curriculum includes a great variety of environmental content including climate change[102], and the impact of tourism on the environment[103].

With the average age of a first time buyer currently at 38[104] we can expect the majority of purchases to be made by people with no *formal* environmental education. However, with the environment enjoying plenty of media attention many people will be self educated in the area.

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[101] Personal Experince
[102] www.orderline.qcda.gov.uk/.../QCDA-10-5020_Science_in_travel_and_tourism.pdf
[103] www.coventry.gov.uk/ccm/cms-service/stream/asset?asset_id=31630001
[104] http://www.independent.co.uk/life-style/house-and-home/property/no-place-like-home-the-generation-who-cant-afford-to-buy-1921781.html

So we can expect with the passage of time more and more consumers to become ever more environmentally driven in their choices from a minimum of 20 years time we can expect everyone who buys a home to be in procession of a formal environmental education. Just as people value the solidarity of bricks and mortar in 2010, will people prefer the environmental credentials of cob by (at the earliest) 2030? Of course there will be other factors affecting their choice such as costs and availability, but we can expect them to consider the environment when making their choice.

4.5.3 LIMITATIONS

Although I used a correct sample size for the overall population statistically at I can only expect a 4.02% margin of error, this does not take in to account the various bias that may have affected the results.

The result came from one town, and as such they will be bias with regards to regional variations in attitude towards the environment and preferences. Cob is comparatively common in the Southwest UK, so we might expect the 7% figure to be lower in other parts of the UK.

Although the questions were clearly stated I definitely got the feeling that people were treating the survey as a test, and give the answer they *thought* I wanted to hear. Some people gave very careless answers.

I included results collected from children in the survey, which some might consider to be misrepresentative due to the fact that children do not seriously consider the implications of buying / living in a house. However, it was remarkable how the children's answers mirrored the adults.

The picture on the design boards were not particularly well thought out I had three three "eco" homes for people to choose from, and only two conventional designs one of which appeared (in my opinion) a higher value property than the other conventional buildings.

4.6 DEMAND

4.6.1 CONCLUSIONS

There is a high demand for housing in the UK. And this benefits anyone wishing to build using cob Construction as when supply is not meeting demand prospective residents will be more open minded with regards to alternate modes of accommodation. This applies to

private purchases, but especially to social housing. With current housing models failing to meet demand, innovation may lead to the wider uptake of Cob Construction in the future.

4.6.1 LIMITATIONS

I believe this area of investigation to be well covered.

4.7 PRICE

4.7.1 CONCLUSIONS

It can be concluded that price is not an obstacle for the wider uptake of Cob Construction, although many new high tech zero carbon homes are comparatively expensive, this is due to the systems that are installed in to them, photo voltaic, super insulation, all come at a price. Just as you can buy an environmental sound car for £7500 you can also buy one for £25000, Cob Construction is the potential Fiat Panda of the construction industry, whilst the new homes at Hanham Hall are more the VW Blue Motions of this world.

4.7.2 SOLUTIONS

Labour costs are very high in the UK, so I suspect cob is destined to remain confined to community and self build projects. However, labour costs can be absorbed by the self builder / community and as such cob may prove a cheaper method for time rich cash poor builders.

4.7.3 LIMITATIONS

There are thousands of components that go in to making your average house. My overview of the pricing of low carbon homes in relation to Cob Construction is very simplistic. However, this dissertation is not intended to make a detailed study pricing its aim it to identify obstacles and solutions to the wider up take of cob. In this respect the information was sufficient to make a decision.

4.8 AVAILABLE EXPERTISE

4.8.1 CONCLUSIONS

There are numerous builders in the UK that specialise or at least have the ability to construct cob buildings; I cannot identify an obstacle to the wider uptake of cob therefore with regards to expertise.

4.8.2 SOLUTIONS

When considering soley the walls of a building sufficient skill is available at present, but additional people could be easily trained facilitated by the relatively low skill levels needed in cob construction.

4.8.3 LIMITATIONS

I have readily identified numerous sources of skilled cob layers and sources of training, in terms of indentify available expertise, there can be no doubt that it can be provided, or extra workers could be easily trained adapted to building with cob.

4.9 STANDARDS

4.9.1 CONCLUSIONS

UK standards for Cob do not exist, perhaps the following example would aid in it wider use;

BS3456 – Specification for Cob Walls in Dwellings

Funding for such documentation will never come from the private sector as who would benefit, there is no manufacturer would reap the financial benefit from selling newly standardised product, as no manufacturing is needed in the creation of these materials. I would like to see such funding given, but with wide spread public sector pay cuts forecast in the next few years where will the money come from?

4.9.2 SOLUTIONS

Perhaps funding could come from companies wish to offset there carbon. Large companies could fund the research needed and as such offset the carbon against the saving made in using low embodied carbon Cob Construction instead of conventional building materials. Suitable companies might include Tesco[105] who already have well an established green agenda, as well as the initiatives under CSR etc.

A specialist institution could be set up to help create standards. The CRA Terre in france is one example, another might be found in germany.

"The Passivhaus-Institut promotes and establishes standards for the Passive House - Passivhaus international program for Low-energy houses and other low-energy building techniques and structures."

[105] http://www.guardian.co.uk/environment/2008/sep/03/corporatesocialresponsibility.carbonfootprints

There are regional bodies in the UK, perhaps these could pool resources to create a national source of advice and guidance.

4.9.3 LIMITATIONS

I would have liked to explore the workings of the CRA Terre a little more than I did, but even with the aid of translation tools such as Google Translate, I found the language barrier hard to cross. Literal translations posing a large obstacle, for example a if I were to translate “thermal properties” in to French and feed it in to www.google.fr there is no such phrase matched, lots of “thermiques” and “propriétés” but it is not a phrase that is used. So for the researcher with a poor grasp of French this poses a problem. Google translate only works for webpage, not pdf files, in which most of the relavent content was published. As such I had to convert pdf to html and publish them on a server before I could translate them, time consuming and the translation pdf to html did not always work very well.

However, for English speaking country, there were no barriers to procuring information on the use / development of standards. Most standards institutes / bodies sell standard to raise revenue, so their sites are easy to use, and content easy to find.

4.10 PHYSICAL CHARACTERISTICS AND PERFORMANCE

4.9.1 CONCLUSIONS

There is no obstruction in terms of design with regards to the uptake of cob; it can be assimilated in to any low rise structure in place of other walling systems.

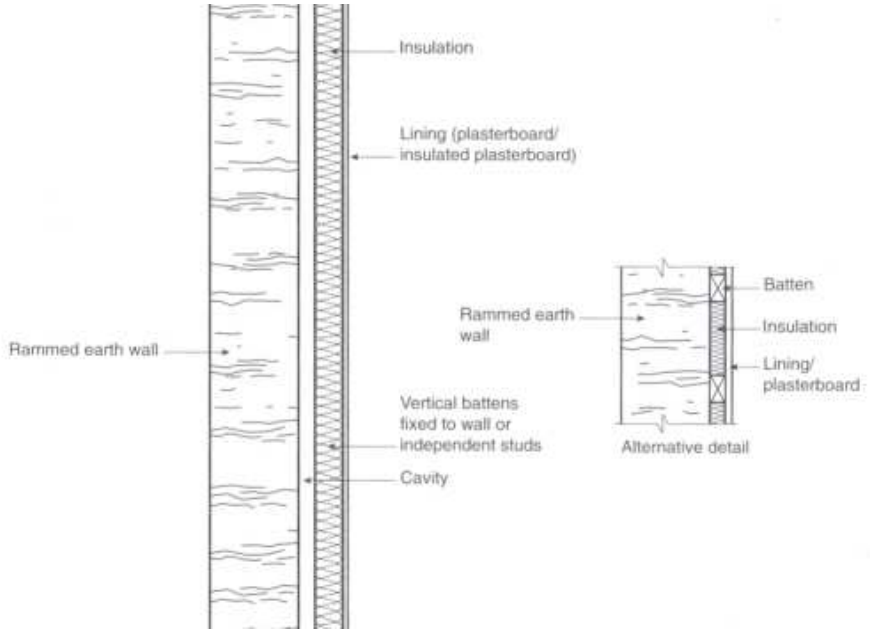
In terms of cob carbon footprint we are left having to “borrow” data from rammed earth LCA which is similar, but not identical.

Cob does not represent a viable option in terms of its thermal efficiencies even in light of its low foot print when compared like for like with an insulated cavity wall, it certainly would have been a good option 10 years ago, but building regulations demand a u value of 0.30, and a traditional cob wall cannot provide this unless it is made very wide in excess of 1m is likely which will pose problem for day lighting of interiors.

When viewing operational carbon over a 60 year life span, the 6 tonne CO^2 saving pales in significance to the vast operational carbon footprint particularly when using non renewables.

4.9.2 SOLUTIONS

The diagram below shows additional insulation being applied to a rammed earth wall. Could this method be applied to cob?



[106]

I would consider that placing the insulation externally would be more beneficial so as to utilise the cob's thermal mass, via solar heating of exposed internal surfaces.

With additional insulation a cob wall would recoup it's operational carbon losses when compared with an insulated cavity wall, and the 6 tonnes saving starts to look more important. However, from a waste disposal point of view the addition of extra insulation adds to the environmental impact of the wall. Although we are yet to see the disposal impact of modern insulation materials on a large scale, we can assume that they are one of the more troublesome elements of the wall to dispose of.

In terms of this like for like comparison I feel that perhaps cob is mis represented, carbon balancing using renewable for an energy source would give better results, but when we consider generation capacities for renewables we would require more energy for space heating, which would require grater areas of solar panels, longer tubing of r ground source

[106] Rammed Earth Design and Construction Guidlines – BRE – Peter Walker, Rowland Keeble, Joe Martin, Vasilios Maniatidis

heating, or more high performance glazing for passive solar heating. How will these additions weigh up in comparison to a standard insulated cavity / timber frame?

4.9.3 LIMITATIONS

I have adapted a thoroughly prepared LCA of rammed earth to illustrate the insignificance of the embodied carbon savings with regards to cob walls. The values were so decisive, I feel that although the method is a little “Frankenstein” but it again proved the point I was aiming to make.

4.10 GENERAL CONCLUSIONS

It would appear that the general populace of the UK (or at least a representative sample) want homes with more perceived resilience than cob can offer. The majority of people want concrete and brick, strong dependable materials, which will last several life times, this understandable as it takes a lifetime to pay for a house.

The primary reason for choosing cob in the context of this discussion is its environmental credentials. However, owing to cob’s poor thermal properties, high heating demands, ergo high operational carbon foot print, I would argue that unless a cob structure can be heated with near 100% renewable energy cob is not worth considering.

In general conclusion therefore I would say that the benefit of modern insulation, of modern technology, has overridden the common sense notion that natural cob is the best option. I think we should forget about cob and concentrate on concepts such as the passivhaus.

I really wanted to prove that cob is still a relevant building material in the 21st century, but sadly I don’t think it is.

APPENDIX 1

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For web references please use footnotes included on each page.

APPENDIX 2

Correspondence

Nationwide: (07/07/2010/1600hrs)

Aim: To deduce how and who controls lending on non-traditional structures.

Entry Point: Customer Services

Passed around various departments, assistant informs me that it is the Surveyors (Countrywide Surveyors) responsibility to judge whether a property is fit to lend on.

Countrywide Surveyors: (07/07/2010/1630hrs)

Aim: To deduce how and who controls lending on non-traditional structures.

Entry Point: Receptionist

Surveyors do NOT make the call, they assess structural “health” but the main decision lies is with the lender.

Nationwide: (Again) (07/07/2010/1700hrs)

Aim: To deduce how and who controls lending on non traditional structures.

Entry Point: Customer Services (Liam Spiers)

A very worthwhile conversation. It would appear the “lendability” of a building is based on its design, and The Nationwide organise the structures under their “lending terms”

These are split in to “black and white” categories. Category A - Cranwell Construction is OK, whilst Category B - Wallis (A type of timber frame) is not OK, and Nationwide will not lend on a property of this type.

The Categories run from A to E. The Sales Man said he would print out and send me the information. So I’ll have to see if it turns up.

Nationwide: (Taunton Branch) (07/08/2010)

Aim: To deduce how and who controls lending on non traditional structures. More clarification needed.

Entry Point: Receptionist

I figure the people that have jobs in branch may be a little more savvy than those in call centres (rightly or wrongly), and they may know the source of the lending terms.

Nationwide (Claire Wilcox):

Aim: Continued.

Received return call from in branch mortgage advisor.

As far as Claire is aware the lending terms are derived by the Technical Underwriters, who she has emailed requesting that they provide some information.

Nationwide

Nationwide Building Society
New Business Service Centre 2
Kings Park Road
Moulton Park
Northampton
NN3 6NW
Tel: 0845 6093421
Fax: 01604 852879

Mr Thorpe
6 The Square
Uffculme
EX15 3AA

Dear Mr Thorpe,

I have put together a list of non-traditional build types for you. You'll see a list of Lending Terms and below this is a list of build types they apply to.

The table is self explanatory. I hope this helps.

Good luck.

Liam Spires
Mortgage Underwriter

Nationwide

LENDING TERM A
Acceptable for normal terms - eg, some post- 1960 timber and steel frame houses, some in- situ concrete and concrete block systems.

LENDING TERM B
Unacceptable **Valuer instructions** – Property must be declined unless you are advised in your instructions that it is already in mortgage to Nationwide. If so special cases of high merit can be accepted. These will be generally high value properties with proven demand; or properties that are accepted locally by other major high street lenders, even if values are lower than traditionally built properties; however, there must be a proven demand for the properties. **Retail instructions** – Cases should be declined. If a borrower selling enquires if we will currently lend on this type of construction we should advise we currently generally do not lend. However, if the seller finds a purchaser who wishes to obtain a mortgage with Nationwide we will consider lending. Advise the purchaser that the type of property is not normally suitable for mortgage purposes but we can consider an application. However, the applicant should be advised future acceptance for mortgage purposes cannot be guaranteed. When instructing a valuer ensure you advise him the property is already in mortgage. Even if already in mortgage a valuer may still decline the case on valuation.

LENDING TERM C
Unacceptable in original condition but suitable for normal terms on completion of acceptable repair scheme. Any repair scheme must include the whole structure/block, please refer details to **RUU, NH**, (for PRC properties designated as defective under the 1984 Housing Defects Act, see **Lending Term F**).

LENDING TERM D
Acceptable up to 85% loan to value in original condition and normal terms on completion of acceptable repair scheme, e.g. BISF houses and other Steel systems. Refer details of repair schemes to **RUU, NH.**

LENDING TERM E
Acceptable for houses and bungalows not more than two storeys in height, provided that a survey and appraisal from a Structural Engineer is available in accordance with the BRE Guidance Appraisal - Part 2 of study of LPS. Do NOT ask the applicant to obtain and pay for a report, one should be available from the Local Authority, as many of these properties are Council/former Council properties. The applicant should request details from the Local Authority. The report must cover the whole structure (e.g. whole terrace). Flats and maisonettes are **excluded** although special cases can be considered. Refer to **RUU, NH** for advice.

LENDING TERM F
PRC properties designated as being defective under the 1984 Housing Defects Act. **Unacceptable** in original condition. **Acceptable** on completion of an approved repair scheme to whole structure/block. Limited terms may be applied. Refer to **Mortgage Handbook Section 3.10**, subsection on **PRC Properties**.

*(3.10 subsection **PRE-FABRICATED REINFORCED CONCRETE (PRC) PROPERTIES***

The following construction types are designated defective under the 1984 Housing Defects Act. They may be acceptable after assessment and repair as described below, but remember that limited marketability could still prevent us from lending, even if the structure is sound.

Airey
Boot
Boswell
Cornish Unit 1
Cornish Unit 2
Dorran
Dyke
Gregory
Myton
Newland
*Orlit**
Parkinson
Reema Hollow Panel
Schindler and
Hawksley SGS
Smith
Stent
Stonecrete
Tarran
Underdown
Unity and Butterly
Waller
Wates
Wessex
Winget
*Woolaway***

**Orlit bungalows are not designated defective, lending terms A apply.*

***Please note Woolaway bungalows built from 1960 onwards are not included, and these are acceptable at normal terms.*

SCOTLAND

Ayrshire County Council (Lindsay)
Blackburn-Orlit
Boot Pier and Panel
Dorran
Myton-Clyde
Tee Beam
Unitroy
Whitson-Fairhurst
Winget)

NAME	ERA	FRAME TYPE	LENDING TERMS
Aberdeen Corporation	1	Timber	B
Aberdeen Corporation (Concrete)	1	In-situ concrete	A
A & C Barvis	3	LPS	B
Accent Homes, Undercliffe, Bradford	3	Timber	A
Acton	1	Various	B
Adams Housing Syndicate	1	Steel	D

Addison	2	Steel	D
Advanced Housing Hybrid System	3	Steel	A
A-Frame (Nucleus Projects Limited)	3	Timber	A
A G B Modular 6	3	Steel	A
Airey	2	PRC	F
Alcrete	2	Alloy	B
Alframe	2	No information available	B
Albetong - See Sunley Albetong	3	In-situ Concrete	A
Aluminium B1- Temporary	2	Alloy	B
Aluminium Bungalows- B2	2	Alloy	B
Aluminium Bungalows- BL8	2	Alloy	C
Aluminium House	2	Alloy	B
A.McK	3	R C Panels	B
American	2	No information available	B
Andover	3	Timber	A
Anglia- see GLC Anglia	3	LPS	E
Anglian - see Taylor Woodrow Anglian	3	LPS	B
Anvil	3	Timber	A
Anvil 6B	3	Timber	A
Applevard	3	Timber	A
Arcal	3	Steel	B
Arcon	2	Steel	B
Arcon Monopitch	3	Steel	B
Arcon Roof	3	Steel	B
Arcon Mark 5*	2	Steel	B
Argyll	2	PRC	B
Arrow	2	PRC	B
Arrowhead Housing (Formerly RFC)	3	Steel	A
Arrowtrim	3	No information available	B
Asbestos Cement Shuttered Houses	1	In-situ Concrete	B

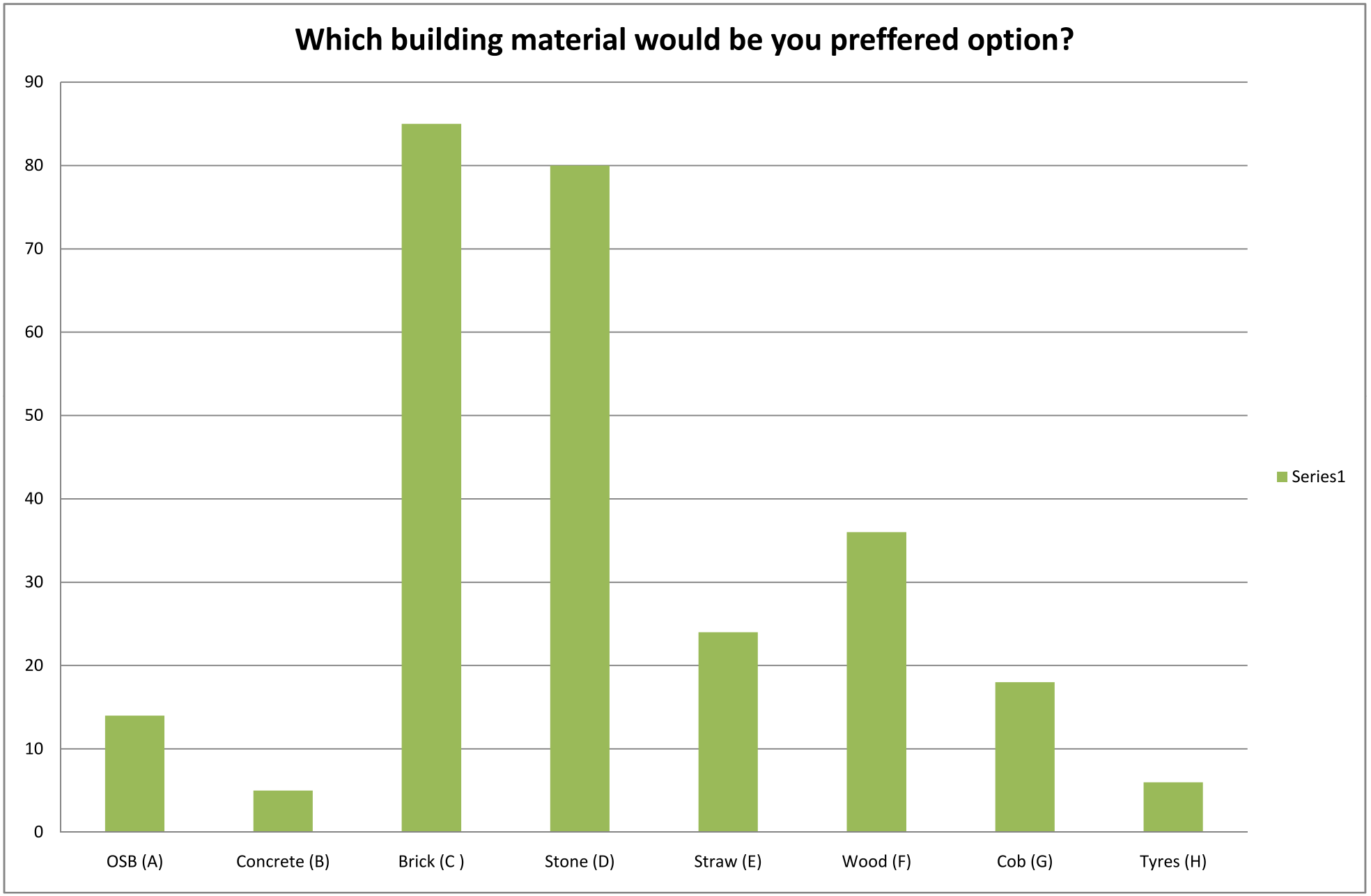
Aspect	3	Timber	A
Atherton	1	Steel	B
Atholl Steel 1926-8	1	Steel	B
Atholl Steel 1945	2	Steel	B
Atholl Steel 1951	2	Steel	D
Atholl Scheme II	2	Steel	D
Atholl 1954	2	Cavity Wall	A
Ayrshire County Council (Lindsay) - See Whitson-Fairhurst	2	PRC	F

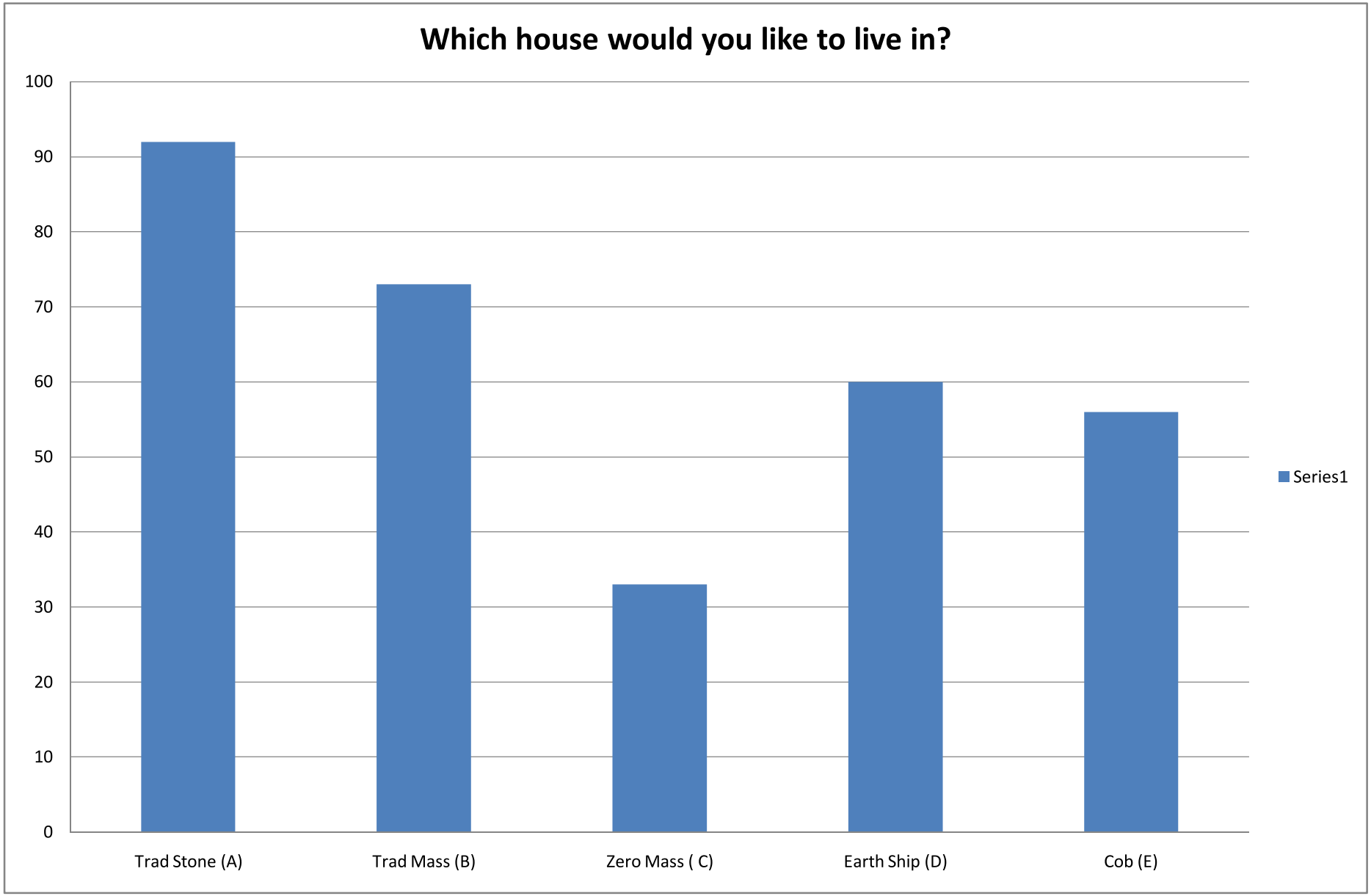
ERA

1	**Pre 1939**
2	**1940 – 1959**
3	**1960 to date**

APPENDIX 3

Survey Results


Which building material would be you preffered option?
90
80
70
60
50
40
30
20
10
0
OSB (A)
Concrete (B)
Brick (C)
Stone (D)
Straw (E)
Wood (F)
Cob (G)
Tyres (H)
Series1


Which house would you like to live in?
100
90
80
70
60
50
40
30
20
10
0
Trad Stone (A)
Trad Mass (B)
Zero Mass (C)
Earth Ship (D)
Cob (E)
Series1

Which building material would be you preffered option?

MATERIALS SURVEY

Materials	Adult	Child	Totals	% Adult	% Child	% Totals
OSB (A)	11	3	14	5	5	5
Concrete (B)	5	0	5	2	0	2
Brick (C)	62	23	85	30	38	32
Stone (D)	57	23	80	27	38	30
Straw (E)	22	2	24	11	3	9
Wood (F)	31	5	36	15	8	13
Cob (G)	14	4	18	7	7	7
Tyres (H)	6	0	6	3	0	2
Pop	208	60	268	100	100	100

MATERIALS SURVEY (Grouped)

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Convential	135	51	186	65	85	69
LUCTs	73	9	82	35	15	31
Pop	208	60	268	100	100	100

Which house would you like to live in?

DESIGN SURVEY

Design	Adult	Child	Totals	% Adult	% Child	% Totals
Trad Stone (A)	82	10	92	32	17	29
Trad Mass (B)	59	14	73	23	24	23
Zero Mass (C)	18	15	33	7	25	11
Earth Ship (D)	45	15	60	18	25	19
Cob (E)	51	5	56	20	8	18
Pop	255	59	314	100	100	100

DESIGN SURVEY (Grouped)

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Convential	141	24	165	55	41	53
LUCTs	114	35	149	45	59	47
Pop	255	59	314	100	100	100

MATERIALS SURVEY

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Convential	135	51	186	65	85	69
LUCTs	73	9	82	35	15	31
Pop	208	60	268	100	100	100

DESIGN SURVEY

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Convential	141	24	165	55	41	53
LUCTs	114	35	149	45	59	47
Pop	255	59	314	100	100	100

COMBINED

Grouping	Adult	Child	Totals	% Adult	% Child	% Totals
Convential	276	75	351	60	63	60
LUCTs	187	44	231	40	37	40
Pop	463	119	582	100	100	100